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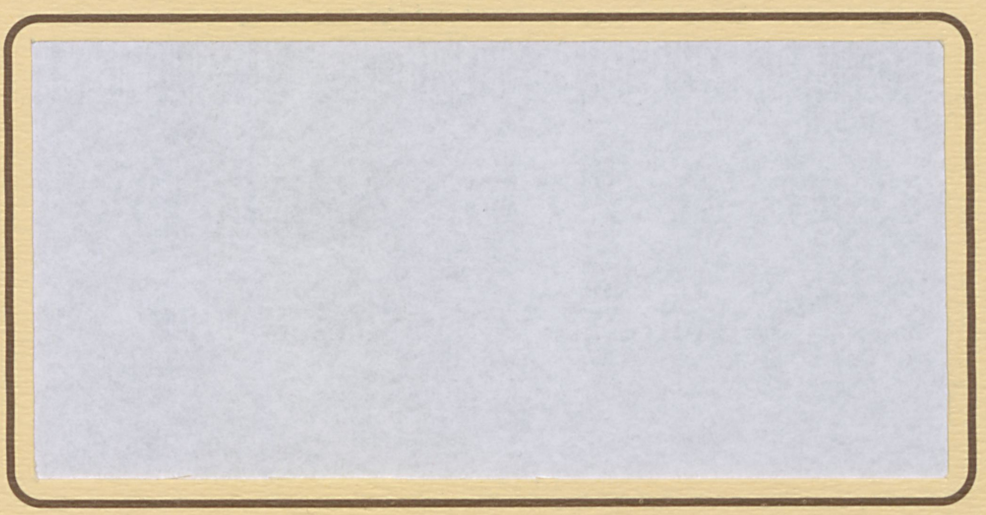

STAFF PAPER

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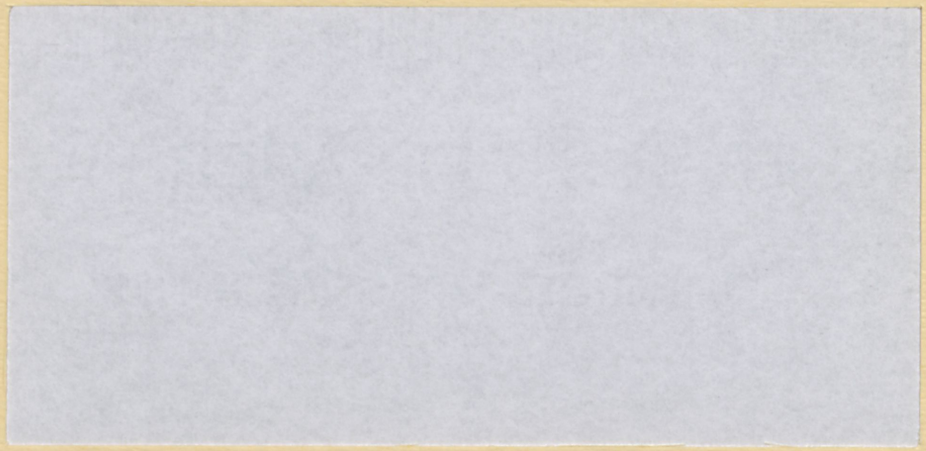

Canadian Forest Tenures as Incentive Frameworks for the Silvicultural Expenditures of Private Firms

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ABSTRACT

In Canada, where most forest lands are publicly owned, forest management responsibilities are delegated to the private sector through licensing arrangements which grant limited usufructuary rights. In order to ensure that public silvicultural goals are met on licensed public lands, various policy instruments have been adopted. These include contractual requirements, the reimbursement of silvicultural costs and investment incentives in the form of shares in the value of timber crops resulting from voluntary silvicultural activities. In this paper, the impacts of these alternative arrangements on the investment behaviour of private forest companies is analyzed, welfare losses are identified and policy implications are discussed.

INTRODUCTION

Governments worldwide have adopted various means to ensure that forest lands are managed in the best public interest. Some rely heavily on market forces to determine forest management strategies, choosing only to regulate where there is a clear dichotomy between private and public goals. Most governments have retained title to some forest resources and exercise direct control over the management of these forests. In Canada, provincial governments have generally retained forest lands under public ownership but delegate forest management responsibilities to private firms holding tenured rights to public forest resources (Haley and Luckert 1990)

Governments in Canada and elsewhere have adopted various policies designed to assign timber management responsibilities to private firms occupying public lands (Luckert and Haley 1989; Repetto and Gillis 1988). These policies can be characterized as one, or a combination, of three types. First, firms' rights to harvest public timber may be conditional upon them undertaking specified silvicultural activities at their own expense. Second, governments may choose to reimburse tenure holders for all, or a portion, of the costs of silvicultural activities. Finally, governments may provide incentives for tenure

holders to invest voluntarily in silviculture by granting them a share, or equity, in the value of timber crops resulting from their activities.

These alternative policies define sets of rules which tenure holders must follow in order to retain their rights to public timber. Assuming tenure holders will attempt to maximize their net benefits subject to the rules dictated by their institutional environment, it is possible to predict their behavior when faced with alternative public policies. The purpose of this paper is to use such analysis to examine, theoretically, the extent to which the alternative policy instruments described above will achieve public goals for timber management.

In order to establish a basis for comparing alternative public policies, the paper will first explore a situation in which private markets determine the extent of silvicultural activities. Next, silvicultural policies associated with requirements, reimbursements, and incentives for voluntary investment will be analyzed. Each of these alternative approaches will be examined both individually and in combination with one, or both, of the other two.

PRIVATE MARKET SOLUTIONS

In allocating capital to and among silvicultural activities, firms operating on private land face a variety of costs and benefits. Costs include direct outlays plus the opportunity costs of committing capital over long periods to the production of future timber crops. Benefits may include increased timber volumes, enhanced wood quality and shorter rotations which serve to reduce the opportunity costs of capital investment. The net value of each possible project to the firm, that is the amount by which each project will increase the firm's assets, is:

$$NPV_i = PVB_i(Ql_i, Qt_i) - PVC_i \qquad [1]$$

where:

NPV_i = Net Present Value of project i;

PVB_i = Present Value of the Benefits of project i which is a function of the quality (Q_{1i}) and quantity (Qt_i) of the wood produced as a result of the project;

PVC_i = Present Value of the Costs of project i.

Profit maximizing private firms operating in a competitive market economy, unfettered by public regulations and with no capital constraints, will undertake all silvicultural projects which return positive NPVs. However, if a firm is faced with a constraint, such as a limited budget, then it may be impossible to conduct all projects

which yield positive net returns. In such cases, the firm will be forced to choose between desirable projects and will attempt to:

$$\text{Max} \sum_{i=1}^{n} PVB_i(Ql_i, Qt_i) - PVC_i \qquad [2]$$

$$\text{Subject To:} \sum_{i=1}^{n} PVC_i \leq Ct$$

where:

Ct = a constraint on the total amount which can be spent on silvicultural projects;

n = the total number of projects undertaken.

In order to choose among profitable projects, maximizing firms will rank alternatives in descending order of their NPVs and choose all projects which lie within the constrained area. In Figure 1, a schedule of NPV_is is shown for all possible projects which will increase wood volumes produced within a given forest. Projects have been ordered from highest to lowest NPV_i. Each project completed has a lower NPV_i than its predecessor but increases the total volume (SQti) of timber produced as a result of silvicultural activities. The relationship between NPV_i and SQt_i can be interpreted as the marginal net present value (MNPV) of increasing timber output or, if each project is assumed to produce one unit of output, the marginal net present value of adding an additional project. As more is produced, less desirable projects are available until the

last positive valued project is undertaken at Qt_A. At this point, the silvicultural program contributes $OAQt_A$ dollars to the firm's net worth.

As more projects are undertaken, the present value of the firm's total silvicultural cost increases. This is represented in Figure 1 as $TPVC^1$. At Qt_C, the firm encounters a budget constraint (Ct) before all projects yielding a positive net present value are exhausted. At Qt_C, the silvicultural program has a total net present value of $OABQt_C$ dollars.

In the absence of budget constraints and market failures, the set of projects Qt_A can be regarded as the socially optimum silvicultural regime, in that the firm's decisions concerning how much capital to invest and where to make expenditures will maximize the net value generated by the land while meeting the opportunity costs of other productive inputs, including capital. However, if private and public valuations of silvicultural benefits and costs differ, then markets may fail to yield optimal capital allocations. It is sometimes argued that private decisions concerning silvicultural investments may overvalue costs from a social perspective while undervaluing benefits. Regarding costs, private firms may choose to discount future returns to silvicultural investments at rates which do not adequately reflect social concerns for the welfare of future

generations[2]. On the benefits side, there may be positive externalities associated with growing forests which private firms do not take into account[3]. In either case, the net social value of undertaking silvicultural investments will be greater than the private value. In Figure 1, the social marginal net present value associated with increasing levels of output is shown as SMNPV. In the absence of a budget constraint, the misrepresentation of social values in private markets results in under investment and a loss of net present benefits to society equal to the shaded area, $Qt_BA'AQt_A$ dollars.

If private and social values diverge[4], governments may choose to use policy instruments to regulate the actions of private forestry firms. In Canada, the most frequent response has been to retain forested lands in public ownership and grant limited usufructuary rights to private firms. However, when private firms operate on public forest lands, governments have found that they frequently lack sufficient incentives to invest voluntarily in silviculture (Luckert and Haley 1989). Consequently, some tenure holders are required to carry out reforestation to specified standards, following harvesting, at their own expense.

REQUIREMENTS

The investment decisions of forestry firms on private lands, as described in the preceding section, are likely to differ substantially from decisions which are made in the face of contractual requirements when operating on public lands. With little or no equity in future timber crops, firms are mainly concerned with the costs of meeting the requirements imposed upon them. Regulations generally specify quantitative goals which firms must meet in order to fulfill their silvicultural obligations. For example, firms may have to plant a minimum number of trees per unit area following harvesting or may be required to maintain a specified annual yield of timber within the context of a sustained yield program. In the following exposition, silvicultural requirements refer to any type of quantitative provision. Faced with such requirements, firms have an incentive to minimize the cost of achieving the mandated level of performance. That is, a firm will seek to:

$$\text{Min} \sum_{i=1}^{n} PVC_i(Qt_i) \qquad [3]$$

$$\text{subject to:} \quad \sum_{i=1}^{n} Qt_i \geq Qt_R.$$

where:

Qt_R = required quantitative standard.

Faced with such a situation, a firm will have an incentive to choose among alternative silvicultural projects by ordering them from lowest to greatest PVC[5], and then selecting projects of increasing cost until its obligation, Qt_R, is met. This ordering is presented in Figure 2 as the marginal present value of costs of producing additional units of output (MPVC). If the firm undertakes silvicultural projects until the required standard, Qt_R, is achieved, the total cost of meeting the requirements is equal to $OAQt_R$.

This analysis assumes that firms will meet contractual requirements voluntarily. However, given that firms may try to avoid costs by failing to meet obligations, the standard, Qt_R, will probably be useless unless enforced. Therefore, governments generally have monitoring procedures backed up by penalties to reduce cheating. In Figure 2, such a penalty is represented by the horizontal line PC. If a firm fails to achieve the required standard, Qt_R, a penalty of P dollars must be paid for each unit (Qt_i) short of the requirement[6]. Under these arrangements, tenure holders will attempt to:

$$\text{Min} \sum_{i=1}^{n} PVC_i(Qt_i) + P(Qt_i) \qquad [4]$$

where:

$P(Qt_i)$ must be paid if $\sum_{i=1}^{n} Qt_i < Qt_R$

That is, firms will attempt to minimize the combined costs associated with silvicultural activities and penalties. Figure 2 shows that for a penalty of P, the firm will choose to expend silvicultural dollars until MPVC = P at Qt_P. Spending more than Qt_P would increase costs because the additional silvicultural expenditures exceed the penalties for not achieving Qt_R. Therefore, the firm will meet requirements until Qt_P has been produced, and then pay penalties between Qt_P and Qt_R. At this point, the total cost to the firm will be equal to area $OBCQt_R$ and it will have saved an amount equal to the area ABC by paying penalties rather than producing the additional output Qt_R - Qt_P. This argument is only valid, of course, if the firm believes that there is a one hundred percent probability of being apprehended for failing to meet its obligations. If the probability of "being caught" is less than one then the firm may well spend less than the amount necessary to reach Qt_P. The actual expenditures will depend on the probability of being penalized, as perceived by the firm, and the firm's attitude towards risk. As far as the government is concerned, the more resources used in monitoring performance and enforcing regulations, the greater the probability of catching and punishing firms for failing to meet the standards. However, the costs of additional enforcement must be carefully weighed against prospective incremental revenues.

REIMBURSEMENTS

If firms do not have equity in timber crops resulting from their investments, but are reimbursed for their silvicultural expenditures, they will seek to:

$$\text{Max} \sum_{i=1}^{n} PVR_i - PVC_i(Qt_i) \qquad [5]$$

where:

PVR_i = Present Value of Reimbursements received for undertaking project i.

Because governments do not usually know tenure holders' actual costs, estimates must be used to determine levels of reimbursement. Therefore, firms may be reimbursed in an amount more than, less than, or equal to their outlays. In Figure 3, the present value of reimbursements, PVR_i, for each project is represented by a + sign. These values are shown to lie above, below and on the MPVC curve. In determining which activities to undertake, firms will seek out those projects which have PVR_is above the MPVC curve (i.e. those projects which yield positive NPV_is). Feasible projects will be ranked in order of their net present value - shown by the line MNPV in Figure 3. If the firm faces a constraint which prevents all profitable projects being undertaken - for example, the government may have a limited budget from which to reimburse tenure holders - then the

tenure holder will work down the MNPV schedule until available reimbursements are exhausted. The maximum number of projects which will be completed - output achieved - at the level of reimbursements assumed in Figure 3, is represented by Qt_V. Qt_V may be shifted to the right, that is more projects will be voluntarily undertaken by the tenure holder, if governments increase levels of reimbursement so that more + signs in Figure 3 lie above the MPVC line. Alternatively, governments may choose to increase silvicultural activity by combining reimbursements with requirements and accompanying penalties.

REIMBURSEMENTS AND REQUIREMENTS

If requirements are combined with reimbursements, firms will:

$$\text{Max} \sum_{i=1}^{n} PVR_i - PVC_i(Qt_i) \qquad [6]$$

if $PVR_i > PVC_i(Qt_i)$, and

$$\text{Min} \sum_{i=1}^{n} NPVC_i(Qt_i) + P(Qt_i) \qquad [7]$$

if $PVC_i(Qt_i) > PVR_i$.

In Figure 4, which combines Figures 2 and 3, Qt_V, which firms will produce voluntarily if reimbursed, is far below the required Qt_R. Therefore, the government has introduced penalties, P, for non-performance. Tenure holders are thus

forced to undertake reimbursed projects which lie on or below the MPVC curve in Figure 3. These projects, ordered from lowest to highest $NPVC_i$, have been labelled as the marginal net present value of costs (MNPVC) in Figure 4. Firms, under the threat of penalties, will increase their investment level until Qt_P' is produced[7]. This amount is still less than the required Qt_R. The cost savings tenure holders enjoy by choosing to pay penalties rather than producing at the required level are equal to areas A'B'C or EFG.

In some cases, tenure holders may attempt to reach Qt_P' but end up producing less, possibly because their regeneration efforts fail. Instead of using a penalty P, governments may require tenure holders to repeat the silvicultural activity at their own expense. However, the following example shows how such a policy may distort decisions by firms attempting to minimize costs within the framework presented above.

Assume that a firm has a choice between natural and artificial regeneration, both of which could satisfy contractual obligations. Artificial regeneration would cost $400/ha and would assure restocking to required standards, while natural regeneration would cost $100/ha and have a 50 per cent chance of success. First, assume that if natural regeneration fails, the firm would be required to replant

and would receive reimbursements for the second attempt. If firms were reimbursed 90% of their outlays, the cost to the firm if it plants would be $40/ha. However, if the firm decides to try natural regeneration the expected cost would be $10 + .5($40) = $30/ha. Thus, the firm, assuming risk neutrality, would opt to try natural regeneration with its lower costs. However, in the presence of policies which only reimburse once, the tenure holder would choose between $40/ha for planting, and $10 + .5($400) = $210/ha for natural regeneration. Thus, planting will be chosen although the overall cost would be less for natural regeneration.[8]

REQUIREMENTS AND REIMBURSEMENTS COMBINED WITH INCENTIVES FOR VOLUNTARY INVESTMENT

In order to create incentives for voluntary investment in silviculture, tenure holders must be allowed to share in the benefits created by their investments. If tenures are structured in such a way that their holders may derive future benefits from planting trees or enhancing the productivity of forests, then these benefits will be included in tenure holders' decisions.[9] That is, they will seek to:

$$\text{Max} \sum_{i=1}^{n} PVB_i(Ql_i, Qt_i) - NPVC_i(Qt_i) \qquad [8]$$

if $PVB_i(Ql_i, Qt_i) > NPVC_i(Qt_i)$, or :

$$\text{Min} \sum_{i=1}^{n} NPVC_i(Qt_i) + Pi(Qt_i) - PVB_i(Ql_i, Qt_i) \qquad [9]$$

if $NPVC_i(Qt_i) > PVB_i(Ql_i, Qt_i)$

The increased benefits derived by tenure holders who are given partial equity in the results of their investments are represented in Figure 5 by a downward shift in the MNPVC curve to MNPVC' and an upward shift in the MNPV curve to MNPV'. Firms will now invest an amount necessary to achieve production level Qt_P''. They will voluntarily achieve level Qt_P. Between Qt_P and Qt_P'', investments will be made to avoid penalties, after which penalties, P, will be paid. The required level, Qt_R, will not be reached. Actual performance could be moved closer to required performance by increasing tenure holders' equity. In fact, by increasing equity to the point where the marginal net present value is represented by MNPV'', requirements can be achieved without resorting to penalties and thus the high costs of monitoring and enforcement, which such procedures involve, can be avoided.

DISCUSSION AND CONCLUSIONS

The above analyses show how various combinations of regulatory tools may influence private silvicultural

expenditures on tenured public lands. In order to assess how these policies affect tenure holders, it was necessary to concentrate on costs and benefits to the forestry firm. However, the question remains, how do these alternative policy instruments affect the costs and benefits borne by and accruing to society? In Figure 1, it is shown, schematically, that social welfare may be diminished by market failures. This loss in welfare suggests that it would be appropriate, where possible, for governments to correct for market failures with regulatory policies. Thus, an important question is whether the regulatory policies followed by governments in Canada and elsewhere, with respect to privately managed public forest lands, increase or decrease deviations from the social optimum. Although an in depth analysis of this question is left for further research, the framework presented in this paper suggests sources of welfare losses which should be investigated further.

Tenure policies which require firms to conduct silvicultural activities result in benefits which are external to tenure holders' decisions. The resulting cost minimizing behavior results in several sources of inefficiency. First, the set of projects chosen as a result of such behavior is likely to be substantially different from the set which would be chosen if the benefits to society at large were considered. Short term returns will govern expenditure decisions since the time horizons of

tenure holders are limited to that period necessary to meet requirements. Furthermore, administrative practicality necessitates that requirements generally take the form of quantitative goals leaving firms no reason to consider the quality of the wood produced. Finally, requirements result in considerable transactions costs.

Reimbursing tenure holders may reduce the need for standards supported by penalties. However, future benefits and wood quality considerations remain external to tenure holders' decisions, perpetuating distortions in resource allocations. Misallocations may be even more severe if tenure holders are only reimbursed for their initial attempt to complete a silvicultural activity but must bear the entire cost themselves if it fails and must be repeated.

If tenure holders are granted equity in future crop values then they have an incentive to consider the quality of the wood produced in addition to its volume. Furthermore, if the equity share is large enough, requirements and penalties may become redundant resulting in the elimination of cost minimizing behavior and the reduction of the transactions costs associated with policing.

Although the above discussion suggests several reasons for granting equity in timber crops to tenure holders,

relying completely on the value of future private benefits to stimulate silvicultural investments may not be desirable. Even if tenure holders are granted as much equity as they enjoy on private lands, market failures may prevent the realization of socially optimum strategies. Accordingly, hybrid strategies containing elements of equity, reimbursements and/or requirements may be in order. For example, one solution may be to grant full equity in timber crops produced as a result of privately financed silvicultural activities while subsidizing private costs through reimbursements in order to meet public objectives. Such a policy may be interpreted as a type of sharecropping arrangement whereby tenure holders and governments share in the costs and benefits of investing in timber production. In return for their expenses, tenure holders gain equity in future timber volumes while governments gain future non-timber returns on behalf of society. Such an arrangement could correct market failures while having the added benefit of not distorting resource allocations. As Cheung (1969) has shown, sharecropping may efficiently allocate resources as long as the costs of all inputs are shared in the same proportion as the benefits which are reaped. If governments wish to contribute more in reimbursements, the sharecropping concept could be further extended so that they receive a portion of future timber values in return for their contributions.

This paper has shown how the behavior of tenure holders may be predicted given the varying incentive frameworks within which they operate. The findings indicate that the current regulatory practices of governments in Canada and elsewhere create several types of costs. Further research is necessary to estimate these costs so that the welfare effects of regulatory policies may be measured and alternative policies compared.

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ENDNOTES

1. TPVC is shown to be increasing at an increasing rate. This assumption is reasonable assuming the firm is operating on a fixed land base of varying quality.

2. For a review of issues associated with social rates of time preference see Markandya and Pearce (1991) and Luckert and Adamowicz (1993).

3. Positive externalities associated with growing trees include their role in preventing global warming. For example, it has been estimated that in 1986 Canada's forests sequestered 116 million tons of carbon - as much as was emitted by all Canada's industrial activities (Forestry Canada 1991)

4. For descriptions of market failures in forestry see Boyd and Hyde (1989) or the Economic Council of Canada (1984).

5. Unless they hold an equity interest in the timber produced as a result of their silvicultural expenditures, firms will only consider those costs which are necessary to meet their contractual obligations. Generally, in Canada, these are the costs of ensuring the successful establishment of a commercial timber crop following harvesting.

6. Governments may adopt numerous types of penalties. In many cases, provincial governments in Canada have reserved the right to cancel and/or not renew tenures if firms do not abide by the regulations. However, such extreme measures are rarely taken. A more common threat is to reduce the allowable annual cut held under tenure. Whatever form a penalty might take, to the extent that is exercised commensurate with the severity of the infraction, the penalty "P" in Figure 2 may be used to describe the type of costs firms would face for non-compliance

7. In Figure 4, the MNPVC curve corresponds with the negative portion of the MNPV curve.

8 A firm operating on private property would choose to regenerate naturally provided that both options produced the same schedule of benefits. Such a firm would compare the $400 planting cost with an expected cost of $100 + .5($400) = $300 for natural regeneration.

9. Luckert and Haley (1989) suggested how tenures might be structured to provide those who hold them with equity in future timber crops.

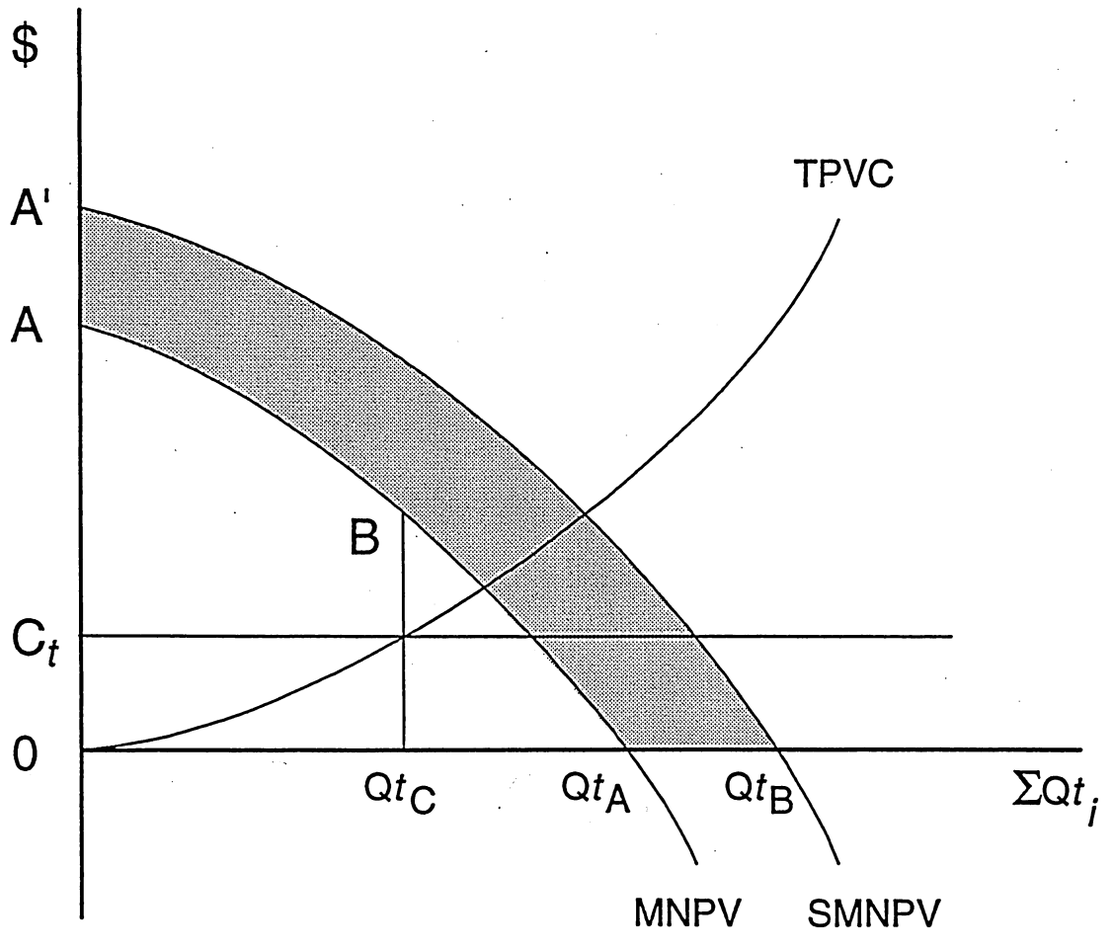

FIGURE 1
Allocation of Silvicultural Budgets
by Firms Operating on Private Lands

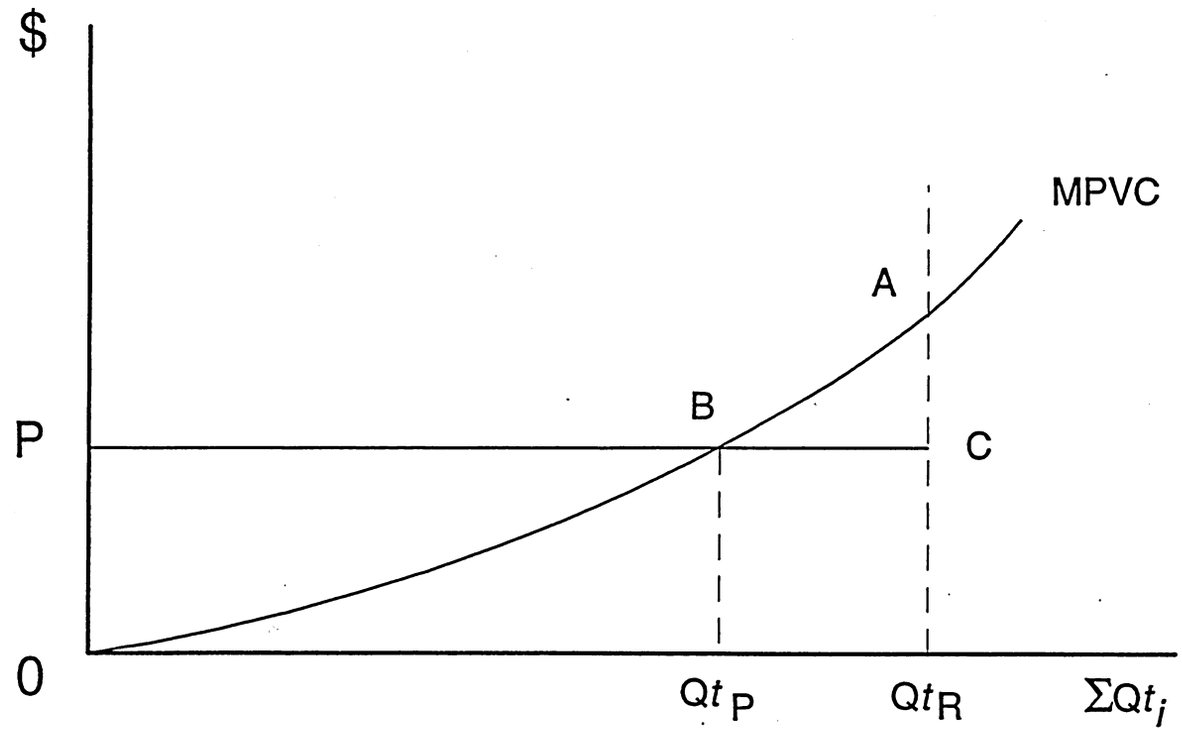

FIGURE 2
Incentives Created By Contractual Requirements

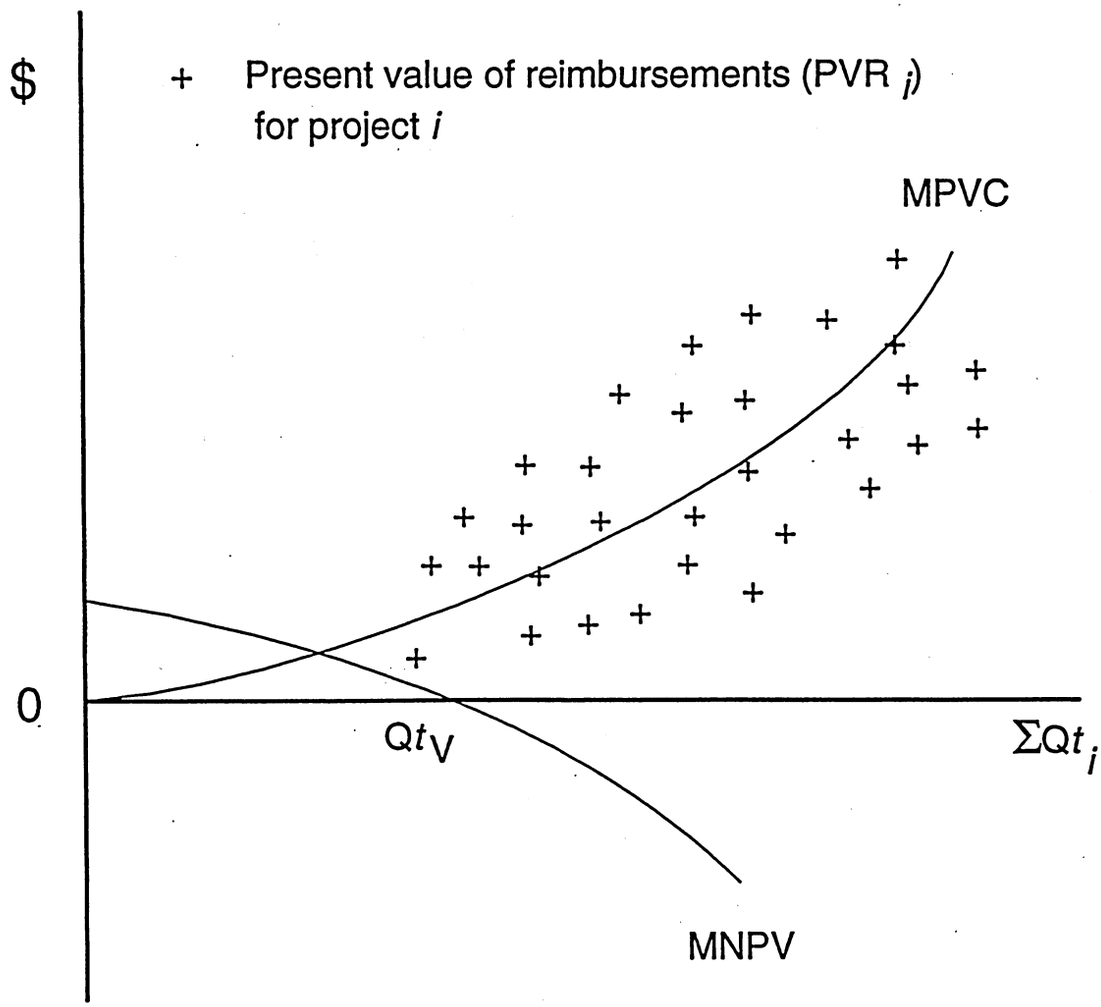

FIGURE 3
Incentives Created By Reimbursements

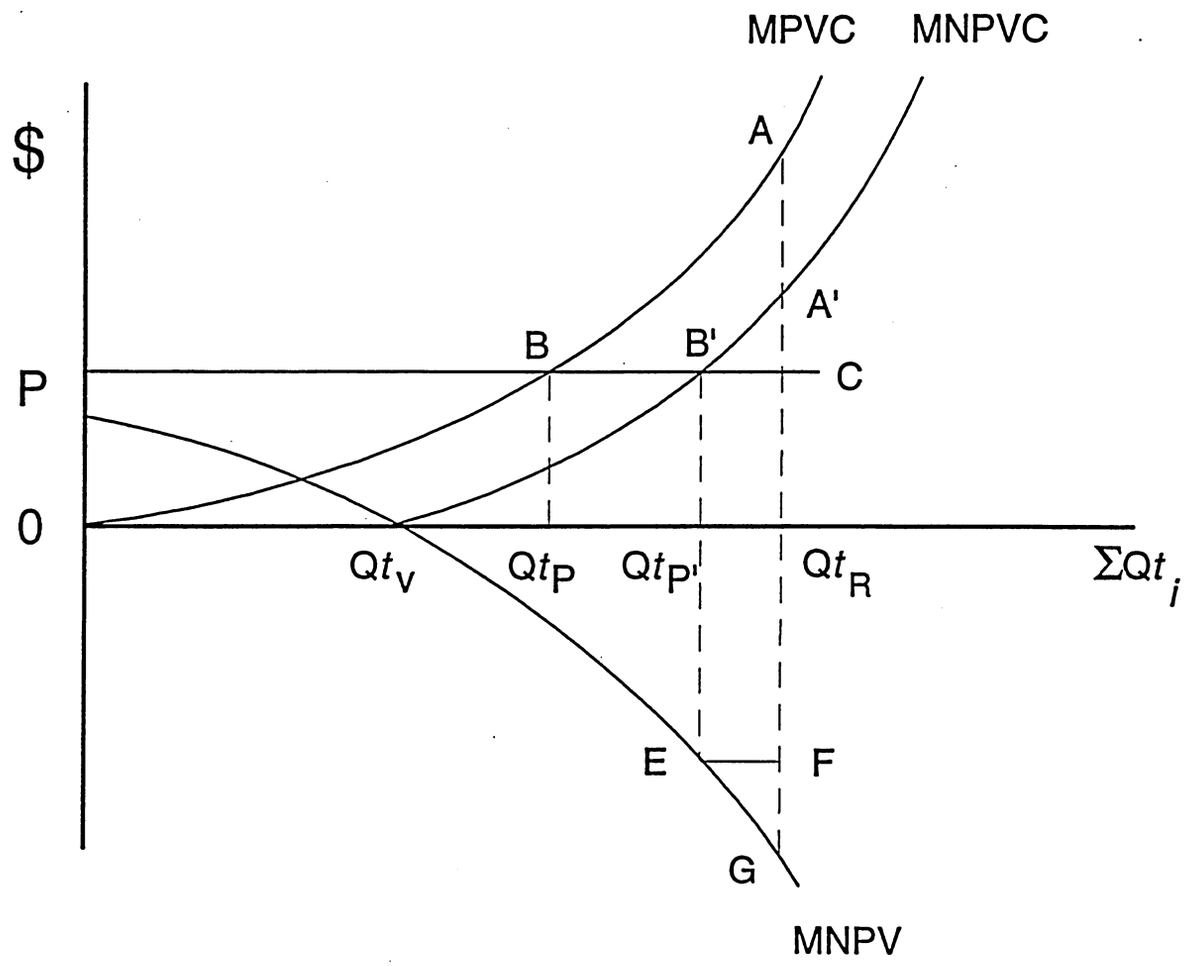

FIGURE 4
Incentives Created by Reimbursements
Combined with Requirements

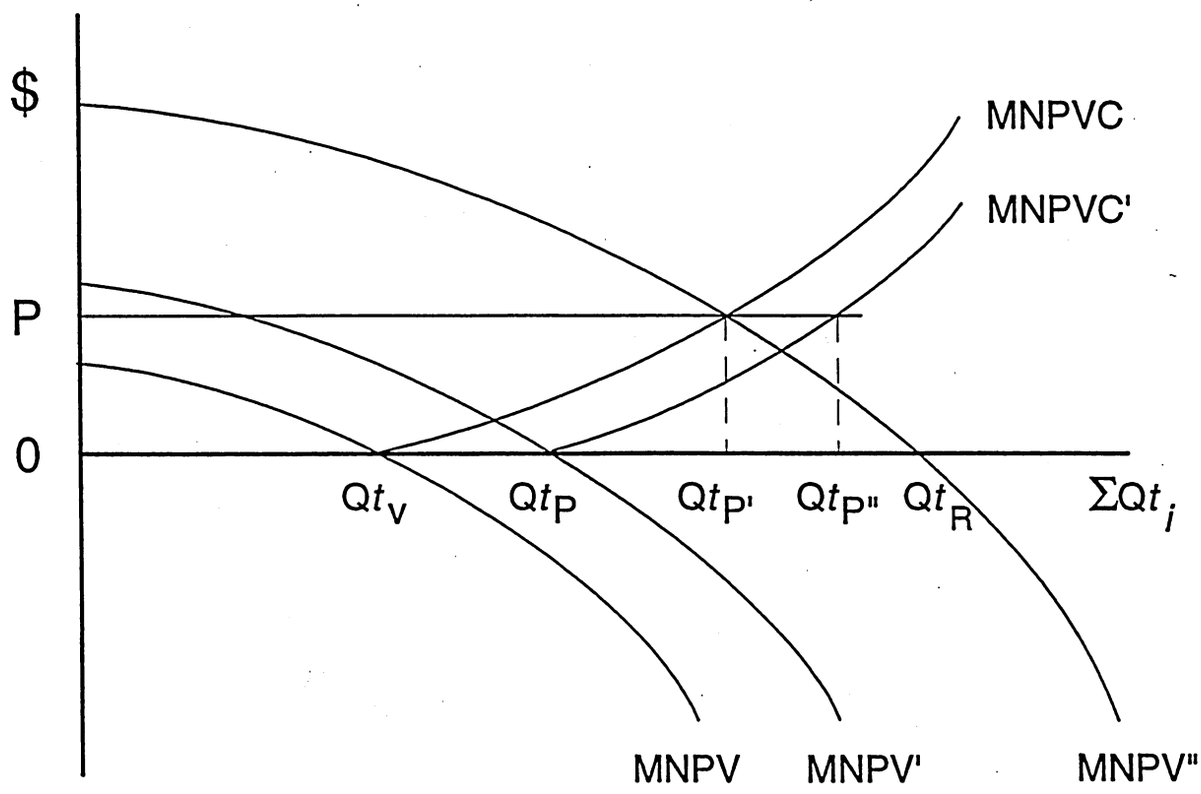

FIGURE 5
Incentives Created by Reimbursements
Combined with Requirements when Firm
is Granted Equity in Benefits Produced