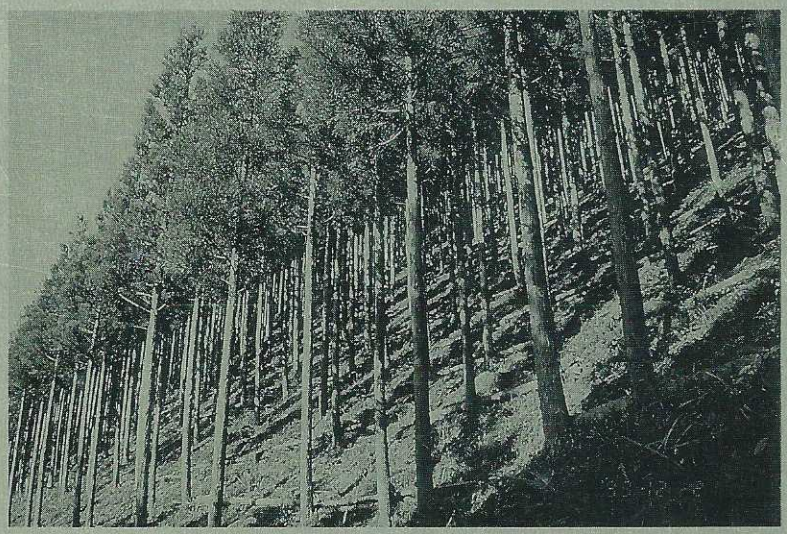
# *FORESEA MIYAZAKI 1998*
## *Forest Sector Analysis*

# *Proceedings of International Symposium on Global Concerns for Forest Resource Utilization*

*-Sustainable Use and Management-*



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## Volume I

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## Volume I

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# FOREST OWNERS' ASSOCIATIONS AS A CASE OF JOINT PRODUCTION OF PUBLIC GOODS AND PRIVATE SERVICES: A GAME THEORETICAL APPROACH[1]

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**ABSTRACT:** Taking the case of forest owners' associations in Northern Portugal, this paper presents some models describing the behaviour of these institutions in a setting where the challenge is to motivate for active forest management absentee private forest owners. The models are framed as non co-operative games between the owners and the directors. The income of each owner and the utility of the directors depend on the services provided by the association. In the first "Portuguese" model these services assumed to be public goods are financed only by fixed membership fees and by the fund raising efforts of the directors. In the second "Portuguese" model private services provision is included. This is compared with the "Scandinavian" model where the owners pay a share of their timber sales. In the first Portuguese" model the directors have a dominant strategy equilibrium which is not the case in the other two models. In all the three models the effect the association's services have on the owners' absenteeism depends on the type of technical interdependence between this factor and the owners' forest management time. For the second "Portuguese" model a characterisation of the optimal price policy for the private services is provided.

**KEYWORDS:** forest owners' associations, absenteeism, game theory

## 1. THE SETTING: FOREST OWNERSHIP AND FOREST MANAGEMENT IN NORTHERN PORTUGAL

### 1.1. Forest ownership distribution

In 1995, 57.5% of the total forest land area in Northern Portugal belonged to private owners, the rest being almost entirely communal forests. According to the data presented in tables 1 and 2:
- in the Northwest the private forests make up three quarters of the forest area and are evenly split between small (less than 5 ha), medium (between 5 and 50 ha) and large (50 ha or more) holdings;
- in the Northeast the communal forests make up two thirds of the forest area and about one half of the remaining area are small private holdings up to 5 ha.

**Tab. 1: Ownership distribution of forest lands in 1995**

| Regions | Total forest area | Private forest area | | Forests managed by the Forest Services | | | |
|---|---|---|---|---|---|---|---|
| | | | | State forests | | Communal forests | |
| | ha | ha | % | ha | % | ha | % |
| Northwest | 345 900 | 259 676 | 75.1 | 143 | 0.0 | 86 081 | 24.9 |
| Northeast | 312 700 | 118 908 | 38.0 | 0 | 0.0 | 193 792 | 62.0 |
| North | 658 600 | 378 584 | 57.5 | 143 | 0.0 | 279 873 | 42.5 |
| Other regions | 2 700 200 | 2 549 642 | 94.4 | 71 748 | 2.7 | 150 558 | 5.6 |
| TOTAL | 3 358 800 | 2 856 478 | 85.0 | 71 891 | 2.1 | 430 431 | 12.8 |

Sources: INE (1997a); DGF (1998).

[1]This is a revised and expanded version of the paper presented at the International Symposium of Forest Economics, Umeå, Sweden, September 8-12, 1997. I thank the participants for their helpful comments. The usual caveats apply.

**Tab. 2: Size distribution of forest holdings in 1995 (%)**

| Size of forest area (ha) | Northwest | | Northeast | |
|---|---|---|---|---|
| | Holdings | Area | Holdings | Area |
| 0 - < 5 | 89.7 | 34.4 | 90.6 | 53.7 |
| 5 - < 10 | 6.4 | 13.6 | 6.6 | 19.9 |
| 10 - < 20 | 2.2 | 9.0 | 2.2 | 13.2 |
| 20 - < 50 | 1.2 | 10.2 | 0.4 | 5.4 |
| >= 50 | 0.5 | 32.8 | 0.2 | 7.8 |
| TOTAL | 100.0 | 100.0 | 100.0 | 100.0 |

Source: INE (1997b).

## 1.2. Forest owners' associations

In 1992 in Northern Portugal a movement was initiated to organise forest owners' associations. This got started with the creation of a non profit organisation now called *FORESTIS-Associação Florestal do Norte e Centro de Portugal* (Forest Association of Northern and Central Portugal) which is a regional association, grouping individual forest owners, representatives of communal forests, foresters, and other individuals interested in the forest sector. The main task of this association has been to promote the creation of local forest owners' associations and provide common services to them (diffusion of technical information, publication of a periodical bulletin, training courses, etc.).

The services provided by the local associations are the following:
- representation of the members and promotion of their common interests;
- diffusion of information about the forest programmes financed by the national budget and the EU;
- preparation of the forest management plans needed to apply for funds from those programmes or assistance to the owners in their contracts with private firms providing this kind of service;
- promotion of agreements between individual forest owners for grouped forest management projects;
- monitoring of the work done by private contractors for the members of the association;
- diffusion of technical information about good forest management practices;
- organisation of training courses for forest owners and private contractors;
- promoting the awareness for the economic and social importance of forestry.

To finance their activities, these organisations have counted mostly on subsidies from the EU and the national budget, the annual membership fees making up only a small part of their income. These fees have a fixed value per year, different according to the size of the forest holding, but independent from the amount of private services the members requests from the association.

For some of these private services (monitoring of planting works carried out by private contractors, technical advice, etc.) the members are not yet charged any specific price. So the financial contributions received from the forest owners are basically the membership fees. Since many of the owners don't pay these fees in due time and their amount is not enough to pay for the costs of the association, one of the major tasks of the directors is to find other sources of funds especially support from the Public Administration and the local governments. There are some private services, however, where the local associations already charge a price to the members, for example, GPS services and timber stands valuation for members and non members.

## 2. THE ISSUES

In the kind of setting we have just described, the challenge is how to motivate for active forest management private forest owners often absentee, with fragmented land holdings, in rural areas where labour supply for forest management is short and the benefits from forestry are not regular and multifunctional like in the past, but sparse and subject to risks (wildfires, soil degradation, etc.). Given this absenteeism of the forest owners, the attention will be focused on the question of how the services provided by the associations can motivate the members to be more active in the management of their forest lands, in the sense of spending more of their time in this kind of activity. Since these associations provide both public goods and private services there are there issues to be discussed:

- amount of public goods to be provided by the association;
- price to be charged by the association for their private services;
- interdependences between the services provided by the association and the owners' absenteeism.

## 3. THE MODELS

### 3.1. Basic features

The models to be presented here have in common the fact that they the association as an organisation made up of two groups of strategically interacting players: the owners who joined the association ("the members") and the board of directors they elected. The directors decide on the amount of services provided by the association. At the present stage of the forest owners' associations in Northern Portugal most of these services have a "public goods" nature. It is the case of services such as the collective representation of the members, promotion of their common interests, diffusion of general information about forest programmes and best forest management practices, etc.

Being non profit organisations, there are no monetary rewards for the directors. So their motivation is assumed to come from the positive utility (good reputation, personal satisfaction) they get from the amount of services provided by the association.

Directors and forest owners are assumed to have other activities besides managing the association and their forest lands. So in allocating their time they have to take into account the costs and benefits (monetary and non monetary) they get from these different activities. In taking these time allocation decisions members and directors are strategically interdependent in the following sense:
- the benefits of the time devoted to forest management by the owners depend on the services they get from the association whose level is decided by the board of directors;
- depending on the regime of membership contributions, the level of services set by the directors might also have to take into account the owners' forest management decisions.

Given the fact that this strategic interdependence depends on the regime of membership contributions, three different situations will be examined here. The first one is the "Portuguese" type of associations described in the first section where members contribute with fixed fees to the costs of the organisation. The second one is a development of this first "Portuguese" model where besides producing public goods, the associations also provide private services to the members for which they charge a price. The third model describes the "Scandinavian" type of associations where the members contribute with a share of the gross value of their timber sales. Since these contributions might not be enough to run the association, one major task of the board of directors is fund raising.

The models presented here focus on the issue of interdependence between the amount of services provided by the association and the amount of time devoted by the members to forest management. We leave aside the issues of membership decisions and the variations in the number of members.

### 3.2. Common assumptions

**Assumption A1.1**

In the internal organisation of the associations there are two types of players: the members and the board of directors they have elected for some fixed term.

**Assumption A1.2**

The directors are considered as a single player and the fact that they are forest owners is ignored.

**Assumption A1.3**

For the time frame of this model, the number of registered members is fixed.

**Assumption A1.4**

Directors and members behave non co-operatively.

**Assumption A1.5**

The directors don't get any monetary reward from their work for the association. Their incentive for this job comes from the fact that their utility W depends positively on the amount of services provided by the association to their members. Utility also depends positively on the following variables:
- $Y$, the amount of consumer goods and services used for their personal consumption;
- $X$, leisure.

**Assumption A1.6**

The utility $U_i$ of each member $i$ depends on the following variables:
- $Y_i$, the amount of consumer goods and services used for their personal consumption;
- $X_i$, leisure.

**Assumption A1.7**

The behaviour of the directors has to meet three economic constraints:
- their personal budget constraint;
- the association's budget constraint;
- a time constraint.

**Assumption A1.8**

The behaviour of each member has to meet two economic constraints:
- a personal budget constraint;
- a time constraint.

**Assumption A1.9**

The directors' personal budget constraint is the following:

(1.1) $pY \leq \omega H + V$ where:

- $p$ is the price of the consumer goods and services;
- $\omega$ is the income per unit of paid labour time;
- $H$ is paid labour time;
- $V$ is the non labour income.

**Assumption A1.10**

The directors' time constraint is the following:

(1.2) $T = X + H + Z$ where:

- $T$ is the total time available;
- $X$ is leisure;
- $Z$ is time devoted to the association.

**Assumption A1.11**

Each members' time constraint is the following:

(1.3) $T = X_i + H_i + Z_i$ where:

- $X_i$ is leisure;
- $H_i$ is paid labour time;
- $Z_i$ is time devoted to forest management.

## 3.3. The "Portuguese" model 1: associations with fixed mandatory contributions to the public good and no private services provision

### 3.3.1. Assumptions

In the forest owners' associations of Northern Portugal what the members pay is a fixed membership fee independent from the benefit they get from the association. This case is described here.

**Assumption A2.1**

The entire output of the association is a public good produced in a quantity $Q$.

**Assumption A2.2**

Each member's budget constraint is the following:

(2.1) $pY_i + m \leq \omega H_i + V_i + F_i(Z_i, Q, B_i)$ where:

- $m$ is the annual membership fee assumed to be the same for all the members;
- $F_i$ is a forest production function with positive first-order partial derivatives and negative second-order own-partial derivatives;
- $B_i$ denotes other inputs of forest production supposed to be fixed.

**Assumption A2.2**

The association's budget constraint is:

(2.2) $C(Q) \leq n(Z)m + S(Z)$

with the following properties:

(2.3) $\frac{\partial n}{\partial Z} > 0, \quad \frac{\partial S}{\partial Z} > 0$ where:

- $C$ is the total production cost of the public good;
- $n$ is the number of members who actually pay the membership fees;
- $S$ represents other sources of funding besides membership fees, namely public grants and other financial support obtained by the fund raising effort of the directors.

### 3.3.2. The directors' equilibrium strategies

The directors' decision problem is the following:

(2.4) $\underset{X,Y,Z,Q}{Max} \quad W(X,Y,Q)$

$$s.t. \quad pY \leq \omega H + V$$
$$T = X + H + Z$$
$$C(Q) \leq n(Z)m + S(Z) \qquad X,Y,Z,Q \geq 0$$

The Kuhn-Tucker conditions for this problem are the following where $\alpha$ is the Lagrange multiplier:

(2.5) $\frac{\partial L}{\partial X} = \frac{\partial W}{\partial X} - \alpha\omega \leq 0, \quad X \geq 0, \quad X\frac{\partial L}{\partial X} = 0$

(2.6) $\frac{\partial L}{\partial Y} = \frac{\partial W}{\partial Y} - \alpha p \leq 0, \quad Y \geq 0, \quad Y\frac{\partial L}{\partial Y} = 0$

(2.7) $$\frac{\partial L}{\partial Q} = \frac{\partial W}{\partial Q} - \beta \frac{\partial C}{\partial Q} \leq 0, \quad Q \geq 0, \quad Q \frac{\partial L}{\partial Q} = 0$$

(2.8) $$\frac{\partial L}{\partial Z} = -\alpha\omega + \beta m \frac{\partial n}{\partial Z} + \beta \frac{\partial S}{\partial Z} \leq 0, \quad Z \geq 0, \quad Z \frac{\partial L}{\partial Z} = 0$$

For an interior solution, from these conditions we get:

(2.9) $$MRS_{QX} = \frac{C'}{mn' + S'}$$ where:

- $MRS_{QX}$ is the marginal rate of substitution between leisure and the public good;
- $n'$ and $S'$ are the first derivatives of $n$ and $S$ with respect to $Z$;
- $C'$ is the marginal cost of the public good.

(2.9) shows that the leisure time the directors are willing to sacrifice in order to increase the services provided by the association is equal to the ratio between the marginal cost of these services and the marginal benefit of the directors' fund raising time. An important feature of this result is that the directors' equilibrium strategies are dominant strategies because they don't depend on the amount of time the members devote to their forest lands. The amount of services provided by the association depends only on their marginal costs, on the marginal productivity of the directors' fund raising efforts and on their preferences towards the public good supplied by the association and the other goods and services they use for their own consumption. So there is no incentive for the directors to care about two things:
- the productivity of the services provided by the association,
- and the productivity of the owners' forest management time.

### 3.3.3. The members' equilibrium strategies

Each member faces the following decision problem:

(2.10) $$\underset{X_i, Y_i, Z_i}{Max} \quad U_i(X_i, Y_i)$$

$$s.t. \quad pY_i + m \leq \omega H_i + V_i + F_i(Z_i, Q, B_i)$$

$$T = X_i + H_i + Z_i \qquad X_i, Y_i, Z_i, Q \geq 0$$

The Kuhn-Tucker conditions for this problem are the following where $\alpha_i$ is the Lagrange multiplier:

(2.11) $$\frac{\partial L_i}{\partial X_i} = \frac{\partial U_i}{\partial X_i} - \alpha_i \omega \leq 0, \quad X_i \geq 0, \quad X_i \frac{\partial L_i}{\partial X_i} = 0$$

(2.12) $$\frac{\partial L_i}{\partial Y_i} = \frac{\partial U_i}{\partial Y_i} - \alpha_i p \leq 0, \quad Y_i \geq 0, \quad Y_i \frac{\partial L_i}{\partial Y_i} = 0$$

(2.13) $$\frac{\partial L_i}{\partial Z_i} = -\alpha_i \omega + \alpha_i \frac{\partial F_i}{\partial Z_i} \leq 0, \quad Z_i \geq 0, \quad Z_i \frac{\partial L_i}{\partial Z_i} = 0$$

For an interior solution, from these conditions we get:

(2.14) $$MRS_{X_i Y_i} = \frac{\partial F_i / \partial Z_i}{p}$$

Since $\partial F_i / \partial Z_i$ depends on Q, the members' equilibrium strategies don't have the "dominant strategy" feature: in allocating their time to forest management, the owners have to take into account the amount of services provided by the association and set by the board of directors. The sign of the members' Nash reaction curve shows how the amount of time they devote to forest management depends on the amount of public good provided by the association. Taking into account that $MRS_{X_i,Y_i}$ is a function of $X_i$ and some utility level $u_i$, from (2.14) we get for this slope:

$$(2.15) \quad \frac{dZ_i}{dQ} = -\frac{(F_i)_{Z_iQ}}{(F_i)_{Z_iZ_i}}$$

where the numerator and the denominator in right hand side are the first-order partial derivatives of $\partial F_i / \partial Z_i$ with respect to $Q$ and $Z_i$ .Since according to assumption A2.2. there are diminishing marginal returns, this shows that the sign of the response of the members' forest management time to variations in the amount of services provided by the association changes with the type the technical interdependence between these variables:

- $Z_i$ varies positively with Q if these two factors are technically complementary (Ferguson, 1969), that is, the cross-acceleration coefficient $(F_i)_{Z_iQ}$ is positive;
- $Z_i$ varies negatively with Q if they are technically competitive (Ferguson, 1969), that is the cross-acceleration coefficient $(F_i)_{Z_iQ}$ is negative.

## 3.4. The "Portuguese" model 2: associations with fixed mandatory contributions to the public good and private services provision

### 3.4.1. Assumptions

We now introduce in the "Portuguese" model the provision of private services to the members for which a price is charged.

**Assumption A3.1**

Besides the provision of public goods, the association also provides a quantity $R$ of private services.

**Assumption A3.2**

The utility of the directors depends positively on $R$.

**Assumption A3.3**

The directors set the price $r$ of the private services and let the demand determine the quantity $R$.

**Assumption A3.4**

The demand function for the association's private services is monotonically negative $\frac{\partial R}{\partial r} < 0$.

Given these assumptions the association's budget constraint takes the following form:

$$(3.1) \quad C[Q, R(r)] \leq n(Z)m + S(Z) + rR(r)$$

### 3.4.2. The directors' equilibrium strategies

The Kuhn-Tucker conditions for the directors' decision problem in this case are the same as in the previous model with the following additional condition for the price of the private services:

$$(3.2) \quad \frac{\partial L}{\partial r} = \frac{\partial W}{\partial R}\frac{\partial R}{\partial r} + \beta\left[R(r) + r\frac{\partial R}{\partial r} - \frac{\partial C}{\partial R}\frac{\partial R}{\partial r}\right] \leq 0, \quad r \geq 0, \quad r\frac{\partial L}{\partial r} = 0$$

For an interior solution, from these conditions we get:

$$(3.3) \qquad MRS_{QX} = \frac{C'}{mn' + S'}$$

This result looks similar to the one in (2.9), but there is an important difference. Now since the association provides both public and private goods the marginal cost $C'$ depends on the quantity of these private services demanded by the members. So the directors' equilibrium strategies loose the dominant strategies' feature they had in the previous model.

Looking now at the private services' price policy set by the directors we have to work with condition (3.2) to get the following result in the case of an interior solution:

$$\beta\left[R(r) + r\frac{\partial R}{\partial r} - \frac{\partial C}{\partial R}\frac{\partial R}{\partial r}\right] = -\frac{\partial W}{\partial R}\frac{\partial R}{\partial r} \Rightarrow \beta\left[\frac{R(r)}{\frac{\partial R}{\partial r}} + r - \frac{\partial C}{\partial R}\right] = -\frac{\partial W}{\partial R} \Rightarrow$$

$$(3.4) \qquad \Rightarrow \beta\left\{r\left[\frac{\frac{R(r)}{r}}{\frac{\partial R}{\partial r}} + 1\right] - \frac{\partial C}{\partial R}\right\} = -\frac{\partial W}{\partial R} \Rightarrow \beta\left[r\left(1 + \frac{1}{\varepsilon_r}\right) - \frac{\partial C}{\partial R}\right] = -\frac{\partial W}{\partial R}$$

where $\varepsilon_r$ is the price elasticity of the demand for private services.

Dividing this condition by the one for the public good we get:

$$(3.5) \qquad \frac{r\left(1 + \frac{1}{\varepsilon_r}\right) - \frac{\partial C}{\partial R}}{-\frac{\partial C}{\partial Q}} = \frac{\frac{\partial W}{\partial R}}{\frac{\partial W}{\partial Q}} \Leftrightarrow \frac{\pi_R}{\pi_Q} = MRS_{RQ}$$

where $\pi_i$ is the marginal benefit of service $i$. What this result shows is that the optimal price for the private services is the one for which the marginal rate at which the directors are willing to substitute the private for the public goods is equal to the ratio of the marginal benefits of these services.

### 3.4.3. The members' equilibrium strategies

Nothing is substantially changed in the features of the members' equilibrium strategies compared with the previous model except for the fact that now there is the usual marginal productivity condition to characterise the demand for private services. Including this demand $R_i$ as new argument in the production function and its cost $rR_i$ as new component in the members' budget constraint we get the following Khun-Tucker condition in addition to the ones in the previous model:

$$(3.6) \qquad \frac{\partial L_i}{\partial R_i} = \alpha_i\left(\frac{\partial F_i}{\partial R_i} - r\right) \leq 0, \quad R_i \geq 0, \quad R_i\frac{\partial L_i}{\partial R_i} = 0$$

For an interior solution the marginal productivity condition immediately comes up:

$$(3.7) \qquad \alpha_i\left(\frac{\partial F_i}{\partial R_i} - r\right) = 0 \Rightarrow \frac{\partial F_i}{\partial r} = r$$

## 3.5. The "Scandinavian" model

### 3.5.1. Assumptions

We are now going to examine the behaviour of associations where, besides a fixed membership fee, the forest owners pay a variable fee equal to some share of the gross value of their timber sales. This regime is similar to the one existing in the Scandinavian countries.

**Assumption A4.1**

Besides the membership fee, each forest owner contributes to the association with a variable fee calculated as a share $\theta$ of his forest income so that his individual budget constraint becomes:

(4.1) $$pY_i + m \leq \omega H_i + V_i + (1-\theta)F_i(Z_i, Q, B_i)$$

**Assumption A4.2**

All the members pay in due time their contributions to the association.

**Assumption A4.3**

The association's budget constraint is the following:

(4.2) $$C(Q) \leq nm + S(Z) + \theta \sum_{i=1}^{n} F_i(Z_i, Q, B_i)$$

### 3.5.2. The directors' Nash equilibrium strategies

The directors' decision problem is the following:

(4.3) $$\underset{X,Y,Z,Q}{Max} \quad W(X,Y,Q)$$

$$s.t. \quad pY \leq \omega H + V$$

$$T = X + H + Z$$

$$C(Q) \leq nm + S(Z) + \theta \sum_{i=1}^{n} F_i(Z_i, Q, B_i) \qquad X, Y, Z, Q \geq 0$$

The Kuhn-Tucker conditions for this problem are the following where $\alpha$ and $\beta$ are Lagrange multipliers:

(4.4) $$\frac{\partial L}{\partial X} = \frac{\partial W}{\partial X} - \alpha\omega \leq 0, \quad X \geq 0, \quad X\frac{\partial L}{\partial X} = 0$$

(4.5) $$\frac{\partial L}{\partial Y} = \frac{\partial W}{\partial Y} - \alpha p \leq 0, \quad Y \geq 0, \quad Y\frac{\partial L}{\partial Y} = 0$$

(4.6) $$\frac{\partial L}{\partial Q} = \frac{\partial W}{\partial Q} + [\beta\theta \sum_{i=1}^{n} (\partial F_i / \partial Q)] - \beta\frac{\partial C}{\partial Q} \leq 0, \quad Q \geq 0, \quad Q\frac{\partial L}{\partial Q} = 0$$

(4.7) $$\frac{\partial L}{\partial Z} = -\alpha\omega + \beta\frac{\partial S}{\partial Z} \leq 0, \quad Z \geq 0, \quad Z\frac{\partial L}{\partial Z} = 0$$

For an interior solution, from these conditions we get:

$$(4.8) \qquad MRS_{QX} = \frac{C' - \theta \sum_{i=1}^{n} (\partial F_i / \partial Q)}{S'}$$

This result shows that in the "Scandinavian" model, like in the "Portuguese" models, the leisure time the directors are willing to sacrifice in order to increase the services provided by the association depends on the comparison between the marginal cost of these services and the marginal benefit of the directors' fund raising efforts, with the following differences:

- the marginal cost of the public good is net of the share of its aggregate marginal benefits contributed by the members to the association;
- because these marginal benefits of the services provided by the association are taken into account by the board of directors, their strategies loose the "dominant strategy" feature they had in the "Portuguese" model without private services provision.

In this type of association the leisure time the directors are willing to sacrifice in order to increase the services provided by the association takes into account the marginal productivity of these services which depends on the time the owners devote to forest management. So the time the directors devote to the association and the time the owners devote to forest management are interdependent and responsive to each other. To determine the direction of this interdependence expression (4.8) can be used to calculate the slope of the directors' Nash reaction curve which is as follows:

$$(4.9) \qquad \frac{dQ}{dZ_i} = -\frac{\frac{1}{S'}[-\theta(F_i)_{QZ_i}]}{\frac{\partial MRS_{QX}}{\partial Q} - \frac{1}{S'}[C'' - \theta(F_i)_{QQ}]}$$

Like in the "Portuguese" model, the sign of the slope of the directors' Nash reaction curve in this model also changes according to the type of technical interdependence between the public good and the members' forest management time. For $\frac{\partial MRS_{QX}}{\partial Q} < 0$, increasing marginal costs ($C'' > 0$) and diminishing marginal returns [$(F_i)_{QQ} < 0$] for the public good, from (4.9) we can says this:

- the amount of services $Q$ set by the directors varies positively with the time $Z_i$ each member devotes to forest management if $Q$ and $Z_i$ are technically complementary;
- the opposite happens when $Q$ and $Z_i$ are technically competitive.

### 3.5.3. The members' Nash equilibrium strategies

Each member faces the following decision problem:

$$(4.10) \qquad \underset{X_i, Y_i, Z_i}{Max} \quad U_i(X_i, Y_i)$$

$$s.t. \quad pY_i + m \leq \omega H_i + V_i + (1-\theta) F_i(Z_i, Q, B_i)$$

$$T = X_i + H_i + Z_i \qquad\qquad X_i, Y_i, Z_i, Q \geq 0$$

The Kuhn-Tucker conditions for this problem are the following where $\alpha_i$ is the Lagrange multiplier:

$$(4.11) \qquad \frac{\partial L_i}{\partial X_i} = \frac{\partial U_i}{\partial X_i} - \alpha_i \omega \leq 0, \quad X_i \geq 0, \quad X_i \frac{\partial L_i}{\partial X_i} = 0$$

$$(4.12)\quad \frac{\partial L_i}{\partial Y_i} = \frac{\partial U_i}{\partial Y_i} - \alpha_i p \leq 0, \quad Y_i \geq 0, \quad Y_i \frac{\partial L_i}{\partial Y_i} = 0$$

$$(4.13)\quad \frac{\partial L_i}{\partial Z_i} = -\alpha_i \omega + \alpha_i (1-\theta) \frac{\partial F_i}{\partial Z_i} \leq 0, \quad Z_i \geq 0, \quad Z_i \frac{\partial L_i}{\partial Z_i} = 0$$

For an interior solution, from these conditions we get:

$$(4.14)\quad MRS_{X_i Y_i} = \frac{(1-\theta)\partial F_i / \partial Z_i}{p}$$

Again, like in the "Portuguese" models, the members' equilibrium strategies don't have a "dominant strategy" feature: in allocating their time to forest management, the members have to take into account the amount of services provided by the association and decided by the board of directors. So by computing the slope of their Nash reaction curves we can determine the sign of this interdependence. This slope has the following expression:

$$(4.15)\quad \frac{dZ_i}{dQ} = -\frac{(F_i)_{Z_i Q}}{(F_i)_{Z_i Z_i}}$$

which leads to the same conclusions as in the "Portuguese" models.

## 4. CONCLUSIONS

The results of these models show that the directors' behaviours have a "dominant strategy" feature in the "Portuguese" model without private services provision, but not in the model with these type of services and in the "Scandinavian" model. This means that in the first case directors have no incentive to care about the forest management behaviour of the owners and the productivity of the services provided by the association which does not happen in the other two models.

The optimal price policy in the case of private services provision has to be such that the directors' willingness to substitute private services for public goods has to be equal to the ratio of the marginal benefits of these two types of services.

About the owners' behaviours in the three cases, the models predict that the way their forest management time reacts to the amount of services provided by the association depends on the technical interdependence between these two factors of production:

- the owners' forest management time varies in the same direction as the association's output if this management time and the association´s output are complementary factors;

- the opposite happens if these two factors are competitive.

## 5. REFERENCES


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