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Endogenous Property Rights Regimes, Common Pool Resources and Trade

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Abstract

This article analyzes the impact of trade on resource stocks through endogenously selected property rights regimes. A two-sector general equilibrium model is developed where opening to trade affects a common property resource stock through a community's voting decision to institute a property rights regime. The model finds that welfare can be maximized when a community degrades its resource stock under optimally selected property rights regimes after opening to trade. Results from a laboratory experiment show that subjects choose labor allocations, property rights regimes and resource stock levels that follow a Markov Perfect equilibrium path. However, subjects are only able to plan choices in three period intervals at most.

1. Introduction

Community-based management schemes governing the use of common pool resources, such as fisheries and irrigation systems, are prevalent in developing countries (Maggs and Hoddinott, 1997). Given the difficulty in establishing government control of common property resources, especially in developing countries, several studies have advocated community-based management schemes to preserve and increase environmental quality (Ostrom, 1990; Sandler, 1992; Baland and Platteau, 1996). Indigenous groups have their own informal social controls and customary laws that protect and regulate use of a resource stock. Such practices have been observed in countries such as Brazil, Colombia, Costa Rica, Japan, the Philippines, Spain and Switzerland (Rudel, 1995; Reinhart, 1988; Ostrom, 1990; Cruz, et al., 1992; Wright, 1992). Social controls, whether formal or informal, change over time. The evolution of property rights regimes can not only protect the environment, but also reduce uncertainty and increase efficiency in the market of the resource (Feder and Feeny, 1991). Communication and external regulations are an effective way to choose the socially optimal property rights regimes that govern the use of natural resource stocks in a community (Maldonado and Moreno-Sanchez, 2007). A voting mechanism can be modeled to facilitate a change in the existing institution governing the use of a resource stock (Vyrastekova and Van Soest, 2003).

The type of property rights regime selected by a community has a significant impact on resource stocks when opening to trade. Developing countries with more open access to natural resources gain comparative advantage in the production of resource-based goods resulting in a degradation of natural resource stock and decline in social welfare (Chichilnisky, 1994; Brander and Taylor, 1997 and 1998). However, existing institutions can evolve from an open-access regime to a more protected system. Hotte, et al. (2000) develop a model of trade and dynamic resource stock with an endogenous cost of enforcing property rights. They show that when countries open to trade, resource stocks increase but social welfare could decrease due to barring entrance of other users in the economy. Similarly, Margolis and Shogren (2002) show that by allowing for endogenous property enforcement rights, welfare losses can occur depending on the new set of world prices adopted by the economy.

In this paper, I analyze the link between international trade, property rights regimes and resource stocks over time. First, I model how property rights regimes change via a voting process and then I model the impact of trade on resource stocks through property rights regime choice. I investigate a new channel by which trade affects resource stocks: endogenously chosen property rights regime through voting. Three hypotheses are tested from the theoretical model using a laboratory experiment: (1) owners of a resource stock select extraction levels that follow a Markov Perfect equilibrium path; (2) the property rights regime chosen by the community follows a Markov Perfect equilibrium path; and (3) an announced price increase in the future results in the community members building the resource stock level prior to the price increase and degrading it afterwards.

A dynamic two-sector general equilibrium model is developed which illustrates how community members allocate labor between a resource-based sector and a manufacturing sector as well as select the property rights regime governing the use of the resource stock using a voting rule. To simplify the analysis, I investigate how a community regulates access to a resource stock by moving from complete open access to community managed open access. In most cases, community members choose to limit access to the resource stock. I find that communities that have comparative advantage in the production of a resource-based good allow the stock to grow prior to the opening of trade. However, the resource stock may still decline even with endogenous property rights regimes under communal management after trade is initiated. Thus, one important message of this study is that as long as a country follows the Markov Perfect equilibrium path that institutes a property rights regime and that governs resource extraction, then welfare is maximized even when the resource stock is degraded.

A dynamic common property resource game is developed to test the theoretical results of the model. Walker, Gardner, and Ostrom (1990) conducted a seminal experimental study that examined behavior within a static common property resource. Nash equilibrium was found to be a good predictor of aggregate behavior in some cases. Given a dynamic stock, efficiency tends to be lower when time dependent externalities are considered (Herr et al., 1995). Allowing communication amongst group members has a positive impact on the preservation of the resource stock. Ostrom and Walker (1991) show that if costless repeated communication is allowed, the cooperative equilibrium can be sustained. Hackett et al. (1993), however, find that heterogeneous individuals create distributional conflict over the access of the resource stock even with communication. The existing institutions governing the resource stock is exogenously given in most experiments. However, Vyrastekova and Van Soest (2003) endogenize the cost of enforcement through community voting in a static common property resource game and showed that individuals are more cooperative as long as majority favors enforcing resource management.

The existing experiments indicate that the intratemporal and intertemporal externalities significantly affect harvesting behavior. Also, communication does seem to have a significant effect on individuals' decisions and property rights regime choice through voting can affect how individuals govern the use of the resources stock. This article attempts to combine these elements by analyzing how subjects within a group determine the type of property rights regime governing the resource stock through a majority voting rule in the presence of intertemporal and intratemporal externality.

The experimental results show that labor allocation and property rights regime decisions do follow a Markov Perfect equilibrium path but for only three-period intervals at most. Also, subjects internalize some of the intertemporal externality by increasing the resource stock prior to an announced price increase by lessening labor and restricting access to the resource stock. After the price increase is implemented, resource stocks are degraded but the stock path is not always socially optimal.

The paper is divided into five sections. Section 2 presents the theoretical model. Section 3 describes the experimental design that tests the hypotheses from the theoretical model. Section 4 presents the results of the experiment and Section 5 concludes the study.

2. Model

The two sectors in the economy are the manufacturing sector and the resource sector. There are three factor endowments available in the economy. The manufacturing sector and the resource sector are endowed with quasi-fixed capital and a dynamic resource stock, respectively; while labor is a mobile input that can be used in either sector.

One unit of labor is interpreted as an hour of hired labor in the manufacturing sector or an hour devoted to harvesting in the resource sector. Henceforth, the terms community and non-community refer to the two main sources of labor. Community members have *de facto* property rights to the resource stock while non-community members do not. That is, the level of labor that can be allocated by non-community members to the resource sector is subject to direct control by the community members. Labor allocated at time t in the resource sector and the manufacturing sector by the community member is represented by l_{ct} and l_{ct}^*, respectively. Also, labor allocated at time t in the resource sector and the manufacturing sector by the non-community member is denoted by l_{nt} and l_{nt}^{*}, respectively. The maximum available labor hours at time t for any individual is h. The total number of community members and non-community members are C and N, respectively where C=N.

Production in the manufacturing sector at time t is characterized by an increasing, concave, constant returns production function, Y_x=(K,L_{xt}) where L_{xt} is the total labor allocated at time t in the manufacturing sector and K is capital endowment in the manufacturing sector. Here, total labor allocated in the manufacturing sector, L_{xt}, is equal to $\Sigma^{C}_{c=1} l_{ct}^{*}+\Sigma^{N}_{n=1} l_{nt}^{*}$. The objective of the owners of capital at period t is to maximize quasi-rent from capital, r_t, by choosing labor given a market wage rate at time t, w_t. Normalizing output price to 1 results in the following objective function,

(1) $\max_{L_{xt}} r_t = Y_x(K, L_{xt}) - w_t L_{xt}$.

The first order condition that determines the amount of labor in the sector is the following,

(2) $\dfrac{\partial Y_x(K, L_{xt})}{\partial L_{xt}} = w_t$.

At each period, the value of marginal product is equal to the equilibrium wage rate.

Entrants into the resource sector, who devote a positive amount of effort, derive earnings from harvest. Effort is a function, f, which captures returns from the resource sector given own labor and labor from other entrants into the sector. Assuming that the harvest per unit effort is directly proportional to the stock, the harvest, H, for the j^{th} individual at time t can be expressed as (Clark, 1985),

(3) $H_{jt}(S_t, L_{-jt}, l_{jt}) = \alpha_j S_t f(L_{-jt}, l_{jt})$,

where $f(L_{-jt}, l_{jt}) \rightarrow D[0,1/\alpha_j]$ is continuously differentiable. Here, D are labor hours in the domain, α_j is the harvestability coefficient of the j^{th} individual, S_t is the resource stock at time t, l_{jt} is the labor devoted by the j^{th} individual at time t, and L_{-jt} is the summation of all labor hours devoted by other individuals at time t. For example, for the c^{th} community member, $L_{-ct}=\Sigma^{C}_{i\neq c}\, l_{it}+\Sigma^{N}_{n=1}\, l_{nt}$ and for the n^{th} non-community member $L_{-nt}=\Sigma^{C}_{c=1}\, l_{ct}+\Sigma^{N}_{i\neq n}\, l_{it}$. Total harvest is nondecreasing in the stock and if there is no stock, harvest is zero. The effort function by the j^{th} individual is assumed to be $f(L_{-jt}, 0)=0$, $\partial f(L_{-jt}, l_{jt})/\partial l_{jt} \geq 0$, $\partial^2 f(L_{-jt}, l_{jt})/\partial l^2_{jt} \leq 0$. Furthermore, we assume that $\partial f(L_{-jt}, l_{jt})/\partial l_{-jt} \leq 0$, $\partial^2 f(L_{-jt}, l_{jt})/\partial^2 l_{-jt} \geq 0$ and $\partial^2 f(L_{-jt}, l_{jt})/\partial l_{-jt}\, \partial l_{jt} \leq 0$ where $l_{-jt} \in L_{-jt}$ representing labor from representing labor from an individual other than j at time t. Lastly, the magnitude of the immediate impact, $\partial f(L_{-jt}, l_{jt})/\partial l_{jt}$, is greater than any secondary effect such as $\partial f(L_{-jt}, l_{jt})/\partial l_{-jt}$, $\partial^2 f(L_{-jt}, l_{jt})/\partial^2 l_{-jt}$ or $\partial^2 f(L_{-jt}, l_{jt})/\partial^2 l_{-jt}$.

Given the common-property nature of the resource stock, two types of externalities are examined: an intratemporal externality during each period, $\partial H_{jt}/\partial l_{-jt}$, and an intertemporal externality, $\mu_{t+1}\partial H_{jt}/\partial l_{-jt}$, where μ_{t+1} is the marginal user cost of the resource stock at time $t+1$. The intratemporal externality results from congestion when effort applied by other individuals interferes with the current harvest. The intertemporal externality refers to the reduction in future harvest due to individuals ignoring the effect that their own action has on future stock productivity.

One critical assumption that is made throughout the analysis is that the harvestability coefficient of community members is always greater than non-community members. The differences arise from the inherent capabilities of community members to harvest given that they have had rights over the use of the resource stock and have had more experience and developed more efficient technologies to harvest. New entrants into the resource stock, such as non-community members, would still have to develop their skills or acquire new technology to extract from the resource stock.

Total wealth, W_j, by the j^{th} individual is the summation of discounted income from a starting period, 0, until the end period, T,

$$(4)\ W_j = \sum_{t=0}^{T} \left(w_t l_{jt}^* + p_t \alpha_j S_t f(L_{-jt}, l_{jt}) \right) \delta^t$$

where δ is the discount factor and p_t is the price of the harvested output from the resource sector relative to price of the output in the manufacturing sector at time t.

The change in stock over time depends on the natural growth function of the stock and harvest by all individuals from the community and non-community. The stock dynamics are expressed as,

$$(5)\ S_{t+1} - S_t = G(S_t) - \sum_{c=1}^{C} \alpha_c S_t f(L_{-ct}, l_{ct}) - \sum_{n=1}^{N} \alpha_n S_t f(L_{-nt}, l_{nt}).$$

Here, S_{t+1}-S_t is the change of stock over time and $G(St)$ is the natural growth function of stock when there is no harvest.

2.1 Homogeneous Community Members

Two property rights regimes are examined: limited open-access and community-managed open-access. The former refers to entrance by any community member and a limited number of non-community members into the resource sector. The limit is determined by community members through a voting mechanism. The latter refers to entrance of community members only into the resource sector. Under community-managed open access, even though non-community members are not allowed into the resource sector, open access amongst community members still prevails. The equilibrium concept is Markov Perfect. It gives the set of labor hours and wage rate in all periods that maximizes earnings for each individual while taking the behavior of all other individuals as given. A differentiated Markov control rule is derived such that $l_{ct} = l_{ct}(S_t)$, $l^*_{ct} =$

$l^*_{ct}(S_t)$, $l_{nt} = l_{nt}(S_t)$ and $w_t=w_t(S_t)$. To simplify the analysis, the total labor constraint during each period is used so that only $l_{ct} = l_{ct}(S_t)$, $l_{nt} = l_{nt}(S_t)$ and $w_t=w_t(S_t)$ are derived.

In the baseline model, community members live a finite period of time. The objective of each community member is to maximize own earnings over T periods given the stock dynamics. Community members are only endowed with their own labor, which they can allocate in either the resource sector or the manufacturing sector. Since community members have *de facto* property rights over the use of the resource stock, they choose the amount of labor that non-community members are allowed to use within the resource sector. In order to ensure that non-community members enter into the resource sector whenever l^*_{nt} is offered by community members, the value of marginal product of non-community members evaluated at l^*_{nt} must be greater than or equal to the prevailing wage rate, i.e. $p_t\alpha_n S_t\partial f(L_{-nt},l^*_{nt})/\partial l_{nt} \geq w_t$. This constraint is similar to a participation constraint for non-community members.[1] Using equations (5) and (6) and assuming homogeneous community members, the maximization problem of the representative c^{th} community member is written as,

$$\max_{l^*_{ct},l_{ct},l_{nt}} W_c = \sum\nolimits_{t=0}^{T} \left(w_t l^*_{ct} + p_t\alpha_c S_t f(L_{-ct},l_{ct})\right)\delta^t$$

$$s.t. S_{t+1} = S_t + G(S_t) - C\alpha_c S_t f(L_{-ct},l_{ct}) - N\alpha_n S_t f(L_{-nt},l_{nt});\;\; l^*_{ct} + l_{ct} = h;\; p_t\alpha_n S_t \frac{\partial f(L_{-nt},l_{nt})}{\partial l_{nt}} - w_t \geq 0$$

where $L_{-ct}=\Sigma^{C}_{i\neq c}\, l_{it}+\Sigma^{N}_{n=1}\, l_{nt}$ and $L_{-nt}=\Sigma^{C}_{c=1}\, l_{ct}+\Sigma^{N}_{i\neq n}\, l_{it}$.

The owners of capital in the manufacturing sector maximize quasi-rent from capital by choose labor as shown in equation (1). Here, even though the general equilibrium model allows for the wage to be endogenously determined by the system, all individuals take wage rate as exogenous. The Lagrangean for the problem is written as,

[1] The difference in marginal profits between sectors instead of total profits is used to give flexibility in choice between sectors.

$$\max_{l_{ct}^*, l_{ct}, l_{nt}} L = \sum_{t=0}^{T} \left(w_t l_{ct}^* + p_t \alpha_c S_t f(L_{-ct}, l_{ct})\right)\delta^t + \lambda_t \left(p_t \alpha_n S_t \frac{\partial f(L_{-nt}, l_{nt})}{\partial l_{nt}} - w_t \right)$$

where $S_t = G(S_{t-1}) + S_{t-1} - \sum_{c=1}^{C} \alpha_c S_{t-1} f(L_{-ct-1}, l_{ct-1}) - \sum_{n=1}^{N} \alpha_n S_{t-1} f(L_{-nt-1}, l_{nt-1})$ and λ_t is the marginal wealth from a change in marginal value product of non-community members in the resource sector. By substituting w_t using (2) into the first-order conditions from the community member's maximization problem, the first-order conditions are,

(6)

$$\frac{\partial L}{\partial l_{ct}} = \left(p_t - \mu_{t+1} C\right)\alpha_c S_t \frac{\partial f(L_{-ct}, l_{ct})}{\partial l_{ct}} \delta^{t-1} - \mu_{t+1} N \alpha_n S_t \frac{\partial f(L_{-nt}, l_{nt})}{\partial l_{nt}} \delta^{t-1} + \lambda p_t \alpha_n \left(S_t \frac{\partial^2 f(L_{-nt}, l_{nt})}{\partial l_{nt} \partial l_{ct}} + \frac{\partial S_{t+1}}{\partial l_{ct}} \frac{\partial f(L_{-nt}, l_{nt})}{\partial l_{nt}} \right) - \frac{\partial Y_x(K, L_{xt})}{\partial L_{xt}} \leq 0 \quad \forall t = 1.T-1$$

$$(h - l_{ct}) \frac{\partial L}{\partial l_{ct}} = 0 ;$$

(7) $$\frac{\partial L}{\partial l_{cT}} = p_T C \alpha_c S_T \frac{\partial f(L_{-cT}, l_{cT})}{\partial l_{cT}} \delta^T + \lambda p_T \alpha_n S_T \frac{\partial^2 f(L_{-nT}, l_{nT})}{\partial l_{nT} \partial l_{cT}} - \frac{\partial Y_x(K, L_{xT})}{\partial L_{xT}} \leq 0 ;$$

$$(h - l_{cT}) \frac{\partial L}{\partial l_{cT}} = 0 ;$$

(8)

$$\frac{\partial L}{\partial l_{nt}} = p_t \alpha_c S_t \frac{\partial f(L_{-ct}, l_{ct})}{\partial l_{nt}} - \mu_{t+1} C \alpha_c S_t \frac{\partial f(L_{-ct}, l_{ct})}{\partial l_{nt}} + \lambda p_t \alpha_n \left(S_t \frac{\partial^2 f(L_{-nt}, l_{nt})}{\partial l_{nt}^2} + \frac{\partial S_{t+1}}{\partial l_{nt}} \frac{\partial f(L_{-nt}, l_{nt})}{\partial l_{nt}} \right) - \mu_{t+1} N \alpha_n S_t \frac{\partial f(L_{-nt}, l_{nt})}{\partial l_{nt}} \leq 0 \quad \forall t = 1.T-1$$

$$l_{nt} \frac{\partial L}{\partial l_{nt}} = 0$$

(9) $$\frac{\partial L}{\partial l_{nT}} = p_T N \alpha_c S_T \frac{\partial f(L_{-cT}, l_{cT})}{\partial l_{nT}} \delta^T + \lambda p_T \alpha_n S_T \frac{\partial^2 f(L_{-nT}, l_{nT})}{\partial l_{nT}^2} \leq 0 ; \; l_{nT} \frac{\partial L}{\partial l_{nT}} = 0 .$$

(10) $$\frac{\partial L}{\partial \lambda} = p_t \alpha_n S_t \frac{\partial f(L_{-nt}, l_{nt})}{\partial l_{nt}} \delta^T - \frac{\partial Y_x(K, L_{xt})}{\partial L_{xt}} \geq 0 \quad \forall t = 1..T$$

Here, $\mu_{t+1} \equiv p_t \alpha_c f(L_{ct}; l_{ct}) \delta^{t+1}$ is the marginal user cost or the shadow price of the resource stock.

Simultaneously solving for equation (6) to (10) along with the market clearing conditions during each time, $l_{ct} + l^{*}_{ct} = h$ and $l_{nt} + l^{*}_{nt} = h$; yield the Markov Perfect equilibrium values for labor devoted by each individual as well as the wage rate. Given the assumption that all community members have the same harvesting coefficient, a symmetric Nash equilibrium in the sequential game is derived.

The interpretation of equations (6) and (7) manifests the conditions for labor allocation in a Ricardo-Viner or Specific Factors Model. Equation (7) states that if an interior solution exists, labor is allocated until the values of marginal product in the resource sector net of the intratemporal externality are equal during the terminal period. Because individuals live only until period T, they do not internalize the intertemporal externality in subsequent periods.[2] From (6), the value of marginal product in the manufacturing sector is equal to the discounted value of marginal product in the resource sector minus the intertemporal and intratemporal externalities from periods 1 to T-1. Thus, community members partially internalize the intratemporal and intertemporal externality over a finite horizon model.

Equations (8) and (9) show the marginal contribution of non-community labor to the income of the representative community member. The community members always opt to close the resource stock during the last period since their returns from allowing non-community labor is always negative as shown in (9). During periods 1 to T-1, increasing non-community labor crowds out some harvest by the community. The community member internalizes some of the crowding out effect from the entrance of non-community members as shown by the positive effect on community earnings from the second term in (8), $-\mu_{t+1}\alpha_c S_t C(\partial f(L_{-ct}, l_{ct})/\partial l_{nt})$. Allowing

[2] If the social planner's problem is solved, the intertemporal and intratemporal externalities fall out from the model. In this case, the social planner can employ instruments, such as a Pigouvian tax, to capture all the rent from the resource stock. However, to simplify the analysis, the focus of the study is on the endogenous choice of the community to keep the resource stock open or closed.

entrance of non-community labor in the current period decreases marginal returns for all entrants into the resource sector. Because the intratemporal externality is internalized by community members, they are willing to shift labor from the resource sector to the manufacturing sector. Less pressure is put on the resource stock and may result in more stock available for future harvest in the next period. Thus, allowing non-community members into the resource stock in the current period may result in more future benefits in the form of more resource stock in the next period. Whenever these marginal gains of allowing entrance into the resource sector is larger than the marginal cost, the community may open the resource sector.

The critical assumption that leads to a potential opening of the resource stock in the earlier periods is larger harvestability coefficient for community members versus non-community members. In this finite-period general equilibrium model, there are more than one property rights regime pattern that may emerge. In contrast, a myopic community member, who does not internalize any of the externalities, closes the resource stock during all periods.

2.2 Heterogeneous Community Members

Now, community members are assumed to differ and are ranked according to their extraction efficiency, while non-community members remain homogeneous with a harvestability coefficient, α_n. The harvestability coefficient is ranked from lowest to highest for all C community members such that, $\alpha_1 < \alpha_2 < \ldots < \alpha_m < \ldots < \alpha_{C-1} < \alpha_C$ where subscripts on α denote the rank of the community member. Here, the C^{th} individual is the most efficient, with a harvestability coefficient α_C, while the 1st individual is the least efficient, with a harvestability coefficient α_1. The m^{th} individual is called the median voter and has a harvestability coefficient α_m. We continue to assume that all community members have a higher harvestability coefficient than non-community members such that $\alpha_1 > \alpha_n$.

Under a majority voting rule, the median voter's preference determines the property rights regime choice. If the median voter earns more welfare by keeping the resource sector open (closed) to non-community members, the community will vote to (dis)allow entrance into the resource sector. The equilibrium concept is Markov Perfect. A differentiable Markov control rule for all community labor, $l_{ct} = l_{ct}(S_t)$, is derived along with a Markov control rule selected by the community through a majority voting rule, $l_{nt} = l_{nt}(S_t)$, and wage, $w_t=w_t(S_t)$.

The median voter's objective is to maximize wealth over T periods by allocating labor in both sectors. He also selects the amount of non-community labor allowed into the resource sector. In order to ensure that non-community members enter into the resource sector whenever l^*_{nt} is offered by median voter, the value of marginal product of non-community members evaluated at l^*_{nt} must be greater than or equal to the prevailing wage rate, i.e. $p_t\alpha_n S_t\partial f(L_{-nt},l^*_{nt})/\partial l_{nt} \geq w_t$. The median voter's maximization problem is written as,

$$\max_{l_{mt},l^*_{mt},l_{nt}} W_m = \sum_{t=0}^{T} \left(w_t l^*_{mt} + p_t\alpha_m S_t f(L_{-mt},l_{mt})\right)\delta^t$$

$$s.t. S_{t+1} = S_t + G(S_t) - \sum_{i=1}^{C} \alpha_{ci} S_t f(L_{-it},l_{it}) - N\alpha_n S_t f(L_{-nt},l_{nt}); \;\; l^*_{mt} + l_{mt} = h; \;\; p_t\alpha_n S_t \frac{\partial f(L_{-nt},l_{nt})}{\partial l_{nt}} - w_t \geq 0.$$

where l_{mt} and l^*_{mt} is the amount of labor allocated by the median voter in the resource sector and manufacturing sector at time t, respectively; $L_{-mt}=\Sigma^{C}_{c\neq m} l_{ct}+N l_{nt}$, $L_{-ct}=\Sigma^{C}_{i\neq c} l_{it}+N l_{nt}$ and $L_{-nt}=\Sigma^{C}_{i=1} l_{it}+(N-1) l_{it}$. Other community members have similar objective functions but the subscript m is replaced by the subscript for the c^{th} community member. The corresponding Lagrangean function that the median voter maximizes is written as,

$$\max_{l_{mt},l^*_{mt},l_{nt}} L_m = \sum_{t=0}^{T} \left(w_t l^*_{mt} + p_t\alpha_m S_t f(L_{-mt},l_{mt})\right)\delta^t + \lambda_t\left(p_t\alpha_n S_t \frac{\partial f(L_{-nt},l_{nt})}{\partial l_{nt}} - w_t\right)$$

where $S_t = G(S_{t-1}) + S_{t-1} - \sum_{c=1}^{C} \alpha_c S_{t-1} f(L_{-ct-1}, l_{ct-1}) - \sum_{n=1}^{N} \alpha_n S_{t-1} f(L_{-nt-1}, l_{nt-1})$. By substituting for w_t using (2) into the first-order conditions from the median voter's maximization problem, the following first-order conditions are derived,

(11)
$$\frac{\partial L_m}{\partial l_{mt}} = p_t \alpha_m S_t \frac{\partial f(L_{-mt}, l_{mt})}{\partial l_{mt}} \delta^{t-1} - \mu_{t+1} \sum_{i=1}^{C} \left(\alpha_i S_t \frac{\partial f(L_{-it}, l_{it})}{\partial l_{mt}} \right) \delta^{t-1} - \mu_{t+1} N \alpha_n S_t \frac{\partial f(L_{-nt}, l_{nt})}{\partial l_{mt}} \delta^{t-1} +$$
$$\lambda_t p_t \alpha_n \left(S_t \frac{\partial^2 f(L_{-nt}, l_{nt})}{\partial l_{nt} \partial l_{ct}} + \frac{\partial S_{t+1}}{\partial l_{ct}} \frac{\partial f(L_{-nt}, l_{nt})}{\partial l_{nt}} \right) - \frac{\partial Y_x(K, L_{xt})}{\partial L_{xt}} \leq 0 \quad \forall t = 1.T-1$$

$$(h - l_{mt}) \frac{\partial L_m}{\partial l_{mt}} = 0;$$

(12)
$$\frac{\partial L_m}{\partial l_{mT}} = p_T C \alpha_m S_T \frac{\partial f(L_{-mT}, l_{mT})}{\partial l_{mT}} \delta^T + \lambda_T p_T \alpha_n S_T \frac{\partial^2 f(L_{-nT}, l_{nT})}{\partial l_{nT} \partial l_{cT}} - \frac{\partial Y_x(K, L_{xT})}{\partial L_{xT}} \leq 0;$$

$$(h - l_{mT}) \frac{\partial L_m}{\partial l_{mT}} = 0;$$

(13)

$$\frac{\partial L_m}{\partial l_{nt}} = p_t \alpha_m S_t \frac{\partial f(L_{-mt}, l_{mt})}{\partial l_{nt}} - \mu_{t+1} \sum_{i=1}^{C} \left(\alpha_i S_t \frac{\partial f(L_{-it}, l_{it})}{\partial l_{nt}} \right) \delta^{t-1} + \lambda_t p_t \alpha_n \left(S_t \frac{\partial^2 f(L_{-nt}, l_{nt})}{\partial l_{nt}^2} + \frac{\partial S_{t+1}}{\partial l_{nt}} \frac{\partial f(L_{-nt}, l_{nt})}{\partial l_{nt}} \right)$$
$$- \mu_{t+1} N \alpha_n S_t \frac{\partial f(L_{-nt}, l_{nt})}{\partial l_{nt}} \leq 0 \quad \forall t = 1..T-1$$

$$l_{nt} \frac{\partial L_m}{\partial l_{nt}} = 0$$

(14)
$$\frac{\partial L_m}{\partial l_{nT}} = p_T N \alpha_m S_T \frac{\partial f(L_{-mT}, l_{mT})}{\partial l_{nT}} \delta^T + \lambda_T p_T \alpha_n S_T \frac{\partial^2 f(L_{-nT}, l_{nT})}{\partial l_{nT}^2} \leq 0; \; l_{nT} \frac{\partial L_m}{\partial l_{nT}} = 0.$$

(15)
$$\frac{\partial L_m}{\partial \lambda} = p_t \alpha_n S_t \frac{\partial f(L_{-nt}, l_{nt})}{\partial l_{nt}} \delta^T - \frac{\partial Y_x(K, L_{xt})}{\partial L_{xt}} \geq 0 \quad \forall t = 1..T$$

Here, $\mu_{t+1} \equiv p_t \alpha_m f(L_{mt}; l_{mt}) \delta^{t+1}$ is the marginal user cost of the resource stock for the median voter.

There are C-1 similar first order conditions as (11) and (12) from the maximization problem of the other community members except the m^{th} subscript would each be replaced with the c^{th} subscript. Simultaneously solving for labor allocated in the resource sector using all $2C+2$ conditions along with the market clearing conditions during each time, $l_{ct} + l^{*}_{ct} = h$ and $l_{nt} + l^{*}_{nt} = h$; yields the Markov Perfect equilibrium allocation of labor, property rights regime choice and wage rate.

The interpretations of the equations are similar to the previous case. The median voter will always vote to close the stock in the last period. The median voter may or may not prefer to close the resource stock from periods 1 to T-1. Non-community labor entering into the resource sector crowds out the harvest for all other entrants into the sector and results in a marginal shift in labor allocation from the resource sector to the manufacturing sector. If the amount of stock preserved through the crowding out of community members is sufficiently large, the median voter would allow some non-community labor to enter the resource sector. The necessary assumption that allows for this result to occur is that the harvestability coefficient of the non-community members is lower than the harvestability coefficient of the lowest ranked community member.

2.3 Trade Effects

In this section, the effect of trade on labor allocation across sectors, property rights regime choice and resource stock levels are determined. The relative domestic price moves to the prevailing world market price when a small economy opens to trade. Countries that have comparative advantage (disadvantage) in the production of the resource-based output will see an increase (decrease) in the relative price of the good. An announced change in future price can affect the labor allocation decisions during the planning horizon. Once the effect of a price change on l_{ct} and l_{nt} are derived, the impact of l_{ct} and l_{nt} on stock is obtained to arrive at the total effect of price changes on stocks.

In obtaining the comparative statics, we rely on Topkis (1978) monotonicity theorem: given a system of complements and a vector of complementary exogenous parameters, monotone shifts in the latter imply a monotone shift of the endogenous variables.[3] Thus, if all the cross-partial derivatives for any smooth function, along with the parameter of interest, are non-negative, then there is an increasing relationship between the parameter and the choice variable.

To simplify the analysis, a two-period model is used to minimize the dimensions of the problem. The cross partial derivatives of the variables, $\{(-l_{c1}); l_{c2}; (-l_{n1}) ; (-l_{n2}); p_2\}$, from the objective function are non-negative (see Appendix 1). Therefore, the following comparative statics are derived,

(16) $$\frac{\partial l_{c1}}{\partial p_2} \leq 0;\ \frac{\partial l_{c2}}{\partial p_2} \geq 0;\ \frac{\partial l_{n1}}{\partial p_2} \leq 0;\ \frac{\partial l_{n2}}{\partial p_2} \leq 0.$$

An improvement in the terms of trade during period 2 results in an increase in the labor allocated in the resource stock by the representative community member during period 2. To raise the stock in period 2, the representative community member decreases own labor in period 1. An improvement in the terms of trade also affects the community's decision to allow non-community labor into the resource sector. When the price of output from the resource sector increases in period 2, the access of non-community labor to the resource stock decreases during both periods. This outcome is similar to Hotte, et al. (2000), where they show that an increase in terms of trade results in more enforcement of property rights.

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[3] Topkis' theorem does not need to impose any assumptions on the concavity of the objection function, interiority of the solution or convexity of the feasible set. Formally, a function $F:R^K \rightarrow R$ is said to be supermodular in z and z′ in $R^K \rightarrow R$, we have $F(z \vee z') + F(z \wedge z') \geq F(z) + F(z')$, where $z \vee z'$ is the coordinate-wise maximum of the points z and z′, i.e. $z \vee z' = (\max\{z_1, z_1'\}, \ldots, \max\{z_m, z_m'\})$, and $z \wedge z'$ is the coordinate-wise minimum of the points z and z′, i.e. $z \wedge z' = (\min\{z_1, z_1'\}, \ldots, \min\{z_m, z_m'\})$. If F is smooth, supermodularity is equivalent to the condition, $\partial^2 F/(\partial z_i \partial z_j) \geq 0 \quad \forall\ i \neq j$.

To derive the impact of a change in price during period 2 on the available stock in periods 2 and 3, we use the comparative statics from (16) along with the transition equation of the stock in (5). The stock in period 2 is written as,

(17) $S_2 = S_1 + G(S_1) - C\alpha_c S_1 f(L^*_{-c1}, l^*_{c1}) - N\alpha_n S_1 f(L^*_{-n1}, l^*_{n1})$.

where L^*_{-c1}, l^*_{c1}, L^*_{-n1}, and l^*_{n1} are the Markov Perfect equilibrium level of labor allocation in the resource sector. Taking the derivative of (17) with respect to p_2, rearranging and assuming C=N yields,

(18) $$\frac{\partial S_2}{\partial p_2} = -CS_1\left(\alpha_c \frac{\partial f(L^*_{-c1}, l^*_{c1})}{\partial l_{c1}} + \alpha_n \frac{\partial f(L^*_{-n1}, l^*_{n1})}{\partial l_{c1}}\right)\frac{\partial l_{c1}}{\partial p_2} - CS_1\left(\alpha_c \frac{\partial f(L^*_{-c1}, l^*_{c1})}{\partial l_{n1}} + \alpha_n \frac{\partial f(L^*_{-n1}, l^*_{n1})}{\partial l_{n1}}\right)\frac{\partial l_{n1}}{\partial p_2}.$$

Whenever the marginal effort from own labor weighted by the harvesting efficiency parameter is greater than the marginal effort from other labor weighted by the harvesting efficiency, i.e. $\alpha_j \frac{\partial f(L^*_{-j0}, l^*_{j0})}{\partial l_{-j0}} + \alpha_{-j} \frac{\partial f(L^*_{-j0}, l^*_{j0})}{\partial l_{j0}} > 0$, the resource stock level increases when price also increases.

The total impact on the stock in period 2 after the price change is ambiguous. Using (5), the stock in period 3 is written as,

(19) $S_3 = S_2 + G(S_2) - C\alpha_c S_2 f(L^*_{-c2}, l^*_{c2}) - N\alpha_n S_2 f(L^*_{-n2}, l^*_{n2})$.

Taking the derivative with respect to p_2 yields,

(20)

$$\frac{\partial S_3}{\partial p_2} = \frac{\partial S_2}{\partial p_2}\left(1 + \frac{\partial G(S_2)}{\partial S_2} - C\left(\alpha_c \frac{\partial f(L^*_{-c2}, l^*_{c2})}{\partial l_{c2}} + \alpha_n \frac{\partial f(L^*_{-n2}, l^*_{n2})}{\partial l_{c2}}\right)\frac{\partial l_{c2}}{\partial p_2} - C\left(\alpha_c \frac{\partial f(L^*_{-c2}, l^*_{c2})}{\partial l_{n2}} + \alpha_n \frac{\partial f(L^*_{-n2}, l^*_{n2})}{\partial l_{n2}}\right)\frac{\partial l_{n2}}{\partial p_2}\right)$$

Two factors increase the stock in the third period: the natural growth rate of the stock, $\partial G(S_2)/\partial S_2$, and the decrease in non-community labor during period 2, $\partial l_{n2}/\partial p_2 \leq 0$. However, the increased pressure from labor allocations by community members degrades the resource stock, $\partial l_{c2}/\partial p_2 \geq 0$. Overall, the remaining stock after the third round may or may not immediately decrease depending on the magnitude of the growth of the stock, property rights regime choice and change in labor allocations by community members. Thus, given a dynamic resource stock and endogenous property rights regime, opening a country to trade does not necessarily imply an immediate degradation of the resource stock in a two-period model. However, degrading the resource stock can be a welfare maximization strategy as long as the community follows the Markov Perfect equilibrium path in labor allocation and property rights regime choice.

3. Experimental Design

The hypotheses tested in the experiment, experimental design and functions and parameters in the experiment are presented in this section.

3.1 Hypotheses

Three hypotheses are tested using a laboratory experiment:

Hypothesis 1. Markov Perfect equilibrium hypothesis governing the extraction of a dynamic resource stock: Owners of a resource stock behave as rational, wealth maximizing individuals and expect all other members of their community to behave in the same manner over time. Thus, when all community members are homogeneous, they choose extraction levels that satisfy equations (6) to (10). When community members are heterogeneous, they choose extraction levels that satisfy equations (11) to (15). As an alternative to this hypothesis, we compare the results of the analysis for the case of myopic Nash equilibrium behavior. Here, individuals maximize earnings for each individual period without taking into consideration the intertemporal and intratemporal externalities. This implies the same equations stated in hypothesis 1 but the marginal intertemporal and intratemporal externality is equal to zero.

Hypothesis 2. Markov Perfect equilibrium hypothesis governing the property rights regime pattern voted by the community over time: The property rights regime chosen by the community depends on the preference of the median community member. The representative community member or median voter chooses the property rights regime that satisfies equations (6) to (10) or (11) to (15), respectively. As an alternative to this hypothesis, the myopic Nash equilibrium behavior of the community is examined where subjects always choose to close the resource stock to non-community members.

Hypothesis 3. Effect of price change on stock in a finite horizon: A price increase results in community members building the stock by following a Markov Perfect equilibrium path in selecting their labor use in both sectors and the property rights regime that govern the use of the resource stock. Specifically, stock levels are higher before opening to trade as shown in (18).

Two important notes regarding the hypothesis are in order. First, the choice of property rights regimes and labor allocation by the community are jointly determined. This implies that *both* labor allocations and property rights regime need to be jointly tested to determine is they follow a Markov Perfect equilibrium or a myopic Nash equilibrium path. Also, subjects may also not completely plan for all rounds but instead plan in segments of 2, 3 or 4 rounds at a time. The choices of subjects are also compared with a Markov Perfect equilibrium path in which decisions are made in segments of 2, 3 or 4 rounds at a time.

3.2 Experimental Design

There are some elements in this experiment that differ significantly from the usual common pool resource game. First, a dynamic version of the common pool resource game is tested. Though static repeated games have the advantage of analytical and theoretical simplicity, the dynamic elements influencing behavior are overlooked. Second, endogenously determined institution governing the use of the resource stock is incorporated. Lastly, the two sectors in the economy are connected by an endogenous wage rate instead of a fixed wage rate.

The experiment was conducted at the University of Maryland using a computerized program that captures the basic elements of the two-sector dynamic general equilibrium model. Subjects were recruited from a pool of graduate and undergraduate students who had prior experience in participating in experiments. Subjects were not informed of any specific details related to the content of the experiment. They were only told of the average duration of the experiment (1 hour), and that earnings are based on their decisions during the experiment.[4]

During an experimental session, each subject participated in two treatments. Subjects were randomly placed into a six-person cluster containing two groups. The first group in the cluster comprised of five individuals representing the community, who had *de facto* rights over the use of a stock. The second group in the cluster contained one individual representing five non-community members that do not have any rights to the use of the resource stock. Each subject stayed in these groups throughout the experiment.

Instructions were simultaneously read to all subjects, after which a two-round practice was conducted. Group 1 individuals acted first in each round, while group 2 members waited. Once all group 1 members finish, group 2 members respond while group 1 waited. After all group 2 members are finished with their decision, the results are displayed in front of all participants in a summary table, after which, the next round follows. Throughout the entire session, subjects were allowed to view their earnings and their past decisions. This sequence

[4] To ensure that all 24 terminals in the computer laboratory are used, more than 24 subjects were recruited during each session. If the session is already full, those that were not able to participate are given a $5 attendance fee as well as a guaranteed slot for a future session. All participants are logged on to their computer with a messenger program and two open windows: a practice window and a window for the actual experiment. Beside each terminal is a hard copy of all the instructions and a copy of the student newspaper, which is used to fill the time during waiting periods between rounds.

continues until the last round. Before paying off the participants, they are required to answer a post survey questionnaire.[5]

Subjects earned "currency dollars" by allocating labor in two types of markets. The decisions of the subjects were framed such that they allocated 10 units of their total labor hours into Market 1 or Market 2. Subjects can allocate labor into the resource sector (Market 1) and earn an amount equal to the value of harvest or allocate their labor units into the manufacturing sector (Market 2) and earn a wage rate equal to the marginal value product of labor in that sector. The wage is endogenously determined by the number of labor hours in Market 2 but a single subject perceives wage as exogenous. To mimic this condition, parameters are chosen such that a marginal change in labor allocation has a small impact on overall wage. In the resource sector, total earnings depend upon the amount of stock, harvest of other participants and the relative price of harvested resource. In all the treatments, subjects were informed that the initial stock level is low but it could grow over time as long as less labor is allocated in Market 1.[6]

Group 1 members allocate their labor between the two markets and choose to keep the resource stock open or closed to non-community members by voting. If they decide to keep the resource stock open, group 1 members vote on the maximum amount of labor hours per individual from group 2 they allow into the resource sector. Once the amount of permits are chosen, group 2 members then choose the amount of labor they allocate into the two sectors given the constraint on allowable labor hours in the resource sector.[7] This two-step procedure in

[5] The response from group 1 members (subjects representing the community) were the main focus of data analysis. Live subjects were chosen as representatives of the non-community members instead of computers because group 1 members may react differently when faced with a computer acting as a group 2 member.

[6] All subjects were provided with a calculator that solves for the profit in each sector if they input their own level of labor along with the predicted labor of other members in the cluster.

[7] Group 1 members are allowed to communicate amongst each other via the MSN messenger system but their individual decisions were kept private. Before the first round of a treatment, all group 1 members were given 5 minutes to chat via messenger to familiarize themselves with the program. In the subsequent rounds, they were allowed to chat throughout the duration of the treatment.

voting is used so that the answer to the dichotomous choice question, which is incentive-compatible, can be analyzed. Gibbard (1973) and Satterthwaite (1975) prove that if three or more choices are available, the resulting outcome is not incentive compatible.

There are four treatments. In one treatment, all community members have the same harvesting efficiency while another treatment has community members with differing harvesting efficiencies. A set of treatments where trade effects through announced output price changes is also conducted with homogeneous and heterogeneous community members. In these treatments, all participants know *a priori* that the price of harvested output will increase on the fifth round. Each treatment consists of 10 rounds. Four sessions were conducted containing two treatments each. The first treatment in the session contained homogeneous community members and in the second treatment, harvesting efficiencies varied. The first two sessions did not have any price change while the last two sessions had price changes. To test for any ordering effects, two sessions were conducted by interchanging the order of the two treatments. Table 1 summarizes the treatments of the experiment.[8]

3.3 Design Conditions and Parameterization of the Model

Table 2 presents the functional form and parameters used in the laboratory experiment. The production function in the manufacturing sector for the j^{th} cluster is quadratic in total labor hired by the owners of capital. The objective function faced by the owners of capital in the j^{th} cluster is written as,

$$\max_{Lx_{jt}} r = aLx_{jt} - bLx_{jt}^2 - w_{jt}Lx_{jt}.$$

[8] Subjects were given a participation fee along with the additional income they earn during each session. In the experiment, all earnings were in the form of currency dollars. The exchange rate for each currency dollar to real dollar was approximately 0.40. On average each participant earned \$21.86.

where a and b are parameters of the production function. The wage of the j^{th} cluster during each time period t is,

$$w_{jt} = a - 2bLx_{jt}.$$

From the parameters of the model, wage ranges from 0.25 to 6.75 currency dollars per labor hour. The marginal change in wage for a unit change in labor is equal to 0.065 currency dollars. Choosing theses parameters allow us to keep marginal wage small enough so that subjects may deem their own impact on wage negligible or exogenous.

The production function for entrants into the resource sector follows the general functional form as specified in equation (3). The effort function for the i^{th} individual in the j^{th} cluster is quadratic in the total number of labor in the resource sector. Also, the individual returns from labor in the resource sector is a proportion of own labor to the total labor in this sector. The harvest from the resource sector for the i^{th} individual in the j^{th} cluster is expressed as,

$$H_{ijt}(S_{jt}, L_{jt}, l_{ijt}) = \alpha_i S_{jt}(cL_{jt} - dL_{jt}^2)\frac{l_{jt}}{L_{jt}},$$

where c and d are parameters in the effort function and L_{jt} is the summation of all community labor and non-community labor in the resource sector.[9]

The net growth function, $G_j(S_{jt})$, is a logisitic functional form, $eS_{jt}(1\text{-}S_{jt}/f)$, where e is the intrinsic growth rate of the stock and f is the natural carrying capacity. The stock in the next period is calculated according to the following equation,

$$S_{jt+1} = S_{jt} + eS_{jt}(1 - S_{jt}/f) - \sum_{i=1}^{N+C} \alpha_i S_{jt}(cL_{jt} - dL_{jt}^2)(l_{ijt}/L_{jt}).$$

[9] We assume for the experiment that the discount factor is equal to 1. This implies that the earnings during each round is equally weighted. This particular assumption simplifies the problem for the subjects without compromising the main results of the theoretical model.

Two solutions are simulated - the Markov Perfect equilibrium path and the myopic Nash equilibrium path.[10] Tables 3 and 4 show the two equilibrium paths with and without price changes for the case where all community members are homogeneous and Tables 5 and 6 simulate the case for heterogeneous community members. In the Markov Perfect equilibrium solution, the voting strategy is to keep the resource sector open during the first four periods and then to close it off during the remaining periods. Labor allocation path following the Markov Perfect equilibrium in the resource sector is equal to zero during the first four rounds but ranges from 3 to 5 during the remaining rounds. When an announced price increase is known during the fifth round, community members limit non-community entrance from the first four rounds to now only three rounds. A comparison of the stock paths with and without the price increase show that the stock is higher in the former treatment.

With myopic individuals, the solution is to keep the resource stock closed during each period. Community members equate the value of marginal product of labor in both sectors of the economy without taking into consideration the intertemporal externality. Furthermore, any price increase starting at the fifth round would result in an intensification of labor in the resource sector leading to a decline in the stock over time.

4. Experimental Results

A total of 96 subjects were recruited for the experiment where 24 subjects volunteered per session. The results are organized using the hypotheses derived from the theoretical section.

4.1 Labor Allocation and Voting Behavior

Figures 1 and 2 display the mean, minimum and maximum labor allocation by group 1 members into market 1 (resource sector) in the treatments with no price change. There is

[10] General Algebraic Modeling System (GAMS) was used to derive simulated results under the assumptions of heterogeneous and homogeneous community members. The algorithm used to solve for the numerical solution is known as the "branch and bound process" which was first proposed by Land and Doig (1960).

considerable variability of aggregate labor hour allocations in the resource sector ranging from 10 to 50 labor hours. Over ten rounds, there is a declining trend in the average level of labor allocation by community members. The average observed path of total labor allocated in the resource sector by community members is larger than both the predicted myopic Nash and Markov Perfect equilibrium paths. However, the average observed aggregate labor allocation seems to converge more closely with the Markov Perfect equilibrium paths towards the latter rounds. Also, average observed labor allocations are higher during rounds 2-5 compared to the Markov Perfect equilibrium paths with 2, 3 or 4 period planning horizons but the gap between predicted values and observed choices becomes smaller in the later rounds.

Figures 3 and 4 illustrate the minimum, mean and maximum labor allocation decisions in the resource sector in the treatment where there is an announced price change in round 5. The average trend of group labor allocations in the resource sector tend to start relatively high in the first two rounds and decline in rounds 3 and 4. The decrease in group labor in these rounds is likely chosen to conserve more of the resource stock for future rounds when the relative price of output in the resource sector increases. During the fifth round, labor increases but subsequently declines in the following rounds.

Another important component determining stock levels over time is the type of property rights regime selected by the community over time. We focus our data analysis on the results from the voting question asking individuals if they prefer to keep the resource stock open or closed to non-community members since this choice is incentive compatible (Gibbard, 1973 and Satterthwaite 1975). During all treatments, majority of group 1 members voted to keep the resource sector open during all rounds, however, the amount of non-community labor allowed into the resource sector varied. The trend lends qualitative proof that community members may consider some of the future impact on their wealth since there is a tendency to initially keep the resource stock open.

The joint mean squared deviations of labor allocation and property rights regime choice for all rounds is calculated to test Hypotheses 1 and 2 jointly. Table 7 summarizes the results from the analysis. Each value in the table displays the mean squared deviation of the observed data from the equilibrium path for a single treatment for a set of rounds. The joint mean squared deviation is $\Sigma_t\Sigma_t\ (l_{ijt}-l_{ijt}{}^N)^2/\ n + \Sigma_t\Sigma_j(p_{jt}-p_{jt}{}^N)^2/n$ where p_{jt} is the observed property rights regime by the j^{th} cluster; l_{ijt} is the observed labor hour by the ith individual at time t in the resource sector; $p_{jt}{}^N$ is the equilibrium property rights choice path by the j_{th} cluster at time t; $l_{ijt}{}^N$ is the equilibrium labor hour path by the i^{th} individual at time t and n is the total number of observations. The property rights regime variable is dichotomous which takes a value of 0 if closed and 1 if opened. To make the dichotomous property rights regime choice variable and continuous labor allocation variable comparable, the means have to be equal. This is done by multiplying the dichotomous choice variable by α = y/x where y is the mean labor allocation by all subjects and x is the mean voting decision by all groups.

Each row in Table 7 compares the mean squared deviation of observed labor allocations and property rights regime choice from the Markov Perfect equilibrium versus the myopic Nash equilibrium path. The smallest mean squared deviation is indicated by an asterisk "*". For all treatments, the smallest mean squared deviation does come from a Markov Perfect equilibrium path but one that follows a two or three period planning horizon. There does seem to be some internalization of the intertemporal externality but results indicate that subjects forecast future decisions only one or two rounds in advance.

Therefore, there is some support for Hypotheses 1 and 2 where individuals follow a Markov Perfect equilibrium path. However, subjects can only internalize the intertemporal externalities one or two rounds at the most in advance. This result contradicts the finding from Herr et al. (1997) where subjects tend to decide myopically when extracting from a dynamic resource stock but supports some of the natural experiments by Maldonado and Moreno-Sanchez (2007) where subjects can internalize some stock dynamics. When subjects are allowed to communicate and given a calculator that forecasts potential earning in future rounds, they seem to be able to formulate strategies as a group that internalize some of the intertemporal and intratemporal externality.[11]

4.2 Price Effect on Stock Levels

When subjects are faced with a price increase during the fifth round, the average stock level across the clusters slightly increases (Figure 5 and 6). During subsequent rounds, the sudden increase in labor allocation into the resource sector during the fifth round lead to a decline in stock levels.

In order to determine the effect of an announced price increase on the stock, the stock levels in the treatments without any price change are compared to the treatment with the price change. Using a t-test that compares the mean stock level of the two treatments, we do find a significant positive difference of stocks in the treatment with an announced price change as shown in Table 8. During the fourth and fifth rounds, the clusters in the homogeneous sessions responded to the price change by increasing the stock level. After the fifth round, community

[11] T-tests across sessions and treatments were conducted to test for any ordering effects. The labor allocations for sessions 1 and 2 were compared with each other as well as sessions 3 and 4 holding community efficiency constant. The mean labor allocations did not show any significant differences in the treatments of homogeneous community members with an announced price change and heterogeneous community members with no price change. However, there does seem to be some significant differences in labor allocations in a few rounds when subjects are homogeneous and there are no price changes and, to a lesser extent, the treatment where individuals are heterogeneous and a price change is announced.

members allocated more labor resulting in a decrease in stock levels over time. During the last round, we do find that the mean stock level is lower with the price change than the baseline case, albeit a statistically insignificant amount. In the heterogeneous community member case, however, stock levels did not increase as much as in the homogeneous community treatment. It is only during the fifth round where we see higher stock levels compared to the homogeneous community treatment. The inability of heterogeneous community members to significantly build up the stock compared to homogeneous community members may be due to distributional conflicts that arise over access to the resource stocks when individuals are heterogeneous (Hackett et al., 1993).[12]

In order to determine if the mechanism by which stock increases comes from changes in labor allocations or property rights regime choices, we compare the treatments with and without price changes to see if there are any significant differences in these choices. Table 9 summarizes a t-test of the mean differences of labor allocation and percentage of votes favoring to keep the resource stock open. Most of the increase in stock is attributed to the decrease in labor allocations prior to the price increase. During the third and fourth rounds in both the heterogeneous community member and homogeneous community member treatments, there is a significant decrease in labor allocations resulting in the increase of the stock. The property rights regime mechanism was also used in order to preserve more of the stock, but to a lesser extent.

The evidence does support Hypothesis 3 wherein the stock is increased in anticipation of a price increase. However, the Markov Perfect equilibrium path is not completely followed. The crucial role of selecting the correct initial levels of labor allocation and property rights regime choice during the first few rounds heavily influence the trajectory of the stock.

[12] The t-test for ordering effects do not show any statistically significant differences in stock levels across sessions.

5. Conclusion

This paper analyzed the impact of opening to trade on resource stocks vis-à-vis an endogenous property rights regime voting channel. The theoretical model shows that when communities internalize the intertemporal and intratemporal externality over time, allowing the resource stock to flourish and then degrading it later may be an optimal strategy for owners of a resource stock if terms of trade improves in a resource-based sector. Therefore, it may be welfare maximizing for a country to degrade their resource when property rights regimes and labor allocations follow a Markov Perfect equilibrium.

Three theoretical hypotheses were tested using a dynamic common property resource game where subjects allocate their labor hours between two sectors in the economy given a dynamic resource stock evolving over time. Results from the experiment show that labor allocation and property rights regime decisions do follow a Markov Perfect equilibrium path but subjects plan in 2-3 interval rounds. Resource stocks do temporarily increase prior to opening to trade. Stock levels rise by subjects decreasing labor in the resource sector and, to a lesser extent, by implementing a common property resource management scheme. These experimental results indicate that even without formal government regulations, informal social regulations can regulate resource use over time to maximize welfare of owners of the resource stock.

The model does not allow for bounded rationality and learning which are crucial aspects in community development. McKelvey and Palfrey (1998) have emphasized the important role of these factors in behavior. Such extensions, theoretically and experimentally, may prove to be a fruitful avenue of future research.

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Appendix 1

In order to prove supermodularity, all the cross partial derivatives must be non-negative. Using the first order conditions from equations (7) to (10), we can derive the cross partial derivatives of the set {($-l_{c1}$); l_{c2}; ($-l_{n1}$); ($-l_{n2}$); p_2} on L_j. First, we take the cross partial derivatives with respect to ($-l_{c1}$);

(A.1) $$\frac{\partial^2 L}{\partial l_{c2}\partial(-l_{c1})} = -p_2\frac{\partial S_2}{\partial l_{c1}}\left(\alpha_c\frac{\partial f(L_{-c2},l_{c2})}{\partial l_{c2}}\delta + \lambda\alpha_n\frac{\partial f^2(L_{-n2},l_{n2})}{\partial l_{n2}\partial l_{c2}}\right) \geq 0;$$

since $\frac{\partial S_2}{\partial l_{c1}} \leq 0$ and $\left|\frac{\partial f(L_{-c2},l_{c2})}{\partial l_{c2}}\right| \geq \left|\frac{\partial f^2(L_{-n2},l_{n2})}{\partial l_{n2}\partial l_{c2}}\right|$, we derive $\frac{\partial^2 L}{\partial l_{c2}\partial(-l_{c1})} \geq 0$.

(A.2) $$\frac{\partial^2 L}{\partial(-l_{n1})\partial(-l_{c1})} = -(p_1 - \mu_1 C)\alpha_c S_1\frac{\partial^2 f(L_{-c1},l_{c1})}{\partial l_{n1}\partial l_{c1}} - (\lambda p_1 - \mu_1 N)\alpha_n S_1\frac{\partial^2 f(L_{-n1},l_{n1})}{\partial l_{n1}^2} \geq 0$$

when $\lambda p_1 - \mu_1 N > 0$ and since $\frac{\partial^2 f(L_{-c1},l_{c1})}{\partial l_{n1}\partial l_{c1}} \leq 0$, we find $\frac{\partial^2 L}{\partial(-l_{n1})\partial(-l_{c1})} \geq 0$.

(A.3) $$\frac{\partial^2 L}{\partial(-l_{n2})\partial(-l_{c1})} = p_2\alpha_c\frac{\partial S_2}{\partial l_{c1}}N\frac{\partial f(L_{-c2},l_{c2})}{\partial l_{n2}}\delta + \lambda p_2\alpha_n\frac{\partial S_2}{\partial l_{c1}}\frac{\partial^2 f(L_{-n1},l_{n1})}{\partial l_{n1}^2} \geq 0;$$

since $\frac{\partial S_2}{\partial l_{c1}} \leq 0$ and $\frac{\partial f(L_{-c2},l_{c2})}{\partial l_{n2}} \leq 0$, we derive $\frac{\partial^2 L}{\partial(-l_{n2})\partial(-l_{c1})} \geq 0$.

(A.4)

$$\frac{\partial^2 L}{\partial p_2\partial(-l_{c1})} = \alpha_c f(L_{-c2},l_{c2})\delta S_1\left(C\alpha_c\frac{\partial f(L_{-c1},l_{c1})}{\partial l_{c1}} + N\alpha_n\frac{\partial f(L_{-n1},l_{n1})}{\partial l_{c1}}\right) - \lambda\alpha_n\left(S_2\frac{\partial^2 f(L_{-c1},l_{c1})}{\partial l_{n1}\partial l_{c1}} + \frac{\partial S_2}{\partial l_{c1}}\frac{\partial f(L_{-n1},l_{n1})}{\partial l_{n1}}\right) \geq 0$$

since we have assumed that $\left|\frac{\partial f(L_{-c1},l_{c1})}{\partial l_{c1}}\right| \geq \left|\frac{\partial f(L_{-n1},l_{n1})}{\partial l_{c1}}\right|$ along with C=N, then $\frac{\partial^2 L}{\partial p_2\partial(-l_{c1})} \geq 0$.

Next , we take the cross partial derivatives with respect to l_{c2}

(A.5) $\dfrac{\partial^2 L}{\partial l_{c2}\partial(-l_{n1})} = p_2 \dfrac{\partial S_2}{\partial(-l_{n1})}\left(\alpha_c \dfrac{\partial f(L_{-c2}, l_{c2})}{\partial l_{c2}}\delta + \lambda\alpha_n \dfrac{\partial^2 f(L_{-n1}, l_{n1})}{\partial l_{n1}\partial l_{c1}}\right) \geq 0$;

since $\dfrac{\partial S_2}{\partial(-l_{n1})} \geq 0$ and $\left|\dfrac{\partial f(L_{-c2}, l_{c2})}{\partial l_{c2}}\right| \geq \left|\dfrac{\partial^2 f(L_{-n1}, l_{n1})}{\partial l_{n1}\partial l_{c1}}\right|$, we derive $\dfrac{\partial^2 L}{\partial l_{c2}\partial(-l_{n1})} \geq 0$.

(A.6) $\dfrac{\partial^2 L}{\partial l_{c2}\partial(-l_{n2})} = -p_2\alpha_c S_2 \dfrac{\partial^2 f(L_{-c2}, l_{c2})}{\partial l_{c2}\partial l_{n2}}\delta \geq 0$;

since we have assumed that $\dfrac{\partial^2 f(L_{-c2}, l_{c2})}{\partial l_{c2}\partial l_{n2}} \leq 0$, we derive $\dfrac{\partial^2 L}{\partial l_{c2}\partial(-l_{n2})} \geq 0$.

(A.7) $\dfrac{\partial^2 L}{\partial l_{c2}\partial p_2} = S_2\left(\alpha_c \dfrac{\partial f(L_{-c2}, l_{c2})}{\partial l_{c2}}\delta + \lambda\alpha_n \dfrac{\partial^2 f(L_{-c2}, l_{c2})}{\partial l_{n2}\partial l_{c2}}\right) \geq 0$;

since we assumed that $\left|\dfrac{\partial f(L_{-c2}, l_{c2})}{\partial l_{c2}}\right| \geq \left|\dfrac{\partial^2 f(L_{-c2}, l_{c2})}{\partial l_{n2}\partial l_{c2}}\right|$, we find $\dfrac{\partial^2 L}{\partial l_{c2}\partial p_2} \geq 0$.

Now, we take the cross partial derivatives with respect to $(-l_{n1})$;

(A.8) $\dfrac{\partial^2 L}{\partial(-l_{n1})\partial(-l_{n2})} = -p_2\alpha_c \dfrac{\partial S_2}{\partial(-l_{n1})}\left(N\dfrac{\partial f(L_{-c2}, l_{c2})}{\partial(-l_{n2})}\delta + \lambda\alpha_n \dfrac{\partial^2 f(L_{-n2}, l_{n2})}{\partial l_{n2}^2}\right) \geq 0$;

since $\dfrac{\partial S_2}{\partial l_{n1}} \leq 0$ and $\left|\dfrac{\partial f(L_{-c2}, l_{c2})}{\partial(-l_{n2})}\right| \geq \left|\dfrac{\partial^2 f(L_{-n2}, l_{n2})}{\partial l_{n2}^2}\right|$, we derive $\dfrac{\partial^2 L}{\partial(-l_{n1})\partial(-l_{n2})} \geq 0$.

(A.9) $\dfrac{\partial^2 L}{\partial(-l_{n1})\partial p_2} = -\alpha_c f(L_{-c2}, l_{c2})\delta S_1\left(C\alpha_c \dfrac{\partial f(L_{-c1}, l_{c1})}{\partial(-l_{n1})} + N\alpha_n \dfrac{\partial f(L_{-n1}, l_{n1})}{\partial(-l_{n1})}\right) - \lambda\alpha_n\left(S_2 \dfrac{\partial^2 f(L_{-c1}, l_{c1})}{\partial(-l_{n1})^2}\right) \geq 0$

since we have assumed that C=N and $\alpha_c \dfrac{\partial f(L_{-c1}, l_{c1})}{\partial l_{n1}} + \alpha_n \dfrac{\partial f(L_{-n1}, l_{n1})}{\partial l_{n1}} > 0$, then $\dfrac{\partial^2 L}{\partial(-l_{n1})\partial p_2} \geq 0$.

Last, we take the cross partial derivative with respect to the remaining p_2,

(A.10) $\dfrac{\partial^2 L}{\partial p_2\partial(-l_{n2})} = -S_2\left(N\alpha_c \dfrac{\partial f(L_{-c2}, l_{c2})}{\partial l_{n2}}\delta + \lambda\alpha_n \dfrac{\partial^2 f(L_{-c1}, l_{c1})}{\partial l_{n1}\partial l_{c1}}\right) \geq 0$;

since $\dfrac{\partial f(L_{-c2},l_{c2})}{\partial l_{n2}} \le 0$ and $\dfrac{\partial^2 f(L_{-c1},l_{c1})}{\partial l_{n1}\partial l_{c1}} \le 0$, we derive $\dfrac{\partial^2 L}{\partial p_2 \partial(-l_{n2})} \ge 0$.

The cross partial derivatives of the set, $\{(-l_{c1}); l_{c2}; (-l_{n1}) ; (-l_{n2}); p_2\}$, are non-negative. Therefore, we derive the following comparative statics,

$$\frac{\partial l_{c1}}{\partial p_2} \le 0; \quad \frac{\partial l_{c2}}{\partial p_2} \ge 0; \quad \frac{\partial l_{n1}}{\partial p_2} \le 0; \quad \frac{\partial l_{n2}}{\partial p_2} \le 0.$$

Figures

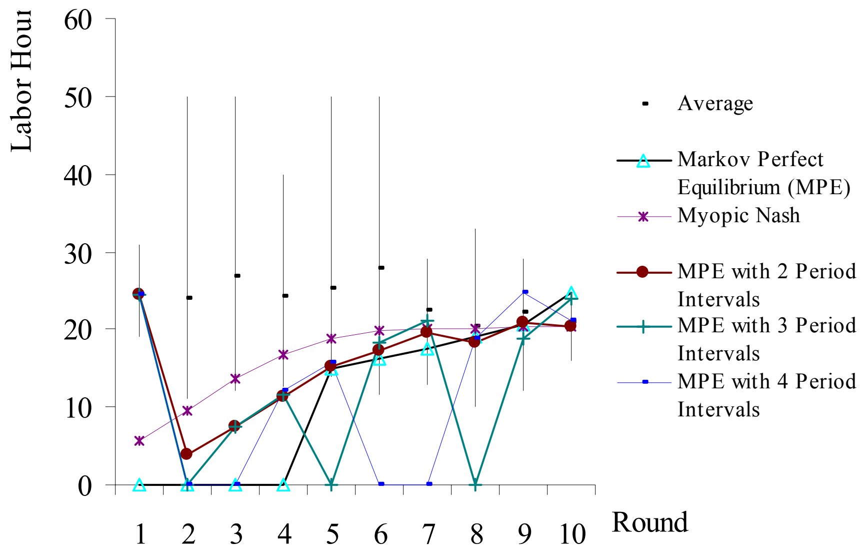

Fig 1. Average Group 1 Labor in Market 1. Treatment: Homogeneous Members without Price Change

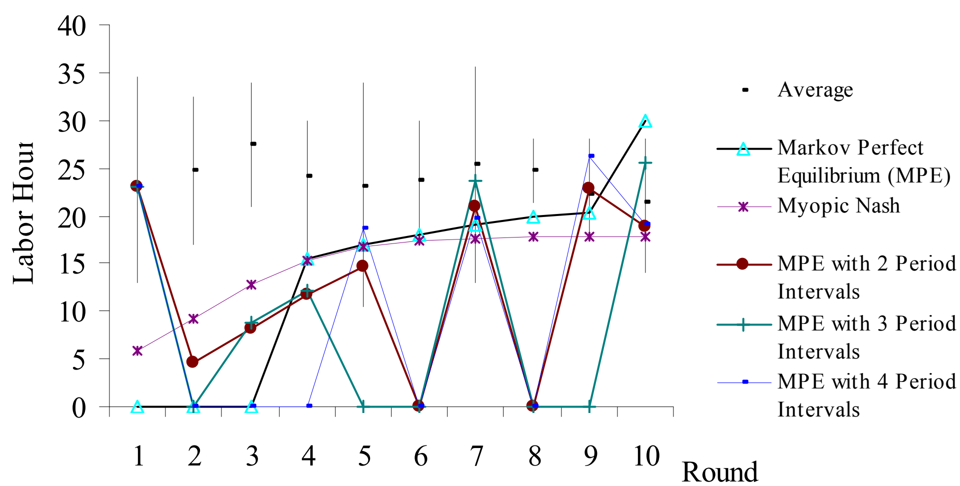

Fig 2. Average Group 1 Labor in Market 1. Treatment: Heterogeneous Members without Price Change

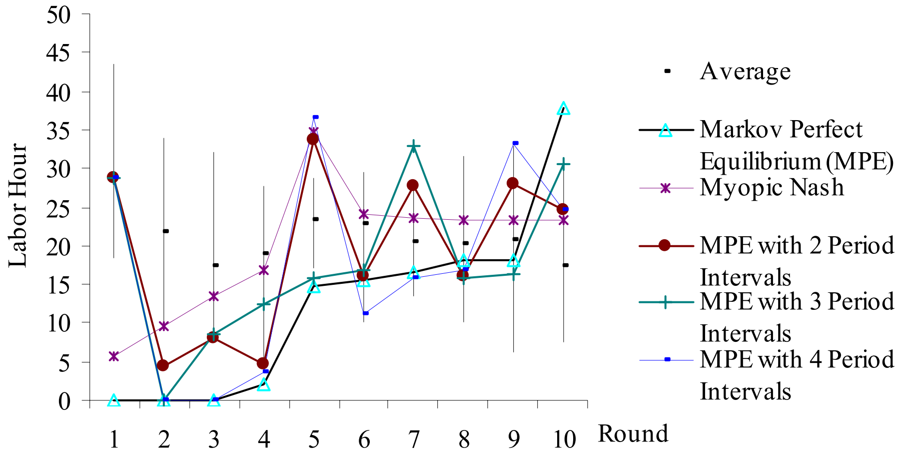

Fig 3. Average Group 1 Labor in Market 1. Treatment: Homogeneous Members with Price Change

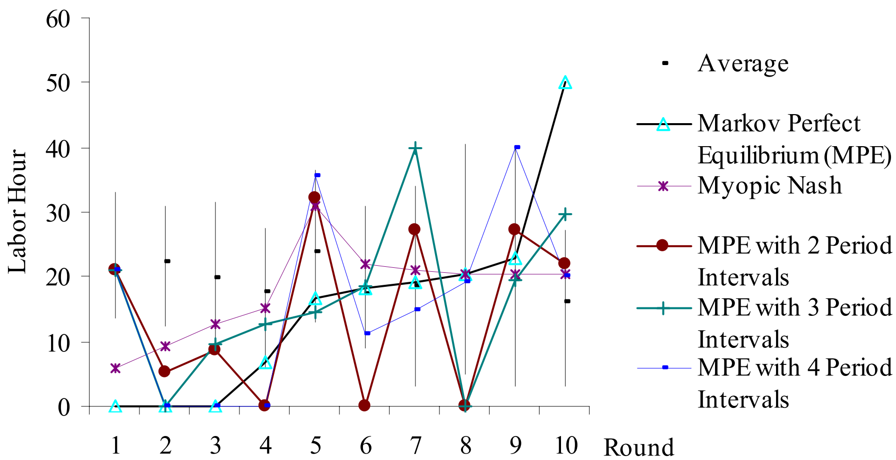

Fig 4. Average Group 1 Labor in Market 1. Treatment: Heterogeneous Members with Price Change

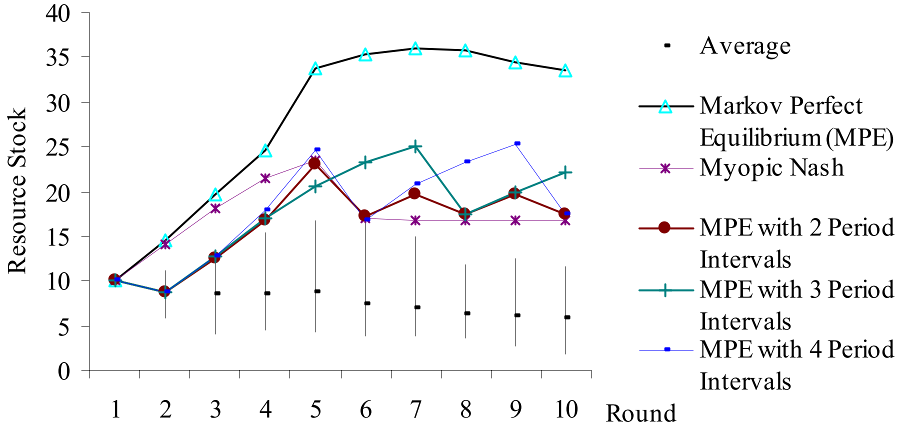

Fig 5. Resource Stock Levels. Treatment: Homogeneous Members with Price Change

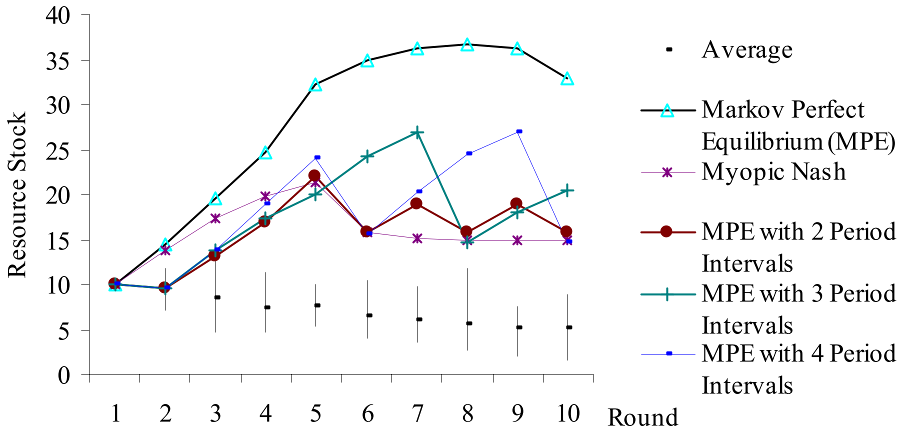

Fig 6 Resource Stock Levels. Treatment: Heterogeneous Members with Price Change

Tables

Table 1
Experimental Design

Treatment Types	Homogeneous Community Members	Heterogeneous Community Members
No Output Price Change	Treatment 1	Treatment 2
Output Price Change	Treatment 3	Treatment 4

Note: Four sessions were conducted containing two treatments each.

Table 2
Parameters of the Laboratory Experiment

Specification	Parameter
Number of subjects in a cluster	5
Number of Group 1 in one cluster	4
Number of Group 2 in one cluster	1
Maximum number of labor hours per subject	10
Production function in the manufacturing sector	a = 6.75
$(aLx-bLx^2)$	b = 0.0325
Production function in the resource sector	c = 50
$p\alpha S_t(cLr-dLr^2)(l/Lr)$	d = 0.001
Harvesting efficiency (α)	
Harvesting efficiency for Group 2 subjects	0.00025
Harvesting efficiencies for Group 1 subjects[1]	0.0003
	0.00035
	0.0004
	0.00045
	0.0005
Relative price[2] (p)	5
Growth of stock over time[3]	e =0.59
$G(S_t)=eS_{t-1}(1-(S_{t-1}/f))$	f = 80

[1] The harvesting efficiency when all community members are homogeneous is equal to 0.0004.
[2] In the treatments with a change in price, price increases from 5 to 8.5 during the fifth round.
[3] The initial stock is equal to 10.

Table 3
Markov Perfect Equilibrium Paths for Homogeneous Community Members

	Baseline				*With price change during round 5*			
Time	Stock	Labor in Market 1	Hours of Group 2 labor allowed in Market 1	Earnings	Stock	Labor in Market 1	Hours of Group 2 labor allowed in Market 1	Earnings
1	10.0	0.0	1.2	6.2	10.0	0.0	1.2	6.2
2	14.4	0.0	2.0	9.0	14.4	0.0	2.0	9.0
3	19.6	0.0	3.0	12.3	19.6	0.0	3.0	12.3
4	24.7	0.0	4.0	15.4	24.7	0.4	0.0	4.6
5	28.6	3.0	0.0	17.1	33.8	2.9	0.0	25.4
6	30.9	3.2	0.0	18.8	35.4	3.1	0.0	27.5
7	32.1	3.5	0.0	20.2	35.9	3.3	0.0	29.2
8	32.3	3.8	0.0	21.6	35.7	3.6	0.0	31.1
9	31.3	4.1	0.0	22.2	34.4	3.6	0.0	30.3
10	29.7	4.9	0.0	24.1	33.5	7.6	0.0	51.7
				166.8				**227.3**

Table 4
Myopic Nash Equilibrium Paths for Homogeneous Community Members

	Baseline				*With price change during round 5*			
Time	Stock	Labor in Market 1	Hours of Group 2 labor allowed in Market 1	Earnings	Stock	Labor in Market 1	Hours of Group 2 labor allowed in Market 1	Earnings
1	10.0	1.2	0.0	6.7	10.0	1.2	0.0	6.7
2	14.0	1.9	0.0	9.8	14.0	1.9	0.0	9.8
3	18.1	2.7	0.0	13.2	18.1	2.7	0.0	13.2
4	21.5	3.4	0.0	16.1	21.5	3.4	0.0	16.1
5	23.5	3.8	0.0	18.0	23.5	6.9	0.0	35.4
6	24.5	3.9	0.0	18.9	17.1	4.8	0.0	23.3
7	24.9	4.0	0.0	19.3	16.8	4.7	0.0	22.9
8	25.0	4.0	0.0	19.4	16.7	4.7	0.0	22.7
9	25.1	4.0	0.0	19.5	16.7	4.7	0.0	22.7
10	25.1	4.1	0.0	19.5	16.7	4.7	0.0	22.7
				160.3				**195.4**

Table 5
Markov Perfect Equilibrium Paths for Heterogeneous Community Members

	Baseline				*With price change during round 5*			
Time	Stock	Average Labor in Market 1	Hours of Group 2 labor allowed in Market 1	Average Earnings	Stock	Average Labor in Market 1	Hours of Group 2 labor allowed in Market 1	Average Earnings
1	10.0	0.0	1.2	6.2	10.0	0.0	1.2	6.2
2	14.4	0.0	2.0	9.0	14.4	0.0	2.0	9.0
3	19.6	0.0	3.0	12.3	19.6	0.0	3.0	12.3
4	24.7	3.1	0.0	14.8	24.7	1.4	0.0	8.5
5	28.6	3.4	0.0	16.7	32.2	3.4	0.0	23.6
6	31.7	3.6	0.0	18.3	34.9	3.6	0.0	26.5
7	33.8	3.8	0.0	19.6	36.3	3.9	0.0	28.5
8	34.9	4.0	0.0	20.5	36.6	4.1	0.0	30.0
9	35.3	4.1	0.0	21.1	36.2	4.6	0.0	34.7
10	35.2	6.0	0.0	32.6	33.0	10.0	0.0	56.0
				171.0				**235.5**

Table 6
Myopic Nash Equilibrium Paths for Heterogeneous Community Members

	Baseline				*With price change during round 5*			
Time	Stock	Average Labor in Market 1	Hours of Group 2 labor allowed in Market 1	Average Earnings	Stock	Average Labor in Market 1	Hours of Group 2 labor allowed in Market 1	Average Earnings
1	10.0	1.2	0.0	7.0	10.0	1.2	0.0	7.0
2	13.7	1.9	0.0	10.2	13.7	1.9	0.0	10.2
3	17.2	2.5	0.0	13.4	17.2	2.5	0.0	13.4
4	19.8	3.0	0.0	15.9	19.8	3.0	0.0	15.9
5	21.4	3.3	0.0	17.4	21.4	6.2	0.0	33.7
6	22.0	3.5	0.0	18.1	15.8	4.4	0.0	23.2
7	22.3	3.5	0.0	18.4	15.2	4.2	0.0	22.1
8	22.4	3.5	0.0	18.5	14.9	4.1	0.0	21.7
9	22.5	3.5	0.0	18.6	14.8	4.1	0.0	21.5
10	22.5	3.5	0.0	18.6	14.8	4.1	0.0	21.5
				156.1				**190.1**

Table 7
Mean Squared Deviation of Labor Hours Allocated by Community Members and Property Rights Regime Choice from the Markov Perfect and Myopic Nash Equilibrium Paths

Treatment	Markov Perfect Equilibrium (MPE)	Myopic Nash Path	Markov Perfect Equilibrium with 2 period planning intervals	Markov Perfect Equilibrium with 3 period planning intervals	Markov Perfect Equilibrium with 4 period planning intervals
Homogeneous Community Members without Price Change	33.85	36.92	34.78	31.08*	31.58
Homogeneous Community Members with Price Change	35.98	34.02	29.78	28.50*	31.10
Heterogeneous Community Members without Price Change	53.93	47.00	42.06	38.44*	40.05
Heterogeneous Community Members with Price Change	46.46	46.23	36.96*	43.31	41.78

* Denotes the Solution Path that Minimizes the Mean Squared Deviation.

Note: Each entry in the table represents the mean squared deviation of the labor hours of community members from the corresponding solution path. Mean squared deviation is equal to $\Sigma_t\Sigma_t\ (l_{ijt}-l_{ijt}^N)^2/\ n\ +\ \Sigma_t\Sigma_j(p_{jt}-p_{jt}^N)^2/n$ where p_{jt} is the observed property rights regime by the j^{th} cluster; l_{ijt} is the observed labor hour by the i^{th} individual at time t in the resource sector; p_{jt}^N is the equilibrium property rights choice by the j_{th} cluster at time t; l_{it}^N is the equilibrium labor hour by the i^{th} individual at time t and n is the total number of observations.

Table 8
Differences in Average Stock Levels Across Treatments.

Treatment	Baseline	Price Change	T-Stat
Homogeneous Community Members			
1	10.00	10.00	-
2	8.00	8.72	0.78*
3	7.32	8.38	0.63
4	6.75	8.50	1.02**
5	6.24	8.61	1.30***
6	5.90	7.44	0.79*
7	5.48	6.88	0.74*
8	5.14	6.29	0.72*
9	5.79	5.99	0.11
10	5.96	5.91	-0.03
Heterogeneous Community Members			
1	10.00	10.00	-
2	8.93	9.52	0.59
3	8.38	8.54	0.1
4	6.53	7.23	0.42
5	6.21	7.57	0.87*
6	6.13	6.55	0.26
7	5.87	6.01	0.09
8	4.73	5.62	0.55
9	4.37	5.14	0.52
10	4.25	5.15	0.54

Note: *** 15% level of significance; ** 20% level of significance; * 25% level of significance.

Table 9
Differences in Property Rights Regime and Labor Allocation Across Treatments.

Treatment	Labor Allocation in Group 1			Property Rights Regime		
	Baseline	Price Change	T-Stat	Baseline	Price Change	T-Stat
Homogeneous Community Members						
1	24.50	28.74	-1.42*	100.0	75.0	1.53**
2	23.94	21.88	0.74	100.0	75.0	1.53**
3	26.75	17.36	3.67***	75.0	87.5	-0.61
4	24.15	18.84	1.96***	87.5	87.5	0
5	25.25	23.44	0.56	87.5	87.5	0
6	27.69	22.91	1.50**	87.5	87.5	0
7	22.28	20.46	0.63	75.0	87.5	-0.61
8	20.45	20.29	0.06	62.5	100.0	-2.05***
9	22.09	20.73	0.44	75.0	75.0	0
10	20.94	17.41	1.38*	87.5	87.5	0
Heterogeneous Community Members						
1	23.00	20.85	0.64	100.0	87.5	1
2	24.76	22.34	0.8	87.5	87.5	0
3	27.50	19.78	2.44***	100.0	100.0	0
4	24.05	17.64	2.04***	100.0	62.5	2.05***
5	23.00	23.95	-0.26	87.5	87.5	0
6	23.75	17.36	1.75**	87.5	100.0	-1
7	25.39	18.41	2.06***	100.0	87.5	1
8	24.80	20.48	1.12*	87.5	87.5	0
9	22.23	19.41	0.84	87.5	100.0	-1
10	21.46	16.05	1.52**	100.0	100.0	0

Note: *** 5% level of significance; ** 10% level of significance; *15% level of significance.