LIQUIDITY CONSTRAINTS AND COLLABORATION IN TIMBER SELLING

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ABSTRACT.– The effects of liquidity constraints on the profitability of forest management plans, and the potentials of a collaborative timber selling scheme to counteract these effects are examined. It is shown how forest owners can increase the profitability of their forest assets by pooling them. Collaborative timber selling scheme offers a way to reduce the negative impacts of the capital-market imperfections by permitting the land owners, under certain conditions, to partially restore the separability of consumption and timber production decisions. Pooling forest assets enables the land owners to better take advantage of their price expectations, and increase the expected value of their forest holdings. Specifically, interpretable measures for two-owner collaborative benefits are derived in the case where the forest owners face borrowing constraints. These benefits are shown to directly depend on the expected timber price changes, interest rates and the extent of borrowing constraints. The prospects of being able, through the collaborative scheme, to circumvent capital market imperfections, translate into the possibility of reducing welfare losses due to those imperfections.

INTRODUCTION

Capital market imperfections and liquidity constraints can be argued to result in a distorted distribution of resources in the economy between present time and future. In the case of forestry, as the privately optimal forest assets or timber stocks are kept below their socially optimal long-term levels, the capital market imperfections lead to sub-optimal timber supplies. This, in turn, results in welfare losses of the forest owners and of the entire society. In practice, it is usually the small non-industrial private forest owners who face capital market imperfections.

This paper examines capital market imperfections and their effects on the values of forest assets and presents a possible remedy to counteract the negative effects of capital market imperfections and liquidity constraints. The main question this paper attempts to answer is: how could private forest land owners collaborate in timber selling to increase the profitability of their forest-assets. The paper shows how a straightforward theoretical outcome from a constrained resource-management problem has some clear-cut and strong practical implications, and readily lends itself to forestry applications. More specifically, the question examined is what the economic conditions are in which collaboration yield benefits to forest owners. The study finds that when there are imperfections in the capital markets, liquidity constrained forest owners gain benefits through collaboration.

First, in this paper, a two-period profit maximization problem of liquidity constrained consumers endowed with forest assets and an access to capital markets is presented. Next, the effects of a simple collaborative scheme on the constraint structure of a combined model is demonstrated. Then, interpretable measures for the benefits of the collaboration are derived, and finally, some practical aspects of the modeling implications are discussed.

THE MODEL

Next, the idea of collaborative pooling of forest assets is demonstrated within a profit-maximizing model framework. The basic set-up of collaborative pooling of forest assets is simple. Two forest owners with compatible price expectations and differing types of forest holdings (in terms of timber assortments) can jointly utilize one of the two types of forests first to meet their liquidity needs of today, and leave the other forest site with higher price

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and value prospects unused till tomorrow. Since more of the forest with better economic outlook can be saved till tomorrow than by acting alone, the collaboration increases the expected combined proceeds of the two forest assets. Therefore also, the collaboration scheme offers natural incentive to both of the forest owners to collaborate.

A forest owner seeks to organize his forest-asset management plans so as to maximize an inter-temporal profit function. We study the maximized values of two forests in two different managerial regimes, first when two forest owners are acting independently, and second, when they plan timber selling in collaboration with each other.

In the case of the two forest owners acting independently, the combined constrained maximized value of two forest assets (i = 1,2 to denote the two forest assets and the two forest owners) can be expressed as follows:

(1) $$V_t^{1,2}(a^i) = \underset{a^i}{\text{Max}} \{\Sigma_i p^i_t a^i Q^i_t + (1+\delta)^{-1}\Sigma_i E(p^{*i}_{t+1}(1+F^i)(1-a^i)Q^i_t - rB^i)\}$$

subject to $p^i_t a^i Q^i_t + B^i = C^i_t$ for i= 1,2.

In the above the symbol denotations are the following:

$V_t^{1,2}(a^i)$	Discounted expected value of two independent forest assets combined
Σ_i	Summation over i = 1,2
p^i_t	Price at period t of timber assortment contained in forest holding i
a^i	Share of period t timber cuttings of the total timber in the forest holding, ($0<a^i<1$), forest owners acting independently
Q^i_t	Timber volume in forest holding at t
B^i	Upper bound on the amount of borrowing for forest owner with assets i
δ	Time preference factor, common for both forest owners
E	Expectation operator
p^{*i}_{t+1}	Timber price at period t+1, a random variable
F^i	A concave (in Q) growth function
r	Interest rate
C^i_t	Consumption at period t

In the model, the forest owners are assumed to be credit rationed and to have only limited access to capital markets, with the upper bound of B^i as the amount of borrowing which they cannot individually exceed. The decision variable is a^i, the percentage that the forest owner wants to cut at the first period of the total volume of his forest assets. The rest, given by the percentage 1- a^i, is left to the second period. The expected value of this remaining forest, $Ep^{*i}_{t+1}(1+F^i)(1-a^i)Q^i_t$, depends on the unit timber price on the second period and on the growth of the forest.

The a^i are chosen so that $(1+r)/(1+\pi^i) < (1+F'^i)$, where π^i are the expected change rates of timber prices, $(Ep^{*i}_{t+1}-p^i_t)/p^i_t$, and F'^i are the first derivative of the growth function at the levels $(1-a^i)Q^i_t$. This implies, given the concavity of the growth function, that the credit rationed forest owners cut more in the current period than what is socially optimal. Thus capital market imperfections distort the optimal allocation of resources between financial and forest assets. This and the timber supply implications of credit rationing are well documented in Koskela (1989) and in Kuuluvainen (1990).

In the case of the two forest owners acting in collaboration, the combined constrained maximized value of two forest assets can be expressed as follows:

(2) $$V_t^{1,2}(\alpha^i) = \text{Max} \{\Sigma_i p^i_t \alpha^i Q^i_t + (1+\delta)^{-1}\Sigma_i E(p^{*i}_{t+1}(1+F^i)(1-\alpha^i)Q^i_t - rB^i)\}$$

α^i

subject to $\Sigma_i(p^i_t \alpha^i Q^i_t + B^i) = \Sigma_i C^i_t$

In (2) α^i are the shares of the two forest assets cut in the first period when the two forest owners are collaborating with each other. They are thus the collaborative decision variables, chosen from the pool of the two forest holdings. For example, α^1 is the share of timber contained in the holdings of forest owner 1 which is cut in the first period, in order to maximize the expected value of the forest asset pool while satisfying the liquidity needs of the two forest owners. Comparing (1) with (2) it can be observed that the constraint structure in (1) places a stronger restriction on the management plans of the two forests than the constraint structure in (2). Therefore, the collaborative timber cutting management, described in (2) and defined by α^i , provides at least as high expected value of the combined forest assets as the individual timber cutting management defined by a^i in (1). We can write the following expression:

(3) $V_t^{1,2} (\alpha^i) \geq V_t^{1,2} (a^i)$

Next the question of what are the specific conditions in which the collaboration provides higher proceeds than the individual timber selling, is studied more closely. Also interpretable measures are derived for the collaborative benefits.

COLLABORATIVE BENEFITS

In what follows, the simplifying assumption of a linear growth function will be adopted. This enables one to proceed to easily interpretable measures of collaboration by working with boundary-point solutions. For a further illustration of the simplifying effects of a linear growth function under future price uncertainty, see Koskela and Ollikainen (1996). The linearity of the growth function implies that the growth of the forest is exogenously given to the forest owner.

With the linearity assumption, the expected discounted change rates of the unit values of the two forest assets can be expressed as:

(4) $D^i = (Ep^{*i}_{t+1} (1+q^i)(1+\delta)^{-1} - p^i_t)/ p^i_t,$

where q^i is the linear growth factor. Throughout the rest of the analysis it is assumed, without loss of generality, that $D^1 > D^2$, i.e., forest owner 1 is designated to be the one whose asset value is expected to rise more than the asset value of owner 2.

To tract down the optimal managerial choices of the forest owners, we need to establish an ordering of the expected returns of the two broad types of assets involved, the financial ones on the capital markets, and the forest assets on the timber markets. For this, we first presume the following configuration between the change rates (time-preference adjusted) of the assets: $D^1 > r(1+\delta)^{-1} > D^2$. The asset value of the first forest owner is expected to grow faster, whereas the asset value of the second forest owner is expected to grow slower than the prevailing interest rate on the capital markets. Under these conditions the case of the forest owners acting alone is studied first, followed by the case where they act in collaboration with each other.

For the first forest owner it is now optimal to use up the entire personal borrowing quota, B^1, to cover as much as possible of the first period liquidity need through a loan from the capital markets, and only cover the rest of the liquidity requirement, $C^1 - B^1$, by selling timber. This way he saves as much as possible of his forest assets, which he expects to give a higher return than assets are gaining on the capital markets. Then the expected value of his forest assets under the liquidity constraint is given by:

(5) $V^1(a^1) = p^1_t a^1 Q^1_t + (1+\delta)^{-1} (Ep^{*1}_{t+1}(1+q^1)(1-a^1)Q^1_t - rB^1)$

with $a^1 = (C^1 - B^1)/ p^1_t Q^1_t$

According to (5) the asset value of the first forest owner is given by the first period timber selling proceeds plus the expected value of the remaining forest assets minus the interest payment on the first period loan due on the second period. As long as the liquidity constraint is binding so that $C^1 > B^1$, a^1 will be larger than 0, and some of the timber will be cut in the first period. If the constraint is not binding, $C^1 < B^1$, none of the timber is cut in the first period. It should also be noted that, since a^i's take values between 0 and 1, the liquidity constraint is assumed not to exceed the present value of the forest assets.

For forest owner 2 whose forest assets are expected to give a return lower than the interest rate, $(r(1+\delta)^{-1} > D^2)$, the optimal behavior is simply to sell the entire forest inventory in the first period and lend out the amount beyond the liquidity need, at interest rate r. The (expected) value of his forest assets therefore is:

(6) $V^2(a^2) = p^2_t a^2 Q^2_t + (1+\delta)^{-1} (p^2_t a^2 Q^2_t - C^2)r$

with $a^2 = 1$

As long as $p^2_t Q^2_t > C^2$, forest owner 2 is not acting as a borrower on the capital markets, and is hence not bound by the upper limit of the borrowing constraint.

Next, the expressions in (5) and (6) can be summed, to obtain the expected combined value of the two forest assets in the case where the two forest owners are acting separately. After some manipulations we get:

(7) $V^{1,2}(a^i) = p^2_t Q^2_t + (1+\delta)^{-1} (Ep^{*1}_{t+1}(1+q^1)Q^1_t - r^*C^1 + (p^2_t a^2 Q^2_t - C^2)r)$

In the above, r* can be called the 'virtual interest rate' and is expressed as follows:

(8) $r^* = r(1+\delta)^{-1} + (D^1 - r(1+\delta)^{-1}) (1-B^1/C^1)$

In (7) the virtual interest rate r* defines the unit price of the 'credit' forest owner 1 needs to have to satisfy his first period consumption C^1. This credit is a combination of a loan from the capital markets and proceeds from timber selling. The timber selling amounts to 'borrowing' from the forest owner's own forest assets, since for the amount $C^1 - B^1$, he is refrained from receiving the expected rate of the value growth D^1 as a result of the borrowing constraint. It is important to note that the virtual interest rate r* is larger than the actual (time-preference adjusted) interest rate r:

(9) $r^* > r(1+\delta)^{-1}$

Expression (9) holds because in (8) $D^1 > r(1+\delta)^{-1}$ and $B^1 < C^1$. The concept of virtual interest rate has previously been studied within forestry context by Kuuluvainen (1990).

Next we proceed to obtaining an expression for the expected combined forest asset value in the case where the two forest owners choose to collaborate with each other. This expression can then be compared with (7).

When collaborating with each other and pooling their forests the two liquidity constrained forest owners have more flexibility to manage their forests than when acting alone. We want to know what is the optimal selling scheme under collaborative timber management, i.e., what are the α^i's in this case when $D^1 > r(1+\delta)^{-1} > D^2$.

When acting together it is optimal for the forest owners to save till the second period the entire forest assets owned by forest owner 1, and generate the expected total value worth of $(1+\delta)^{-1} Ep^{*1}_{t+1}(1+q^1)Q^1_t$. Furthermore, when acting

together, the forest owners want to have the entire forest assets owned by forest owner 2 cut in the first period, and earn the selling income of $p^2_tQ^2_t$, plus the interest income on the amount exceeding the combined liquidity needs, $(p^2_tQ^2_t - C^1 - C^2)r$. Therefore $\alpha^1 = 0$, and $\alpha^2 = 1$. Then the combined expected asset value is given by:

(10) $$V^{1,2}(\alpha^i) = p^2_tQ^2_t + (1+\delta)^{-1} (Ep^{*1}_{t+1}(1+q^1)Q^1_t + (p^2_tQ^2_t - C^1 - C^2)r)$$

The term $p^2_tQ^2_t - C^1 - C^2$ can either be positive or negative, or zero. If the income from selling the forest assets 2 exceeds the combined consumption requirements, the remaining money can be lent out on the capital markets at interest rate r, while if the converse is true, the remaining consumption needs can be satisfied by borrowing from capital markets at the same rate. (We assume that $p^2_tQ^2_t - C^2 \geq C^1 - B^1$, i.e., the second forest owner's forest assets, net of his own consumption, are at least as high in value as the first forest owner's consumption subtracted by his borrowing limit.)

By comparing the two expressions (7) and (10) of the expected values of the combined forest assets in the two alternative schemes above, it is easy to see that $V^{1,2}(\alpha^i) > V^{1,2}(a^i)$. This result comes out from the fact that the virtual interest rate for the forest owner 1 is higher than the market interest rate, as stated in (9). Therefore, collaboration in timber selling promises higher returns for the forest owners than acting independently from each other. Through collaboration, the consumption of forest owner 1 can be satisfied based on 'borrowing' either from the capital market or from the forest assets of the second forest owner, which both credit sources are less costly than the forest assets of the first forest owner, since $D^1 > r(1+\delta)^{-1} > D^2$. Thus, collaborative selling leads to expected gains over individual selling, since it offers a means to partially circumvent the liquidity constraints imposed on the forest owners.

Subtracting (7) from (10), the economic gains from collaboration can be expressed as follows:

(11) $$(D^1 - r(1+\delta)^{-1}) (C^1 - B^1)$$

The benefits of pooling forest assets and integrating timber selling are expressible as the difference of the expected percentage returns of the forest assets with the better price outlook, and the actual interest rate, $D^1 - r(1+\delta)^{-1}$, times the difference between the consumption expenses and borrowing constraint of the owner of these forest assets, $C^1 - B^1$.

Above the case has been analyzed when $D^1 > r(1+\delta)^{-1} > D^2$. The two other cases of configurations (recalling that we set $D^1 > D^2$) between timber price expectations and the interest rate, $D^1 > D^2 > r(1+\delta)^{-1}$, and $r(1+\delta)^{-1} > D^1 > D^2$, can be studied in a similar way. Accordingly, one finds that the collaborative benefits in the former case will be:

(12) $$(D^1 - D^2) (C^1 - B^1)$$

Now the expected benefits from collaboration are determined by the difference in the expected returns of the two forest assets, and the extent of the borrowing constraint of the forest owner with the forest assets of the higher price outlook. On the other hand, when $r(1+\delta)^{-1} > D^1 > D^2$, i.e. the interest rate is higher than either one of the expected returns of the two forest assets, both forest owners are cutting their entire timber stocks in the first period in the case of individual selling, as well as in the case of collaborative selling. Therefore, no benefits could be gained through collaboration.

DISCUSSION

The above analysis has demonstrated how, through a collaborative timber selling scheme, liquidity constrained forest owners can achieve gains in the expected values of their forest assets. Pooling their forest resources, two forest owners can partially circumvent borrowing constraints imposed on them individually on the capital markets.

Recently, some empirical evidence has been found suggesting that non-industrial private forest owners may be subject to (perceived) credit rationing (Kuuluvainen and Salo 1990, Kuuluvainen et al. 1996).

The reasons for the existence of credit rationing among forest owners - or other asset holders - could lie on the fact that creditors and debtors have asymmetric information, or simply on creditors' risk management policies. It seems plausible to assume that it is mainly the small land-owners that might face borrowing limits. Therefore, the collaboration in timber selling could offer a possible means specifically for these forest owners to lessen the effects of credit rationing, and improve the profitability of their forest management operations.

In this study, some simplifying assumptions were used to make the collaborative benefits more interpretable. These benefits were shown to depend on the differences between the expected asset growth rates on the capital and timber markets, and on the extent of the credit rationing. The higher the expected change in the value of the forest assets of one of the forest owners compared to the interest rate, and the tighter the credit rationing, the larger the benefits of the collaborative scheme will be.

In a further analysis, it could be shown, that not only does the collaboration in timber selling lead to improved profitability under the conditions of credit rationing, but also, when the capital markets exhibit imperfections in general - in the sense of differing borrowing and lending rates of interest - the same type of forest asset pooling offers a means to avoid the negative effects of these imperfections. This analysis, however, is left out of this report.

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