IMPLICATIONS OF TENURE FOR FOREST LAND VALUE AND MANAGEMENT IN BRITISH COLUMBIA

by

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Abstract

The forest tenure system in British Columbia is a fundamental element of provincial forest policy with important economic implications. The effect of tenure on land value and forest management has generated a great deal of speculation, but the lack of empirical information has hindered informed debate.

This thesis contributes to this need for empirical information. Forest property rights are described in terms of bundles of characteristics. Analyzing differences in these characteristics locates each form of tenure in the spectrum from complete property rights to the complete absence of property rights. A model for predicting land value and the intensiveness of forest management is developed.

An event study of forest policy changes, and a hedonic study, are used to analyze the value of thinly traded forest tenures and that of frequently traded tenures, respectively. The results suggest that the particular property characteristics embodied in a specific form of tenure are important factors in determining the value of forest lands.

This thesis also analyzes empirically the effect of forest tenure on silvicultural investment and the quality of forest practices. The results show that variations in silvicultural investment and forest practice are strongly related to the specific characteristics of forest tenure.

Variations in land value, silvicultural investment and productivity are attributed to differences in tenure characteristics: a strong and complete form of tenure leads to high land value, high investment and high outputs. Policy implications of this thesis are discussed, and research needs are identified.

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I. Introduction: The Research Project

This thesis investigates the economic implications of property rights in forests. This first chapter outlines the current status of literature on this subject, the rationale and plan for this study.

The chapter first discusses the economic nature of property in general and property rights in timber specifically. Section 2 summarizes current literature on the characteristics and effects of tenure, the theoretical interpretation of the effects, and methodologies used in empirical studies. Section 3 explains the rationale of this study and Section 4 describes the plan of this thesis.

1. Background

In most parts of the world, governments influence management of natural resources such as forests, minerals and fisheries for a variety of purposes: to compensate for the failure of markets, to account for the full social costs and benefits of resource use, and to achieve certain distributive objectives. The degree of government involvement ranges from the traditional socialist state where government owns, manages and utilises the resources, to the market state where government intervention is limited to regulating private resource owners. Canada lies within this range, characterized by public ownership of resources that are utilized by private enterprises.

The link between publicly owned resources and the privately owned enterprises is the tenure system. In Canada, and in developing countries such as China, Malaysia and Kenya which have sought to use market forces to develop their economies, tenure systems have had profound impacts on the economic efficiency and social impacts of natural resource sectors. As a result of the practical importance of tenure arrangements, the economics of property rights and contracts has emerged over the last three decades, as a significant, specialized field of study.

Forest tenure refers to rights over forest land. In Canada, where the majority of forest lands are publicly owned, most forms of forest tenure are contractual arrangements between the government and those who use forest resources. The forest tenure system is the instrument for allocating public timber to private enterprises. It has played a major role in forest policy since early European settlement. The result of a century of evolution is a complicated array of rights over forest land and timber. The characteristics of different forms of tenure affect the management and the development of resources, the division of responsibilities for these activities, the efficiency of the dependent industries and the distribution of the economic benefits from resources used (Pearse 1990b).

2. Literature Review

2.1 Characteristics of Tenure

In law, property is often defined as a bundle of rights (Pearse 1990a). In order to analyze the effect of tenure as a whole on resource management, tenure can be described in terms of its integral parts or "bundles" of rights (Scott 1990; Pearse 1990a). Depending on the author, between six and eight such dimensions of property can be identified.

- Comprehensiveness —— the range of benefits from an asset which a property holder can claim.
- Exclusiveness —— the extent to which a property holder can prevent others from

freely sharing in the benefits of the asset.

- Duration —— the time over which the rights can be exercised.

- Flexibility —— the extent to which the specifications of a particular property can be modified during its duration.

- Quality of title or security —— the extent to which a person's ownership of a property right is secure, socially acknowledged and enforceable. In Canada, security has no statutory or common law basis but depends on the socio-political environment in which a particular set of property rights is granted (Scott 1990).

- Transferability —— the rights of property holder to transfer the entitlement to another party through sale, donation, bequest or the similar mechanisms.

- Benefits conferred to the tenure holder —— how much of the economic return generated by an asset can be captured by the holder? Property rights may be limited by the imposition of taxes, fees and restrictions which require the property to be managed or maintained in certain ways. Even freehold title does not convey the right to all benefits from property because rules and regulations restrict the use of assets and taxes expropriate part of the gains.

Although all seven characteristics bestow benefits on the owner of a right, they can be separated into two classes according to the nature of the benefits conferred (Scott 1991). Increases in the first four characteristics (comprehensiveness, exclusiveness, duration and flexibility) yield benefits to tenure holders whether or not they are in a position to adjust the amounts of labour and capital they employ. These dimensions are valuable because they facilitate better use of inputs, by preventing overlap of property possession with successors or neighbours. For example, an enhancement of duration allows more efficient allocation over time, while an increase in exclusiveness enables the holder to avoid common property problems with neighbours in the same space.

Increases in the second three characteristics (quality of title, transferability and the benefits conferred) yield benefits to the owners chiefly by assisting them to change their factor/land ratio profitably. They are valuable because they simplify the process of attaining the best combination of labour and capital (or allow the transfer of property to those with better access to suitable labour and capital). Thus, an increase in transferability of land promotes its "highest and best use". Moreover, superior quality of title facilitates access to credit; the value of such benefits has been demonstrated for rural Thailand where farmers with secure title were able to increase their capital/land ratio and the productivity of lands (Feder *et al.* 1988).

2.2 Effects of Forest Tenures and Their Characteristics

Forest tenures in Canada are the primary means of reconciling the interests of private users with those of public landlords (Pearse 1990b). They also have a major influence on how resources are allocated, managed and developed, and on the distribution of the economic benefits from resources used. Commercial timber contracts and small-scale tenure arrangements determine the incentives for depletion of, and investment in, forest resources (Hyde, Mendelson and Sedjo 1991). Poorly-defined property rights in tropical countries distort incentives for efficient land use. Along with policy spill-over from other sectors, poorly designed and enforced tenures are widely recognized as a major factor in wasteful deforestation.

Among the characteristics of property, comprehensiveness, security, duration and transferability are widely regarded as the most significant factors affecting Canada's resource tenure arrangements (Pearse 1988, 1993; Schwindt 1992). Hyde and Newman (1991), using examples in developing countries, suggest that security, comprehensiveness, and duration are key factors in long-term stewardship of lands and forests. Their conclusions are summarized in the following paragraphs.

First, the absence of security encourages over-exploitation and disinvestment. Security encourages resource users to invest in the long-term management of the resources, including conservation and resource protecting investments. Second, without property rights extending to the full range of potentially valuable resources, local people (often squatters) have no incentive to protect the long-term productivity of the lands, or to produce non-marketable values from the forests. Rather, the incentive is to extract what is commercial in the short-run and to move on. Third, timber concession arrangements are often too short to encourage silvicultural activities beyond the first harvest.

Feder *et al.* (1988) emphasize the importance of transferability. Without it, property holders forgo not only access to credit, which may be used to support long-term conservation investments, but also the right to sell, which limits the potential returns on their investments by making the holding period equal to the physical maturity of the investment. Without the opportunity to make land sales and transfers, there is no incentive to leave property in good condition should the holders choose to move.

Why do tenures and their characteristics have these effects? The economic theory of property rights postulates that property rights steer economic behaviour within a society assuming that property rights are exogenous factors of any given firm (Libecap 1989). Jensen and Meckling (1979) argue that a firm's position on its production function is constrained by the structure of property rights, just as the production function is constrained by the state of technology. This concept is related to that of Coase (1960), who argues that property rights are factors of production.

More specifically, the structure of property rights affects the range of choice available to a firm, and the costs of using alternative inputs. By influencing the relative costs of inputs (capital, labour and land), property rights affect the quantity of input used, which in turn determines the outputs or the location on the relevant production functions. Furthermore, by affecting the economic income of the firm, property rights determine its incentives to invest. For example, restrictions on the length and transferability of a tenure are likely to dull the tenure holder's incentive for long-term investment. With reduced investment, production falls and output decreases, and the resulting reduction in income lowers the value of the tenure itself.

If one treats the tenure system endogenously at society level rather than specific firms, however, the above conclusion about more inputs and more outputs is less certain. In this case, the tenure system is subject to change, but transaction costs of the change might overshadow the benefits. Then the forms of tenure currently used may be the best ones from society's point of view in spite of poor economic performance of individual firms.

To make this point clear, it is necessary to step back and look at the role of transaction costs in the evolution of property rights. In his seminal article, Coase (1960) articulates what has come to be known as the Coase theorem: that when transaction costs are zero, the gains from trade are maximized independently of any initial distribution of property rights. Transaction costs, as stated by Allen (1991), are the costs of establishing and maintaining property rights. Thus regardless of how the government assigns property rights and liabilities among interest groups, if the costs of creating and maintaining property rights for various users of forest resources are zero, then the forest resources will always find the same uses. All parties will calculate costs and benefits and reach the same decisions on resource uses. In other words, zero transaction costs mean that the initial distribution of rights is unimportant, because the eventual outcome will always be the same[1].

Transaction costs are always positive in the real world since property rights to assets cannot be perfectly delineated due to incomplete knowledge and the heterogeneity of the assets[2] (Barzel 1989). According to the Coase theorem, if transaction costs are too high, they might block any reallocation, and the initial allocation determines the efficiency of resource use and distribution of income. For example, rearrangement of common property can increase productivity or resource rents (Cheung 1970). However, the social benefit of reorganizing property rights cannot in itself justify the changing of property rights; the costs of organizing and enforcing such rights (and the distribution of net gains) must be considered as well. As Coase (1960) noted, the existence of common pool losses does not necessarily mean that it is in society's best interest to take actions to more completely defined property rights: "[But] the reason why some activities are not the subject of contracts is exactly the same reason why some contracts are commonly unsatisfactory — it would cost too much to put the matter right." Therefore, transaction costs as well as the net gains (and their distribution) of property right adjustment determine the evolution of property rights over time (Demsetz 1967; Libecap 1989).

The above arguments need qualification. Even if changing the property rights does move the production possibilities curve outwards, such changes might affect the distribution of wealth adversely. Therefore, from the viewpoint of positive economics, it is impossible to evaluate the

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[1] Several recent articles show that initial distribution of rights does matter. For example, Kahneman, Knetsch and Thaler (1990) argue that measures of willingness to accept greatly exceed measures of willingness to pay. They label the increased value of a good to an individual when the good becomes part of the individual's endowment the "endowment effect."

[2] These conditions require that every exchange contains some mechanism for measurement and enforcement. See Barzel (1989) and Cheung (1974) for discussion about the heterogeneous (or multi-dimensional) nature of assets (gasoline and house renting, respectively).

impact of changes in property rights on social welfare (Furubotn 1985). Eggertsson (1990) also observes that it is difficult to resolve the distributional conflicts inherent in major changes in ownership arrangements. Considering the complexity of distributional effect, most authors discuss the effect of tenure from an utilitarian point of view (the more, the better) and implicitly employ the Pareto potential compensation principle, i.e., if the gainer from an action can potentially compensate the loser, the action should be approved.

2.3 Methodology Used in Empirical Studies

There have been several studies on the effects of different forest tenures and their characteristics on economic efficiency and resource allocation. Luckert (1988) and Luckert and Haley (1989, 1990) use an interview method to analyze the effect of tenure characteristics on the distribution of economic rent, the allocation of forest resources, and investment in silviculture in British Columbia. Leffler and Rucker (1991) use the transaction costs method to analyze the effect of timber-harvesting contracts in Southern United States. Gillis (1990) analyzes descriptively forest concession management and revenue policies in tropical countries. Vincent (1990) illustrates how the inefficiency of tropical timber royalty systems affects the feasibility of tropical forest management. There are apparently no other empirical studies done in the forestry sector.

More studies have been conducted on agricultural tenure arrangements. Feder *et al.* (1988) measure the benefits of providing secure tenure to farmers in agricultural communities in rural Thailand and conclude that the benefits, in terms of additional long-term productivity, outweigh the initial administration costs. Mighot-Adholla *et al.* (1990) apply the model provided by Feder *et al.* (1988) to examine agricultural tenures in sub-Saharan Africa. They find that indigenous African

(Kenya, Ghana and Rwanda) institutions adapt as needed and that less secure tenure does not retard agricultural development in these countries. A study by Anderson and Lueck (1992) observes that land tenures on American Indian reservations have significant impacts on agricultural productivity.

The relationships between the methodologies used in these studies can be summarized as follows. First, the interview method (Luckert 1988; Luckert and Haley 1989, 1990) reveals the preference of tenure holders; the observation method (Leffler and Rucker 1991; Anderson and Lueck 1992) shows their behavioral choices. Analyzing actual behaviour is always preferable given the well-known problems associated with the use of the interviews to predict actual behaviour (Cummings *et al.* 1986). Second, the tenure-characteristics method attributes the effect of a specific form of tenure to its characteristics (Feder *et al.* 1988; Luckert 1988; Luckert and Haley 1989, 1990) and the transaction costs method attributes the effect of tenure to transaction costs (Leffler and Rucker 1991; Anderson and Lueck 1992). They are related or sometimes even similar methods. To understand this relationship, it is necessary to address the relationship between tenure characteristics and transaction costs.

Tenure characteristics and transaction costs are related concepts. Changes in some characteristics of a tenure (comprehensiveness, exclusiveness, duration, flexibility and benefit conferred) may increase or decrease the transaction costs of the tenure itself. However, the enhancement of these characteristics yields benefits to the tenure holder, and therefore may help reduce the transaction costs of factor inputs (e.g., easy access to credit and labour). Enhancement of the others (security and transferability) will not only reduce the transaction costs of factor inputs, but also the transaction costs of the tenure itself, by definition. Thus the effect of tenure could be attributed to either tenure characteristics or transaction costs or both, depending on the particular circumstance.

The conceptual model tested by Feder *et al.* (1988) illustrates this point. The model looks at the indirect relationships between "security ownership of land", measured by the holding of a legal title, and land productivity. Farmers with greater security of title have a higher probability of recouping the benefits from land improvements and are therefore more inclined and able to make medium or long-run land improvements. Moreover, because greater security implies a greater likelihood of repayment, lenders are more willing to offer credit (or in other words, the transaction costs of capital are reduced), leading to easier financing of improvements and inputs. Therefore their conclusions could be attributed to either the characteristics of the tenure (security) or transaction costs or both.

3. The Rationale for This Research

Although there have been recent studies on the effect of forest tenure, there is a paucity of research on the implications of the forest tenure system, and a still greater scarcity of empirical guidance in this important forest policy issue. The consequence is serious, especially for British Columbia, where more than 95 percent of forest lands are publicly owned, with the rights to harvest timber and to manage the forests granted to private industry through various tenures.

The importance of tenure in the British Columbia forest industry is widely recognized, and it is the impetus behind many forest policy changes. For example, in 1987 the government of British Columbia attempted to change most Forest Licenses, a volume-based tenure covering over 50 percent of timber harvests, into the area-based Tree Farm License (Ministry of Forests and Lands 1987; Haley and Leitch 1992). The move was intended to give companies "more tenure security" and to "create a positive environment for investment in forest industry." A similar recommendation was made by the British Columbia Forest Resource Commission (1991), based on the similar assumption that the insecurity of tenure and lack of equity in future timber crops act as major disincentives for private sector to invest in silviculture on Crown lands held under various tenure arrangements. However, the question remains, all else equal, how much more will a Tree Farm Licence holder invest than a Forest License holder? There is no substantial empirical evidence to back up the assumption that the tenure system is an impediment to investment. Not surprisingly, these recent efforts to reform the tenure system have failed to win public support and have not been implemented.

This project has emerged from the importance of and apparent need for empirical studies on the forest tenure systems. Pulling further relevant threads of economic theory and testing those theories by economically sound empirical studies are the major tasks of this project. Specifically, the objective is to address the following questions:

- How do the characteristics of forest property rights affect the value of the property?
- What is the role of tenures in determining silvicultural investment?
- How do tenures affect outputs and silvicultural performance?

By contributing to a better understanding of forest tenures, this study not only has important implications for British Columbia forest policy, but it also has relevance to forestry problems in other jurisdictions. In particular, the conclusions of this thesis may be applied to countries who use or attempt to use the private sector to manage public forests. In addition, the theory and methodology developed in this thesis can be adopted to address many kinds of property rights and leasing problems.

2.4 Thesis Plan

The main body of the thesis is organized in three parts, each of which addresses one of the three questions.

Part one includes chapters II and III. Chapter II reviews the forest tenures in British Columbia in terms of their characteristics. Chapter III establishes a theoretical model for predicting the value of forest property rights, silvicultural investment and output, based on forest tenure characteristics. The development of the model generates the general hypothesis of this thesis.

Part two consists of chapters IV, V, VI and VII, all of which deal with empirical studies. Chapters IV and V analyze the effect of forest tenure on property (land) value. Since most Crown forest lands under various tenures in the province are rarely traded, their market value can only be approximated, based on the stock market's implicit valuation of harvesting rights. The study reported in Chapter IV is based on the premise that given the relative efficiency of stock markets, any reduction in harvesting rights should be reflected in the stock prices of affected firms.

Chapter V employs a hedonic study method to examine the more frequently traded forest tenures, concentrating on private forest lands and Timber Licenses. Chapters VI and VII address the effect of forest tenure on silvicultural investment and the quality of forest practice, respectively.

All chapters in this part follow a general outline: introduction, methodology, data, empirical results, and conclusions and discussions. Each chapter itself is a more-or-less self-contained study.

Part three consists of Chapter VIII. It summarizes the study and its contributions to the general knowledge of property rights. It also addresses the policy implications of the findings. The report concludes by identifying areas for further research.

II. The Context: Forest Tenure Arrangements in British Columbia

This thesis focuses on the effects of forest tenures. Based on a description of existing private rights to forest resources on Crown lands and private forest lands in British Columbia, this chapter describes the relative importance of each specific tenure, the rights and obligations conveyed by each form of tenure and the key characteristics that distinguish one tenure from another. By doing so, this chapter will indicate which types of tenure are the subject of this study, locate specific interests in the range from complete property to the absence of any private rights, and help to single out the tenure characteristics to which the findings of this thesis should be attributed, and to which improvement of future policy could be usefully directed.

Table 1 presents the distribution of actual harvests and the committed annual allowable cut (AAC) among forest tenures in B.C. Four types of tenures — private forest lands, Tree Farm Licenses, Timber Licenses and Forest Licenses — accounted for, respectively, 8.2, 16.4, 6.3, 53.5 percent, together 84.5 percent of actual harvests in 1991-1992. They also made up some 80 percent of the committed AAC in the same year. These tenures are the subject of this study. Other tenures, such as Woodlot Licenses and Timber Sale Licenses (Major) are not considered here because they hold an insignificant portion of annual timber harvests and because there is too little information on them[3] to make useful analysis possible. Minor Timber Sale Licenses (issued under Small Business Forest Enterprise Programs) are excluded for two reasons. First, they are not transferable and therefore no market price can be observed. Second, the government assumes the management responsibilities after harvesting (Gillespie 1991, p.5), and the silvicultural activities are recorded

[3] However, Timber Sale Licenses (Major) are included in the event study on land value in Chapter IV since they are included in the forest policy changes. See Chapter IV for discussion about changes of forest policy in B.C. in September, 1987.

Table 1. Distribution of AAC and Harvests among Forms of Tenures in 1991-1992

Form of Tenure	AAC(10^3m^3)	%	Harvest (10^3m^3)	%
Private Lands[a]				
Within Tree Farm License			419	0.56
Outside Tree Farm License			5,752	7.68
Sub-total			6,172	8.24
Crown Lands				
Timber License[b]			4,695	6.27
Tree Farm License[c]	17,322	23.61	12,312	16.43
Forest License	41,562	56.70	40,109	3.54
Woodlot License	482	0.64	407	0.54
Minor Timber Sale License (SBFEP[d])	9,216	12.56	8,465	11.30
Timber Sale License (outside SBFEP)	3,110	4.24	1,083	1.45
Others	1,657	2.26	1,505	2.01
Sub-total			68,575	91.53
Federal Lands and Indian Reserves			173	0.23
Total	73,405	100	74,920	100

Source: British Columbia Ministry of Forestry, 1991-1992 Annual Report.

[a] All Crown Granted lands.
[b] Both within and outside Tree Farm License.
[c] AAC figures include both Schedule "A" and "B" lands; harvest figures include "B" lands only.
[d] Small Business Forest Enterprise Programs.

differently from other tenures. Therefore this form of tenure cannot be directly compared to the others.

1. Private Forest Lands

The origins of the private forest lands in B.C. can be traced back for more than 100 years[4]. Before 1906, the Crown had granted extensive areas of forest lands to private users as fee-simple lands, now often called Crown granted or private forest lands. Private lands are the most complete form of right over forest lands conveyed to private parties. The right is comprehensive, including both the land and the timber. It is exclusive, freely transferable, flexible, secure and perpetual. Furthermore, private land holders reap all of the economic benefits after paying for property tax and bear all of the management and development costs.

Few regulations apply to private forest lands[5]. As a general rule, private forest owners may harvest their timber and manage their lands as they wish. They may classify their lands as either managed or unmanaged forest lands. The holders of managed forest lands must make a work plan and a commitment to practice sustainable forestry, in return for a preferential property tax treatment. The owners of unmanaged forest lands enjoy fewer restrictions. Most industrial private forest lands in B.C. are private forest lands within Tree Farm Licenses (see below), which are usually classified as managed forest lands as well[6]. Unlike the owners of other private forest lands, the owners of

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[4] See (Pearse 1992) for a succinct summary of the evolution of forest tenure in B.C.

[5] Log export restrictions apply to some private forest lands and to all of the other tenures discussed below. These may have a large, negative impact on land and timber values, and therefore on the absolute level of investment but not the relative level across tenures.

[6] R.B. Townshend. Personnel Communication. 1993.

these managed forest lands within Tree Farm Licenses have to report harvesting and silvicultural activities to the B.C. Ministry of Forests, although they do not need cutting permits to harvest their forests.

2. Tree Farm Licenses

The Tree Farm License is a relatively long-term, large-scale tenure, serving large industrial enterprises which are often required, as a condition of the license, to operate a timber processing facility in B.C. Five characteristics of Tree Farm Licenses are important for this study. First, the holders have rights to the timber on the land only. Their rights are therefore less comprehensive than those of private forest owners. Second, Tree Farm Licenses have a limited term of 25 years, with provisions for "evergreen" replacement[7]. Third, Tree Farm Licenses may include private forest lands and Timber Licenses (called "Schedule A" Lands), in combination with Crown lands ("Schedule B" Lands). Fourth and most important, the forests and lands under Tree Farm Licenses have to be managed under approved management plans and the holders of these tenures are obligated to obtain cutting permits from the Ministry of Forests. Lastly, Tree Farm License holders pay stumpage at an appraised rate for timber harvested, and land rental for standing timber on "B" lands, and they must carry out silviculture and road building (until 1987 some of the costs were reimbursed by the government).

In contrast to private forest lands and Timber Licenses, transfers of Tree Farm License require the consent of the Minister of Forests. Furthermore, the transactions should include part or all of the

[7] "Evergreen" replacement means that, after 10 years of the license term have expired, the holder may call for a new 25-year license to replace the original one and the government is obligated to offer a replacement license with only minor modifications of the terms and conditions.

appurtenant manufacturing facilities (Haley and Leitch 1992; Schwindt 1992). When a Tree Farm License is transferred, five percent of the allowable annual cut (AAC) attributable to "Schedule B" lands is retracted by the Crown. In short, the transaction costs for Tree Farm Licenses are significantly higher than for private lands.

Holders of Tree Farm License are required to make 50 percent of the harvests from "Schedule B" lands available for harvesting by independent contractors. Tree Farm Licenses are further restricted by cut control, which dictate that licensees must harvest within 50 percent of AAC annually and within 10 percent over a 5-year period. Up to 5 percent of the AAC of a Tree Farm License may be taken without compensation during the 25-year term[8]. These restrictions, added to legislated changes[9] to the Tree Farm License have weakened the security of this tenure (Luckert 1991).

3. Timber Licenses

Timber Licenses came into existence with the conversion of the Old Temporary Tenures[10] since 1978. In this form of tenure, the Crown owns the land and timber and the licensees are given a non-renewable right to harvest the mature timber within a specified period. The right is not comprehensive since it excludes the land. It also has finite duration. Nevertheless, it is exclusive,

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[8] There is some uncertainty over the maximum amount which may be deducted without compensation. According to some interpretations Section 53 of the Forest Act allows for 5 percent deletion for highways, pipelines and similar rights of way and an additional 5 percent for other purpose (Schwindt 1992, p.76).

[9] The two most recent legislation changes to Tree Farm Licenses occurred in 1978 and 1987. See Pearse (1976) for the proposal that led to the former change and Chapter IV of this thesis for the latter.

[10] See Pearse (1992) for discussion of the historical origin of Old Temporary Tenures.

and transferable under the condition that the holders pay five percent of the higher of the market value of the timber standing in the area of the license and the value that the licensee has declared to the Crown. Since 1987, the holders of Timber Licenses pay an annual rental and at their choice, either a fixed royalty or a variable stumpage on timber harvested. If the royalty is chosen, the holders must bear the costs of all works, notably reforestation and road-building required under the Forest Act and other related regulations. As Pearse (1992) notes, "with few exceptions, Timber License holders chose the royalty option". Therefore, it is safe to say that the Timber License holders are responsible for the reforestation costs.

Timber Licenses exist both within and outside Tree Farm Licenses, accounting for less than 5 million cubic metre, or, 6.3 percent of the total 1991-1992 billed harvests. Roughly half of that volume came from areas within Tree Farm Licenses. All Timber Licenses contained in Tree Farm Licenses are subject to the Tree Farm License agreement and its management and working plans, and once harvested, they are rescheduled as "B" lands. Those Timber Licenses outside Tree Farm Licenses are subject to an operating plan, which must be submitted to the Chief Forester for approval and they simply revert to the Crown once harvested. All harvesting operations on these Timber Licenses must be carried out under cutting permits that conform to approved operating plans prepared by professional foresters. Because of these regulations Timber Licenses are less flexible and less secure than private forest lands, and probably Tree Farm Licenses. Moreover, because Timber Licenses outside Tree Farm Licenses will revert to the Crown once harvested, the rights associated with these Timber Licenses are weaker to their holders than that with Tree Farm Licenses in term of equity in future crops.

4. Forest Licenses

Forest License is the most important type of tenure in term of harvests in British Columbia (Table 1). It is a volume-based license[11] by which the licensees has a "quota" or right to cut a specified volume of timber per year within a broad administrative area. The specific location of operations is designated from time to time. As in the case of the Tree Farm License, Forest License holders have rights to the timber only; thus their rights are less comprehensive than those of private forest land holders. The licenses are issued for 15 years and most of them are renewable or replaceable on an "evergreen" basis. They are transferable, subject to Ministerial consent and a take-back of 5 percent of AAC. All harvests under Forest Licenses must be conducted under the terms of cutting permits from the Ministry of Forests, and in return for the cutting rights, the licensee must submit successive five-year management and working plans which include a description of operations to be conducted and silviculture treatment to be undertaken. The licensees pay stumpage and rental to the Crown and practise silviculture at their own expense to ensure successful regeneration within a specified period. A cut control similar to Tree Farm Licenses applies to Forest Licenses; the licensee must harvest within 50 percent of the AAC each year and to within 10 percent over a 5 year

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[11] Traditionally area-based tenures refer to the rights to timber in a given geographical area, and volume-based tenures refer to the rights to certain volume of timber irrespective of location. The area-based tenures in B.C. (Tree Farm License, Timber License and Woodlot License) are consistent with the above definition: they all have a specified geographic area; harvest and silvicultural activities are confined within the boundary of the geographic area.

In contrast, the volume-based tenures have slightly changed their meanings in B.C. There is no specific geographical area for volume-based tenures (Forest License and Major Timber Sale License). However, there are broad areas (Timber Supply Areas) that define the operational boundary for these licenses. Therefore licensees' actual harvest areas (and subsequent silvicultural activities) are changed over time although licensees usually have enough timber to log for 3-5 years once they set up a log camp. Because the licensees are responsible for their actual harvest area until they have, after 15-20 years, completed their silvicultural responsibilities, the volume-based tenure also fits the traditional definition of area-based tenures: which have well-defined locations in this period.

Since volume-based tenures do not guaranteed that their holders may come back to the same area where they logged and made investment in silviculture a long time ago, they are considered as less attractive than area-based tenures in terms of silvicultural investment. This hypothesis is verified by empirical studies in this thesis.

period.

The obligation of licensees to provide independent contractors with the opportunity to cut a portion of the authorised harvest now applies to Forest Licenses as well (Pearse 1992). In addition, up to 5 percent of AAC can be withdrawn from Forest Licenses without compensation during the 15-year term. All Forest Licenses bear a lesser degree of security than Tree Farm Licenses since Forest License holders perceive that they are unlikely to return to the same area in which they invest in silviculture, and thus can not recoup the benefits.

5. Summary

Table 2 summarizes the rights conferred by the more important forest tenures. Collectively these tenures occupy a wide range within the spectrum of "property". They are similar in exclusiveness[12], but vary considerably in the characteristics of comprehensiveness, duration, security, transferability and benefit conferred. These are the key characteristics, and the rest of this study investigates their effects on land value and forest management.

[12] Forest License is exclusive in terms of harvesting rights, but not exclusive over time.

Table 2. Characteristics of Major Forest Tenures in British Columbia

	Private Lands	Tree Farm License	Timber License	Forest License
Comprehensiveness				
Land and Timber	Yes	No	No	No
Timber only	No	Yes	Yes	Yes
Exclusiveness	Yes	Yes	Yes	Yes
Duration				
Term	Perpetuity	25 years	Until timber removed	15 years
Replacement	Perpetuity	Evergreen	No	Evergreen
Security				
Deletion Conditions	No	Yes	No	Yes
Area or Volume Based	Area	Area	Area	Volume
General Security	Yes	Less secure	Yes	Less secure
Transferability				
Free Transferable	Yes	Permitted with consent	Yes	Permitted with consent
Takeback when Transfer	No	Yes	Yes	Yes

Table 2. continued

	Private Lands	Tree Farm License	Timber License	Forest License
Benefit Conferred				
Property Tax	Yes	No	No	No
Crown Charge: Stumpage	No	On "B" lands	No	Yes
Crown Charge: Royalty	No	On some Timber Licenses	Yes	No
Crown Charge: Rental	No	Yes	Yes	Yes
Obligation: Reforestation	On managed forest lands	Yes	Yes	Yes
Restriction: Cut Control	No	Yes	No	Yes
Restriction: Log Export	Some	Yes	Yes	Yes
Restriction: Contractor Clause	No	Yes	No	Yes

III. A Model of Predicting Land Value and Forest Management

This chapter examines the expected effect of forest tenure on land value and forest management by applying a model incorporating a simplified version of forest tenure in British Columbia and the traditional theory of capital. Results from the model suggest hypotheses about the direction of the effect of an increase in the characteristics of tenure on land value, silvicultural investment and outputs.

The chapter is divided into three sections. The first states assumptions about the land and land market, capital market, tenure, tenure holder and production. The second develops the model itself[13] and determines the expected effect of tenure. The thesis hypothesis and methodology are addressed in Section 3.

1. Assumptions

Capital theory postulates that the value of a tract of forest land (or any other capital asset), is the present value of the future net revenues that the asset is expected to produce. The present value can be viewed as the demand price of the assets: the maximum price that a buyer would be willing to pay for the rights to the asset's expected income. It can also be viewed as the supply price of the asset: the minimum amount that a seller would be willing to accept to relinquish the rights to the

[13] The model developed in this chapter is consistent with other models. It is similar to the model of Feder *et al.* (1988), but has gone one step further by incorporating more tenure characteristics. It has implicitly used the concept of transaction costs since the key factor considered in the model, the probability of eviction, affects the transaction costs in terms of maintaining the tenure. Therefore it is by and large consistent with the transaction cost method in Leffler and Rucker (1991) as well. However, the model in this chapter is deterministic and those in Feder *et al.* (1988) and Leffler and Rucker (1991) are stochastic.

income. In this context, the present value of the expected net revenues is the asset's market equilibrium price (Washburn 1990). Based on these concepts, a model of forest land value, investment, outputs and tenure characteristics can be developed for British Columbia under the following simple assumptions, necessary to focus on the main issues.

1.1 Land and Land Market

a. Forest lands are suitable only for growing timber and are uniform in quality, accessibility and species composition; but differ in tenure arrangements. (This assumption is relaxed in empirical study by using suitable indices to control the heterogeneity of land quality, location and species composition.)

b. All lands are divisible and transferable without transaction costs.

c. Tenure arrangements cannot be changed by tenure holders alone.

1.2 Capital Market

a. All tenure holders can obtain the necessary amount of capital from the capital market at fixed, real interest, r.

1.3 Tenure

a. All forest tenures are exclusive and flexible. The latter refers to the specification that a tenure can be modified during its duration.

b. Timber is the only benefit conferred to a tenure holder, and all tenure holders pay a uniform tax, say, a certain percentage of net income. (This assumption is relaxed in the empirical study.) Thus, all tenures have the same conditions of comprehensiveness and benefits conferred.

Under these assumptions, only security and duration are left. The most important characteristic is security, which is affected in part by duration (Pearse 1990a; Schwindt 1992) and transferability. Renewability of tenure is also a factor of security where the tenure is renewable, but for simplicity it is not considered here.

c. Free-hold tenure is secure; others are not. Under free-hold tenure, the probability of losing the property and/or of losing a proportion of the property are zero. There is a non-zero risk of eviction and/or expropriation of a proportion of the property under other tenures. Security is positively related to duration. In other words, the longer the duration, the smaller the likelihood of losing tenure.

1.4 Tenure Holder

a. A tenure holder begins with purchasing or negotiating some amount of forest lands, on which there is mature timber standing, under a particular form of tenure. She or he harvests the mature timber in t years, and decides the amount of investment in two kinds of forest activity (discussed below). The tenure holder maximizes net terminal wealth after harvesting the mature timber[14].

b. The tenure holder is risk averse and has a risk premium (s) in risky activities such as investing in tenured forest lands. The risk premium goes up when the risk of eviction increases. The discount rate for the tenure holder is r+s.

1.5 Production

a. The yield of the mature timber is not affected by any human inputs, but by time alone. Therefore, it does not directly enter the maximization of terminal net worth for the tenure holder.

However, the presence of the mature timber represents an opportunity for the tenure holder to capture part of the economic rents generated from it, which may be used directly to finance the investments in forest lands, and/or to use it as a collateral to borrow money in capital market. The risk of eviction affects the likelihood of the tenure holder to capture the rents and to use it as collateral, which affects the risk premium (s) of the tenure holder to invest in forest lands. In other words, higher risk of eviction (higher probability of losing the mature timber and the lands) leads to higher financial costs of investment. Therefore, by affecting the risk premium, the chance of losing the mature timber affects indirectly the terminal net worth of the tenure holder.

b. After harvesting the mature timber, the holder can invest in two types of activity with

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[14] An alternative is to assume a tenure holder will maximize present net worth when acquiring a tenure. This does not change the results, but alters the equations slightly.

regard to forest lands. The first is ***Silviculture, K=B+I,*** where ***B*** is the costs of basic silviculture[15] (seed collecting, site preparation, regeneration and brushing), which is mandatory and uniformly carried out for all tenures; ***I*** is costs of intensive silviculture (tending, thinning, pruning and fertilization), and is dependent on the perception of the holder of the possibility of acquiring the value of second growth forests, which, in turn, is affected by the characteristics of tenure. The second is ***land improvement and infrastructure, M*** (road building, soil conservation practice and so on), which increases the value of bare land and depends on the tenure holder's perception of the likelihood of collecting land rents, and the amounts of these.

The cost function for these activities is linear with respect to K and M.

(1) $c = f(k, m); \qquad c_k > 0, c_m > 0; c_{kk} = 0, c_{mm} = 0$

where c is per-hectare cost; k is per-hectare silvicultural expenditure and m is per-hectare land improvement expenditure.

c. The production function of second growth (and the subsequent) forests (Y) exhibits constant returns to scale in land, silviculture and land improvement. Productivity is also affected by rotation age (T).

(2) $y = y(k, m, T)$

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[15] In B.C. Forest Act, basic silviculture refers to harvesting methods and silvicultural operations, including seed collecting, site preparation, artificial and natural regeneration, brushing, spacing, stand tending and other operations that are required for the purpose of establishing a free growing crop of a commercially valuable tree species. In practice, spacing and tending are often seen as intensive silviculture. Here all lands are assumed to be within the intensive margin of timber production (Pearse 1990a); i.e., it is economically worthwhile to invest in silviculture and land improvement if tenure were secure.

where $y_i = \partial/\partial_i > 0$, $y_{ii} < 0$, $y_{ij} > 0$ for $i \neq j$, $i = k, m, T$ and lowcase letters denote per-hectare variables.

d. The rotation age (T) is identical for all forests under different tenure systems. All harvesting involves clear-cutting.

e. Investments in land improvement and infrastructure (which only occur right after harvesting the mature timber) increase the net terminal value of bare lands (Q) (after the rotation of second growth forests), but have decreasing marginal returns:

(3) $q = q(m)$ $\qquad q' = dq/dm > 0;\ q'' < 0$

f. The products of forest lands under different tenure arrangements are homogeneous and the prices of output are set to unity.

2. Development of Model: The Expected Effects of Tenure

The per-hectare net terminal wealth of the holder at the time when the mature timber is harvested can be expressed as:

(4) $V = y(k, m, T) \cdot \exp(-rT-sT) + q(m) \cdot \exp(-rT-sT) - c(k,m)$

where the first term is the value of the second growth; the second term is the net value of bare lands after harvesting the second growth (both terms are discounted to the date when the mature timber is harvested); the third term is cost after harvesting the mature timber. The tenure holder chooses k and m to maximize the terminal wealth.

First-order conditions for a maximum require that:

(5) $y_k \cdot \exp(-rT-sT) - c_k = 0$

(6) $y_m \cdot \exp(-rT-sT) - q' \cdot \exp(-rT-sT) - c_m = 0$

The Hessian Matrix of the system (5) and (6) is given by:

(7) $$H = \begin{pmatrix} H_{11} & H_{12} \\ H_{21} & H_{22} \end{pmatrix}$$

where

$H_{11} = y_{kk} \cdot \exp(-rT-sT) < 0$

(8) $H_{22} = (y_{mm} + q'') \cdot \exp(-rT-sT) < 0$

$H_{12} = H_{21} = y_{mk} \cdot \exp(-rT-sT) > 0$

The second-order conditions for a maximum require that the determinant of H be positive:

(9) $H_{11} \cdot H_{22} - H_{12}^2 = (y_{kk} \cdot y_{mm} + q'' \cdot y_{kk} - y_{mk}^2)$

By the concavity of the per-hectare production function, $y_{kk} \cdot y_{mm} > y_{mk}^2$. The other term is clearly positive, so the determinant is positive.

The effect of tenure insecurity is demonstrated by assuming a small increase in the likelihood of eviction, which leads to a small increase in risk-premium, s. The effect of an increase in the likelihood of eviction is shown by differentiating equations (5) and (6) with respect to s, which yields the following comparative static results:

(10) $dk/ds = T \cdot y_k / y_{kk} < 0$

(11) $dm/ds = T \cdot (y_m + q')/ (y_{mm} + q'') < 0$

Proposition 1. The value of the tenure is related positively to the security and duration of the property rights.

This proposition is supported by equation (4). When the risk of eviction goes up, the risk premium increases and the value of equation (4) decreases.

Proposition 2. Both silvicultural and land improvement expenditures are related negatively to tenure insecurity and are related positively to tenure duration.

This point is given by equations (10) and (11).

Proposition 3. The productivity of forest lands is related negatively to tenure insecurity and related positively to tenure duration.

This point can be seen by comparing equations (2), (10) and (11). As $y_k > 0$, $y_m > 0$ and $dk/ds < 0$, $dm/ds < 0$, output, y, is related negatively to riskiness of tenure, but positively to duration of tenure.

A Word about Transferability

Since forest tenures are assumed to be transferable, the above model does not deal explicitly with the effect of transferability. Forest tenures in B.C., as I have shown in Chapter II, have different degrees of transferability: there is no restriction for private lands and Timber Licenses, but some restrictions apply to Tree Farm Licenses and Forest Licenses.

From an economic viewpoint, the importance of transferability is that it affects efficiency of resource allocation. Restrictions to marketability of an asset may prevent it from being transferred to those who can use the asset most productively and apply it to its best use. Thus, it is expected that the value of forest tenure is related positively to the degree of transferability.

A high degree of transferability also leads to more investment. Since those who are able to bid tenures away from others are always the more efficient producers in an economy, they would be expected to use optimal inputs at a given output level. High transferability means a high possibility to recover the potential returns on investment at any time. On the contrary, if transferability is truncated, holders can not liquidate the tenures as they wish and will face high risk to recover the potential returns on investment. Therefore, their incentives to invest are affected[16]. Low investment results in a low output level. The above points can be summarised as:

Proposition 4. The value of forest tenure is related positively to the degree of its transferability. When forest tenure is highly transferable, the tenure holder has an incentive to invest more and hence gets a high level of output.

3. Hypothesis and Methodology

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[16] When the transfer of tenures is subject to official consent or approval, holders may recoup some benefits of their investments from those to whom they sell, but the benefits will be less than full market value of the property because of the costs and uncertainty associated with obtaining the required authorization.

The above discussion leads into the hypothesis of the thesis:

The characteristics of forest property rights affect the value of forest land, owners' investment behaviour, the productivity of lands, and thus the economic efficiency of forest land management.

Given this general hypothesis, the following part of this section discusses the linkage between theory and observation, and designs some empirical analysis frameworks to be tested.

The empirical analysis of this study tests how institutions (tenures) affect inputs and outputs, rather than testing the traditional relationship between inputs and outputs by assuming that institutions are invariant. The methodology which will be used quantifies the relationship between dependent variables, observed economic indicators which reflect forest land value and management and independent variables, tenure systems, and other factors. Cross-section regression analysis will be applied.

3.1 Econometric Model to Test the Influence of the Form of Property Rights on the Value of Forest Property

There are two ways to test empirically the effect of tenure on the value of property rights. The first, more direct method, is to analyze the market transaction value of forest lands under different tenures. It can be hypothesized that the expected future net revenue of a tract of forest land is affected by (1) its forest cover characteristics such as species, timber volume and size of trees; (2)

its natural attributes such as size, soil quality, topography which determine the natural productivity of land; (3) its location and distance to markets; and (4) the nature of property rights over it.

However, the regulatory environment, such as the sustained yield policy, can modify the property rights. In particular, the allowable cut effect[17] can affect the value of forest land (Pearse 1965). Under this regulatory environment, potential buyers can afford to pay a higher price for a tract of forest land if they can add it to a sustained yield forest because this will enable them to increase the regulated harvests on their other lands. This implies that private lands added to Tree Farm License as "Schedule A" lands are worth more than private lands alone because of their impact on AAC from "Schedule B" lands. This can be expressed as a hedonic equation[18]:

(12) $P = f(C_l, L, C_f, T_t, ACE)$

where P = per hectare market value of a tract of forest land

C_l = natural attributes of land (site index, size, etc.)

L = location

C_f = forest characteristics (volume, species composition, etc.)

T_t = tenure type

ACE = allowable cut effect

[17] The allowable cut effect was first described and formally analyzed by Schweitzer *et al.* (1972) although it was realized at least as early as 1965 by Pearse (1965). The use of allowable cut effect in allocating investment in timber production was rigorously analyzed by Binkley (1980).

[18] It should be noted that taxation can affect land value directly. It can be treated in two ways. One is to treat it as an independent variable and explicitly put it in the right-hand-side of equation (12). As taxation also represents a characteristic of tenure (economic benefit conferred to the holder), it can also be explicitly ignored (and its effect will be caught in the tenure variable). The second method is used in this paper for simplicity.

Since specification of the functional form of a hedonic equation is usually arbitrary, the Box-Cox transformation technique or the maximum likelihood method can be used to find the functional formulation. The regression results will estimate the contributions to forest land value of the characteristics of the land, forest, and tenure type.

It should be noted that the concept of land value used in this study is not the same as that used by forest land appraisers in B.C. The latter is in fact a "bare land value", i.e., the value of the land after the mature timber is removed. It is conventional for the appraisers to estimate the value of a forest property by assessing the value of the merchantable forest first and then, according to the timber growing capacity of the land, assessing its "residual land value" or so-called "land value". In contrast, the land value used in this thesis corresponds to the economic definition of an asset's value, i.e., its discounted future net income of land. For example, if a land tenure has only a duration of 20 years, its holder may only appreciate the income derived from the land in this 20-year period. This is likely to be less than the value under a tenure with a 100 year term. In this simple case, the difference in land value can be attributed to one of the characteristics of tenure, duration.

The application of this land valuation method in B.C. is conspicuously limited. Although private lands are heavily traded in B.C., Crown lands under tenure arrangements other than Timber Licenses are not. When transactions of Crown lands do take place, the prices are usually blurred by mill and chip transaction arrangements. In other words, the dependent variable, market price (P), for forest tenures other than private forest lands and Timber Licenses is not observable. Therefore this method is only applied to private lands and Timber Licenses in Chapter V.

The second, indirect method, tries to find price information from stock markets. It is widely accepted that the stock market is relatively efficient (commonly referred to weak-form efficiency in the context of financial economics) (Malkiel 1990; Fama 1991). Whenever there is a firm-specific event or regulation change that affects a firm, it will reflect on the stock price of the firm or that of a series of firms. Under this assumption, an "event study" is carried out to examine the impact of a forest policy change in British Columbia, involving cancellation of a percentage of the allowable annual cut attached to timber companies under certain forms of license, in an attempt to quantify the value of these cutting rights, or of the lands withdrawn. The results are reported in Chapter IV.

In summary, a hedonic study will be applied to frequently traded tenures and an event study will be used to examine thinly traded tenures. The hedonic study will reveal the total value of forest lands, while the event study only examines the marginal value of forest lands since the AAC takeback was only a fraction of the total AAC committed to companies. Moreover, the hedonic study is also more intuitive than the event study.

3.2 Econometric Model to Test the Effect of Forest Property Rights on Silvicultural Investment

The effect of forest tenure on silvicultural investment can be tested by using an equation similar to equation (12):

(13) $I = f(C_l, L, C_f, C_p, T_t)$

where I = per hectare silvicultural investment on a tract of forest land

C_p =producer's characteristics

It is necessary to clarify the role of property in silvicultural investment decisions. Property rights provide a framework of incentives and constraints within which their holders operate and make decisions. All else being equal, the characteristics of tenure determine the future returns tenure holders receive, if any, and how much they will invest. Consider two types of tenures. One is secure and lasts in perpetuity; another has a 25-year duration, renewable on an "evergreen" basis, and its security is in doubt. The holders of the former tenure are likely to invest more than their counterparts since they have more certain rights to future crops. In this simple case, the difference in silvicultural investment, if any, could be attributed to a characteristic of the tenure, security.

Another example is area-based tenure versus volume-based tenure. Since the main purpose of volume-based tenures is to allow the government to maintain flexibility in forest resource use, they cannot be an effective instrument for attracting private investment. The holders of volume-based tenures are unlikely to return to the same areas in which they have invested, and therefore cannot expect to recapture the benefits of investments in the subsequent crops. They would invest less than the holders of area-based tenure who could recapture some of the benefits of their silvicultural activities. Again, all else being equal, the difference in silviculture investment in these two types of tenure can be attributed to whether the tenure is area-based or volume-based.

Three other influences on silvicultural investment behaviour must be noted. One is mandatory silvicultural requirements. All major forest tenure holders in B.C. are required to ensure the success of reforestation activities (trees must achieve free to grow status) within a certain period of time. However, such a requirement must be flexible enough to allow field foresters to cope with various site classes and other factors. Furthermore, regulation does not specify how much tenure holders should invest and what kind of activity they should do. As long as they are able to meet the requirement and avoid penalties, they can use the least cost method if they do not expect to capture the future return. Otherwise, if they have the incentive to invest, they can adopt whatever method that yields them the greatest benefit relative to cost, which often call for investing more. Therefore, if the characteristics of tenure are significantly different, their implications for investment behaviour can be revealed .

Another influence is the allowable cut effect. Silvicultural activities undertaken beyond contractual requirements may result, through the allowable cut effect, in immediate increases in the volume of mature timber that licensees may harvest (Luckert and Haley 1991). However, the allowable cut effect applies to all area-based tenures. Therefore, the dummy variables used for area-based tenures (see Chapter VI) capture the allowable cut effect as well.

Finally, the lack of an open timber market in B.C. is another factor which could affect licensees' decisions. It has been pointed out that the constraints on the timber market (e.g., partial absence of competitive stumpage, log and chip markets; log export restrictions) lead forest tenure holders to transfer some economic rents from timber growing and harvesting activities to forest products manufacturing (Luckert and Haley 1991). This issue, too, is controversial. Even if it is true, it happens in all kinds of tenure and thus can be seen as a residual factor that need not be explicitly considered in this study.

The empirical study on the effect of tenure on silvicultural investment will be addressed in Chapter VI.

3.3 Econometric Model to Test the Effect of Tenure on Outputs and Forest Practice

Given the revealed amounts of silvicultural investment, the next step looks at variables that describe forest growth (forest coverage, absence of not-satisfactorily restocked land, survival rate of plantations, etc.). In the same site, the productivity of forest lands under tenure forms that provide incentives for more investment can be expected to be higher than that on other forest lands. Therefore it can be hypothesized that these growth related factors (Y_i) are a function of silvicultural investment (I), time after standing timber is harvested (T_s), and all the factors in equation (13):

(14) $$Y_i = f(I, C_l, L, C_f, C_p, T_t, T_s)$$

A challenge for using this model in forestry is to find good output indicators. An answer to this challenge and the empirical results, are reported in Chapter VII.

IV. An Event Study of the Effect of Forest Tenure on Land Value

1. Introduction

On September 15, 1987, a provincial-wide "new forest policy" was announced in British Columbia. The new forest policy: (1) shifted the responsibility for silviculture from the government to private companies; (2) transferred immediately five percent of the AAC from all replaceable licenses (Tree Farm License, Forest License, Timber Sale License, and Timber Sale Harvesting License), with another five percent to be taken upon renewal of the licenses (to provide more scope for the Small Business Forest Enterprise Program); and (3) increased stumpage and other forest charges from $580 million to an estimated $680 million annually.

This new forest policy was one of the most significant forest policy changes since the 1976 Pearse Royal Commission and the subsequent Forest Act in 1978. The media intensively covered it and reactions were mixed. Small forest operators generally welcomed the change. Companies that were dependent on licenses to Crown forests were distressed, even "very dismayed" (Financial Post 1987). According to newspapers, the stock prices of publicly traded B.C. forest firms fell after the announcement (Financial Post 1987; Vancouver Sun 1987).

The fall of B.C. forest products firms's stock price may have been related to the objectives of the new policy. The new policy intended to: (1) rebuild, through small business, the jobs that were eliminated by big forest products firms during the 1981-1985 recession; (2) generate a fair return to the provincial government and cut government spending; and (3) replace the 15 percent countervailing duty imposed by the US. In pursuing the first objective, timber companies lost 5 percent of their previously "secured" rights to Crown timbers. The second and third objectives increased the cost to the forest industry. This policy was regarded as an unfavourable development, especially for the big firms.

The opposition to this policy change cited weakened investor confidence and industry competitiveness. If investors lose their confidence in B.C.'s forestry industry, it becomes difficult for the industry to attract capital. Without enough capital investment, the industry could lose its competitiveness and reduce employment still further. Since the forest industry is the predominant sector in the province, any negative changes in the industry would have a major impact on the provincial economy. How significantly was investor confidence affected by the new forest policy? The answer lies in the performance of the shares in forest products firms, around the policy announcement date.

This chapter investigates the attitude of investors towards the new forest policy by determining if the policy change is indeed a negative event from the perspective of shareholders, i.e., if the changes in stock prices were abnormal, after accounting for risk and market-wide effects. More importantly, this chapter catches the unique opportunity of the AAC takeback to study the value of the forest tenures, which, as discussed in Chapter III, are rarely traded. The results will provide an indication of the relative perceived values of forest lands held by private companies through forest tenures.

Because of the imposition of the 15 percent export tax on Canadian softwood lumber exports to the United States on December 30, 1986 and the declared intention of the B.C. government to replace this tariff by increasing stumpage, it is plausible that the market would have already reacted somewhat to the increase in stumpage before the arrival of the new policy. In fact, the former Premier announced that the government was undertaking a review of its stumpage system in September, 1986 (Vancouver Sun 1986), roughly one year prior to the new policy announcement. Moreover, the increase in stumpage of 100 million is very small relative to market capitalization of firms in this study. Therefore the results of this chapter cannot be interpreted to be the effect of the stumpage hike (Financial Post 1987).

The next section reviews the methodology of event study, followed by a description of hypotheses, data and results in Section 3. Section 4 interprets the results and discusses policy implication.

2. Methodology

Event-study methodology has been used by financial economists to determine the impact of a specific financial decision on shareholder returns (e.g., Desai and Stover 1985; Zinkhan 1988), or to analyze the impact of a variety of regulations and regulation changes on the expected profits of firms (e.g., Schwert 1981; Binder 1985a, 1985b; Boardman, Vertinsky and Whistler 1992). Although the method can be applied to a single firm, event studies typically focus on a group of firms that experience similar events.

There are two distinctive cases when several firms are considered. In the first, each firm experiences a series of events, but the event periods are specific to the firm and bear no relation to the events of any other firms in the sample except that the events are of the same kind (mergers, takeovers, etc.). The second case is one of identical events across a sample of firms, e.g., regulatory changes or industry-wide shocks. To simplify the following discussion, these two cases will be identified as non-regulatory and regulatory events.

The event study methodology, along with the underlying assumptions, varies in each case. However, the methodologies can be classified into two basic approaches. The older, more common, method is called residual analysis. It has mainly been applied to non-regulatory events, but its application to regulatory events has grown. The second method is a multiple regression analysis, known as "covariance method" (Boardman, Vertinsky and Whistler 1992). It is a "one-step" method in which the intercept and risk parameters of the market model, and the shift in the mean return due to an event, are estimated simultaneously by multiple regression analysis. It has been used exclusively in regulatory events. The basic ideas of these two methods and their advantages and disadvantages are reviewed in the following paragraphs.

Suppose that there is only one event. At a single-firm level, the residual analysis partitions the data into two periods, uses the "non-event" period data to establish a "benchmark" for what is expected to happen in the "event period" in the absence of event. The remaining data (with event) are then used to estimate "abnormal " and "cumulative abnormal" returns by comparing what actually happened to the benchmark scenario. To set a benchmark, the capital asset pricing model (CAPM) developed by Sharpe (1964) and Lintner (1965) is often used to control for risk and market-wide effects. According to CAPM, a security's expected return is a positive function of that proportion of total risk that investors cannot divert (commonly known as systematic risk). The market model shown below is generally used to estimate the parameters of the capital asset pricing model:

(15) $$R_{it} = \alpha_i + \beta_i R_{mt} + \varepsilon_{it}$$

where

R_{it} = the rate of return for stock i on day t;

R_{mt} = the rate of return on the market portfolio on day t;

α_i, β_i = regression parameters.

ε_{it} = a random disturbance term, assumed to be normally distributed as N(0,1), independent of the explanatory variable R_{mt}.

After the regression parameters are estimated by using non-event period (0, T_0) data, daily abnormal returns for security i can be calculated for each day of the event period[19]:

(16) $$AR_{it} = \hat{\varepsilon}_{it} = R_{it} - \hat{R}_{it} \qquad t>T_0$$

The cumulative abnormal returns, CARs can be constructed as either

(17) $$CAR_{it} = \sum_{t>T0} AR_{it}$$

or

(18) $$CAR_{it} = \left[\prod_{t>T0} (1+AR_{it})\right] - 1$$

The hypothesis test statistic for CAR_{it}=0 is a familiar t statistic when the non-event period is large (so that CAR_{it} has a normal distribution). The variance of CAR_{it} is assumed, with some methods of adjustment[20], to be the same as that of the non-event period.

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[19] The AR and CAR used in this chapter are all random variables, not true variables.

[20] See Collins and Dent (1985), Dann and James (1982), Desai and Stover (1985), Theil (1971), Boardman, Vertinsky and Whistler (1992) for different adjustment methods in residual analysis and portfolio approach.

Applying residual analysis to a set of (say, N) firms involves aggregation of CAR_{it} and computation of the relevant variance. After estimating all parameters of the N firms during the non-event period and computing the CAR_{it}, the mean CAR_t of the N firms is calculated as weighted average of CAR_{it}. Computation of the variance of CAR_t is based on either a weighted average variance of each firm, or the residual variance of the weighted portfolio of the N firms in the non-event period (Collins and Dent 1984; Desai and Stover 1985). In each case, the weight can be equal or unequal, depending on the assumption made (Dann and James 1982).

Note that the estimation implicitly assumes that there is no contemporaneous cross-correlation among equations (firms), which is probably not a valid assumption for industry-wide regulatory events. Also, when equal weight is used to get the variance of CAR_t, it is assumed that all firms have equal residual variance. This is also probably inappropriate in most empirical settings.

A variant of residual analysis is the portfolio approach, which uses an appropriate weight mechanism to form a portfolio (Thompson 1985), and estimates the portfolio analogously to a single firm. It is a simple and effective way to conduct event study. The portfolio will have parameters equal to the weighted average of individual security parameters. Thompson (1985) points out that hypothesis testing can be carried out with the portfolio residual variance estimate; moreover, the variance estimate is consistent and enables asymptotically (as T_0 goes to infinity) valid inferences to be drawn about the true population parameters, even if the portfolio weighting scheme is based on an invalid covariance matrix assumption. Thus, the use of a simple average in forming a portfolio is growing in popularity. This approach avoids the computational burden of searching for appropriate weight, such as the inverse of an individual firm's residual variance.

Since residual analysis and its portfolio approach variant have the appealing characteristics of simplicity and usefulness, they have been used increasingly to study regulatory events (e.g., Dann and James 1982; Boardman, Vertinsky and Whistler 1992). However, their use could have serious consequences if the underlying assumptions of equal variances across firms and no contemporaneous correlations among equations are invalid (Collins and Dent 1984; Binder 1985a, b). These shortcomings of residual analysis can be overcome in multiple regression analysis.

A multiple regression analysis begins by parameterizing the abnormal returns γ_i in the individual return equations:

$$(19) \qquad R_{it} = \alpha_i + \beta_i R_{mt} + \gamma_i D_{it} + \mu_{it}$$

using the dummy variable D_{it}. D_{it} equals one during the event periods and zero otherwise. μ_{it} is a random error which is independent of R_{mt} and has a normal distribution of N(0, 1). Note the identity of ε_{it} in equation (15), and μ_{it} and $\gamma_i D_{it} + \mu_{it}$ in equation (19) during the no event period and the event period, respectively. In equation (19), γ_i measures the average abnormal return for firm i during the event period.

When the explanatory variables in the return-generating process are the same for each of the N firms the multiple equations below can be estimated jointly as a seemingly unrelated regression model (Zellner 1962; Theil 1971):

$$R_{1t} = \alpha_1 + \beta_1 R_{mt} + \gamma_1 D_{1t} + \mu_{1t}$$

$$(20) \qquad R_{2t} = \alpha_2 + \beta_2 R_{mt} + \gamma_2 D_{2t} + \mu_{2t}$$

$$\vdots$$

$$R_{Nt} = \alpha_N + \beta_N R_{mt} + \gamma_i D_{Nt} + \mu_{Nt}$$

This approach allows that individual abnormal returns and residual variances differ across firms. It also incorporates the cases where the contemporaneous covariances of the disturbances across equations $E(\mu_{it}, \mu_{jt})$ are non-zero, whereas the non-contemporaneous covariances $E(\mu_{it}, \mu_{j,t-k})$ all equal zero. Note that the multiple regression analysis gains no efficiency in estimating coefficients and the residual variances, producing estimates which are identical to those obtained from OLS estimation of the individual equation (Theil 1971, Chapter 7). The advantage of this approach is in hypothesis testing since heteroscedasticity across equations and contemporaneous dependence of the disturbances are explicitly incorporated into the hypothesis tests. This technique avoids the statistical problems encountered in the application of residual analysis in regulatory events.

Three hypotheses are of primary interest in event studies, especially studies of regulatory change. The first (H_1) is that the sum of the abnormal returns during the event period across the N equations equals zero (i.e., $\Sigma\gamma_i = 0$). The second (H_2) is that all abnormal returns during the event period equal zero (i.e., $\gamma_i = 0$, for all i). The third (H_3) is that some abnormal returns during the event period equal zero (i.e., $\gamma_i = 0$, for some i). Tests of H_2 and H_3 will be more powerful than tests of H_1 if an event affects the sample firms but the abnormal returns differ in sign. These joint hypothesis tests are of special importance in regulatory events since there are good reasons to believe that regulation benefits some firms and hurts others.

Although tests of H_1 and H_3 in the residual analysis and multiple regression analysis are well specified, using the portfolio approach to test this hypothesis is preferred because it is both correctly specified and economically and computationally simpler (Thompson 1985). Tests of H_2 and H_3 can not only be done by using residual analysis, but also by using portfolio approach if one can distinguish the firms who will benefit from those who will be hurt. The following analysis employs both the portfolio approach and multiple regression analysis.

3. Hypotheses, Data and Results

As discussed earlier, there are two main components of the new forest policy left to address. They have different impacts on big and small firms. Small firms which can bid for the Small Business Forest Enterprise Programs have access to more timber under the new policy, but do not bear the responsibility for silviculture. Clearly they gain from the policy change. The big firms which cannot bid for the Small Business Forest Enterprise Programs lose five percent of their AAC under forest tenures. At the same time, they must shoulder the silvicultural costs. These companies seem to lose as a result of the new policy. Therefore it is expected that the new policy should have a negative impact on the share prices of big forest products firms. Therefore the main null hypothesis of this chapter is that the aggregate of the abnormal returns to big firms during the event period equals zero. A rejection of this hypothesis would mean that shareholders of the big firms in the industry suffer from the policy change. As none of the small firms are listed on the stock market, this study does not draw any conclusions about them.

The second null hypothesis is that the abnormal return for every big firm equals zero. The effect of regulation may not be even among firms since the value of the stock is a function of both the content of the regulation and the circumstances of each firm. While the forest policy may harm firms heavily dependent on Crown timber obtained under the affected tenures, it will benefit those who own rights to close substitutes, such as private lands and Timber Licenses. Firms that have diversified themselves by operating in other provinces would be in a better position than those who have all of their forest operations in British Columbia. In addition, because B.C. is such a big player in the Canadian forest industry, the forest policy may also positively affect firms that do not operate in B.C., but face the same major market (the US market). Thus, a group of non-B.C. firms is also included in this study.

Initially the sample consisted of fifteen firms that had operations in B.C. and six non-B.C. firms, which were on the TSE / Western Data Base of the Toronto Stock Exchange. Four of the B.C. firms were dropped because they were involved in mergers within a year prior to the event date. The eleven firms used in this study are: Canfor Corporation, Canadian Pacific Forest Products Limited, Crestbrook Forest Industries Limited, Doman Industries Limited, International Forest Products Limited, Macmillan Bloedel Limited, Slocan Forest Products Limited, Scott Paper Limited, Weldwood of Canada Limited, Westar Timber Limited and West Fraser Timber Co. Limited. The non-B.C. group consists of Abitibi-Price Inc., Cascades Inc., Consolidated Bathurst Inc., Domtar Inc., Donohue Inc., and Tembec Inc..

The hypotheses are first tested using the portfolio approach. Four portfolios are formed in light of the characteristics of each firm and the possible impacts of the policy on them. In addition to the portfolios of B.C. firms and non-B.C. firms, there are two other portfolios which are further derived from the portfolio of B.C. firms :

Less-diversified B.C. Companies. These companies own small quantities of timber land, hold small Timber Licenses and operate mainly in B.C. They should be hit hardest by the forest policy changes. In this study seven companies are used. They are Crestbrook Forest Industries, Doman Industries, International Forest Products, Slocan, Weldwood, Westar Timber and West Fraser Timber. Table 3 shows these firms on average only harvested 2.2 percent of their timber from their private

Table 3. Harvesting Volume Distribution of Forest Products Firms in 1987

Firms	Private & Timber License (%)	Tree Farm License (%)	Other Tenures[a] (%)
Less-diversified B.C.	2.2	12.5	85.8
Crestbrook forest Industries	1.8	8.4	89.9
Doman Industries	0.0	0.0	100.0
International Forest Products	7.0	0.0	93.0
Slocan	0.0	12.7	87.3
Weldwood	4.3	19.4	76.3
Westar Timber	2.1	46.9	51.0
West Fraser Timber	0.0	0.0	100
Diversified B.C.	31.3	58.3	10.4
Canfor Corporation[b]	29.2	60.5	10.3
Canadian Pacific Forest Products	38.2	31.2	30.6
Macmillan Bloedel	51.3	46.2	2.5
Scott Paper[c]	2.4	97.6	0.0
B.C. firms	12.4	29.2	58.5

Sources: Timber Harvesting Branch, Ministry of Forests, British Columbia.

[a] Forest Licenses, Timber Sale Harvesting Licenses, Major Timber Sale Licenses and others.
[b] Figure of 1992 estimated by the company.
[c] Because Scott Paper has mainly operated outside of B.C., it is classified as a diversified B.C. firm (although it neither owns much private industrial forest lands, nor holds lots of Crown timber through Timber License in B.C.).

lands and Timber Licenses in 1987[21]; the rest came from Tree Farm Licenses and Forest Licenses, for which they have to lose 5 percent of AAC under the new policy. Henceforth this group is referred to as "less-diversified B.C."

Diversified B.C. Companies. These companies are the large integrated forest products companies that own most of the private industrial forest lands and Timber Licenses in B.C., and have diversified themselves outside of the province (or have actually come from other parts of Canada). They are subject to conflicting effects. Reduced access to Crown timber will be harmful, but increased prices for their own timber and the better position that results from operating outside of the province will be beneficial. Four companies (Canfor, Canadian Pacific Forest Products, Macmillan Bloedel and Scott Paper) are used in this study. These firms on average harvested 31.3 percent timber from their private lands and Timber Licenses in 1987[4] (Table 3). Henceforth this group is referred to as "diversified B.C."

The market model during the non-event period is then estimated separately for these four portfolios. The daily return to each portfolio is calculated as the equally weighted daily return to each security in the portfolio. The TSE 300 price return index is used as the market index[22]:

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[21] Ideally, I would want to examine the sources of timber for the mills of these firms. Forest products firms in B.C. purchase some timber through the open market (e.g., Vancouver log market) and through contracts. Because the relevant data cannot be found, the distribution of timber harvested under different tenures is used as a substitute for the source of timber supply. The implicit assumption is that all of the timber harvested by a firm will go to the firm's mills, and that all of the firms have the same proportion of timber that comes from the open market and contracts. In reality this assumption is not strictly valid. Thus the classification of the less-diversified B.C. and diversified B.C. groups is loose in terms of source of timber supply.

[22] Another form of capital asset pricing model is:

$$R_{it} - R_{ft} = \alpha_i + \beta_i [R_{mt} - R_{ft}] + \varepsilon_{it}$$

where R_{ft} is a risk-free rate (say, a one-month T-bill rate). This model is often used in monthly and annual studies, where R_{ft} changes. When R_{ft} (and β_i) is constant, this model will reduce to equation (21). This model has not been used here since the day-to-day R_{ft} is not available and R_{ft} (and β_i)

$$(21) \qquad R_{pt} = \alpha_0 + \beta_p R_{mt} + \varepsilon_{pt}$$

$$p = \{a, b, c, n\};\ t = \{1 \ldots T_0\}$$

Where p = a, B.C. forest products firms;

= b, less-diversified B.C. forest products firms;

= c, diversified B.C. forest products firms.

= n, non-B.C. forest products firms.

Equation (21) is estimated by OLS using 147 observations, beginning on February 2, 1987 and ending on September 1, 1987, two weeks prior to the announcement date. Observations prior to 1987 are excluded to eliminate the impact of the 15 percent countervailing duty which was threatened by the US in the middle of 1986, and subsequently imposed on December 30 of 1986. Observations in January of 1987 are also dropped to avoid the possible "January effect". The results are reported in Table 4[23] [24].

A number of diagnostic tests are performed to assess the suitability of these equations. The fits, as measured by the R^2-adjusted, are quite high. The hypothesis for normality among residuals cannot be rejected for all of the four portfolios. Furthermore, the tests for heteroscedasticity (B-P-J tests and ARCH tests) reveal that the models are appropriate. However, Durbin-Watson statistics

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hardly changes during the 147-day estimation period used in this study.

[23] Equation (21) is a "seemingly unrelated regressions" model. The correlation of contemporaneous residuals across equations is expected. However, since each equation has the same explanatory variables OLS provides efficient parameter estimates.

[24] Equation (21) has also been estimated by including one period lead and lag of the market return index to control the thin trading (Scholes and Williams 1977). Since all of the results are similar to these reported here and the coefficients of the lead and lag of market return index are not significant at the 10 percent level, the lead and the lag are dropped.

Table 4. Parameter Estimates for Capital Asset Pricing Models

Explanatory Variables	Portfolio			
	B.C. Firms	Less-diversified B.C.	Diversified B.C.	Non-B.C.
R_{mt}	1.2251** (9.7596)	1.2806** (8.1736)	1.1720** (7.5045)	0.9094** (8.0942)
Constant	0.0008 (1.0160)	0.0005 (0.4672)	0.0009 (0.8781)	-0.0010 (-1.2331)
R^2-adjusted	0.3923	0.3107	0.2748	0.3065
D.W	1.8299	1.9527	1.9748	1.6523
Observation	147	147	147	147

t statistics in parentheses.

** Significant at the 5 percent level.

indicate that the null hypotheses of no serial correlation of estimated residuals can be rejected at the 5 percent level for three of the four portfolios[25].

The cumulative abnormal returns for the four portfolios are then computed using an equation analogous to equation (18), where the subscript i is replaced by p for portfolio for a 23-day interval, starting at September 2 (day -8)[26]. For computational purposes it is useful to note that:

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[25] To control the autocorrelation of the residual, autocorrelation regressions are run for equation (28). The follow-up prediction uses the estimated serial correlation coefficient RHO. However, the prediction results are not significantly different from those reported in this chapter. These results are not surprising because most estimated RHOs are not significantly different from zero at the 10 level.

[26] There is little agreement in the literature regarding when the event "window" should start and for how long it should last. Therefore a trial-and-error method is often used to choose the starting date. Desai and Stover (1985) start the window at -20 (20 days before event); Dann and James (1982)

(22) $CAR_{pt} = CAR_{p,t-1} + AR_{pt} + AR_{pt}\ CAR_{p,t-1}$

Assuming no serial correlation and that the null hypothesis of no effect is true, the variance of CAR_{it} can be estimated as (Boardman, Vertinsky and Whistler 1992):

(23) $Var(CAR_{it}) = Var(CAR_{i,t-1}) + Var\ (\varepsilon_{it}) + Var(\varepsilon_{it})\ Var(CAR_{i,t-1})$

where $Var(\varepsilon_{it})$ is the estimated residual variance of the no-event period. The CARs and test statistics are reported in Table 5; the daily CARs are presented in Figure 1.

The CARs for the 23-day event interval for all B.C. firms are negative but not statistically significant at the 10% level. The negative sign of CARs prior to the event date indicates that information might have been leaked to investors. Also, the sign of CARs following the event date means that new information was absorbed by investors as negative. However, the CAR rebounds back to its pre-event level at October 5 (day 14).

The CAR curves for less-diversified B.C. and diversified B.C. have similar shape and the CARs are all not significantly different from zero at the 10% level. However, the CARs are quite different in sign. The less-diversified B.C. group has negative CARs during the 23-day event interval, but the CARs for diversified B.C. have positive signs in 10 days of the 23-day event interval. The CARs for non-B.C. firms follow the same pattern as those of diversified B.C. group. These findings indicate that the new forest policy had a minor impact on diversified B.C. and non-B.C. forest products firms. In short, the results show: (1) investors perceive the new forest policy as a

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start at -10. Zinkhan (1988) and Boardman, Vertinsky and Whistler (1992) use -5 as the starting day. Equation (29) is estimated by using day -10, -8, -6, -4, -2, -1 and 0 as the starting date. The results does not significantly differ with those reported here.

Table 5. Performance of Stock around the Announcement Date of Forest Policy Change

	B.C. Firms			Less-diversified B.C.			Diversified B.C.			Non-B.C.		
day	Percent of AR	Percent of CAR	t-Statistics of CAR	Percent of AR	Percent of CAR	t-statistics of CAR	Percent of AR	Percent of CAR	t-statistics of CAR	Percent of AR	Percent of CAR	t-statistics of CAR
-8	-1.944	-1.944	-1.601	-1.943	-1.943	-1.522	-1.005	-1.005	-0.790	-0.082	-0.082	-0.090
-7	0.107	-1.839	-1.272	-0.089	-2.030	-1.125	1.001	-0.014	-0.008	-0.115	-0.198	-0.153
-6	0.328	-1.517	-0.857	1.630	-0.433	-0.196	0.798	0.784	0.356	0.921	0.722	0.455
-5	-0.380	-1.891	-0.925	-0.952	-1.381	-0.541	0.579	1.367	0.537	-0.634	0.083	0.045
-4	-0.514	-2.396	-1.048	-0.556	-1.929	-0.676	0.101	1.470	0.517	-0.357	-0.274	-0.134
-3	-0.038	-2.433	-0.971	0.231	-1.703	-0.545	-0.733	0.726	0.233	-1.563	-1.832	-0.818
-2	0.406	-2.037	-0.753	0.941	-0.778	-0.230	0.393	1.122	0.333	2.080	0.209	0.086
-1	-0.617	-2.641	-0.913	-0.850	-1.621	-0.449	0.514	1.641	0.460	0.947	1.157	0.447
0	-0.290	-2.923	-0.953	0.283	-1.342	-0.351	-0.498	1.135	0.297	-0.155	1.000	0.364
1	-0.947	-3.843	-1.188	-0.723	-2.056	-0.509	-0.501	0.628	0.156	-0.540	0.455	0.157
2	-0.529	-4.352	-1.283	-0.521	-2.566	-0.606	-0.885	-0.263	-0.062	-0.192	0.262	0.086
3	-0.042	-4.392	-1.240	-0.170	-2.731	-0.617	0.226	-0.038	-0.009	-0.409	-0.148	-0.047

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Table 5. continued

day	B.C. Firms			Less-diversified B.C.			Diversified B.C.			Non-B.C.		
	Percent of AR	Percent of CAR	t-Statistics of CAR	Percent of AR	Percent of CAR	t-statistics of CAR	Percent of AR	Percent of CAR	t-statistics of CAR	Percent of AR	Percent of CAR	t-statistics of CAR
4	-0.099	-4.487	-1.217	0.141	-2.594	-0.563	-0.187	-0.225	-0.049	0.156	0.008	0.002
5	-0.127	-4.608	-1.204	-0.416	-2.999	-0.628	0.191	-0.035	-0.007	-0.964	-0.957	-0.279
6	-0.204	-4.803	-1.212	0.174	-2.830	-0.572	-0.791	-0.825	-0.167	0.300	-0.659	-0.186
7	0.002	-4.800	-1.173	0.402	-2.440	-0.478	0.098	-0.728	-0.143	-0.474	-1.130	-0.309
8	-0.273	-5.061	-1.200	-0.743	-3.164	-0.601	-0.268	-0.994	-0.189	-0.298	-1.425	-0.378
9	-0.037	-5.096	-1.174	-0.951	-4.085	-0.754	0.272	-0.724	-0.134	0.636	-0.798	-0.206
10	-0.250	-5.333	-1.196	0.296	-3.801	-0.683	-0.823	-1.541	-0.278	0.404	-0.397	-0.100
11	-0.725	-6.020	-1.316	-0.503	-4.285	-0.750	-0.163	-1.702	-0.299	0.078	-0.320	-0.078
12	1.374	-4.729	-1.009	2.396	-1.991	-0.340	0.695	-1.019	-0.177	1.076	0.753	0.179
13	1.914	-2.905	-0.605	1.131	-0.883	-0.147	2.404	1.361	0.228	0.991	1.751	0.408
14	0.387	-2.529	-0.516	0.891	0.000	0.000	0.617	1.987	0.325	1.781	3.564	0.812

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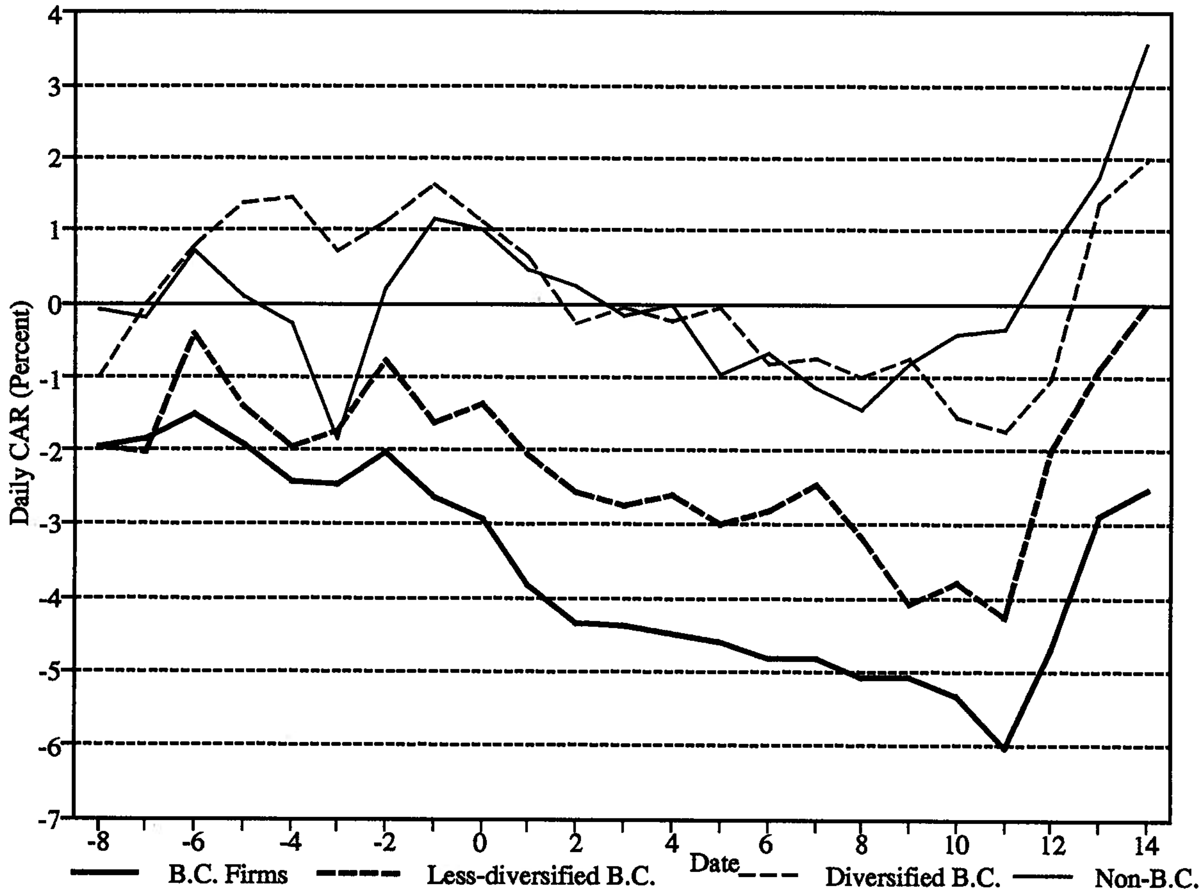
Figure 1. Stock-Market Performance around the Announcement Date of Forest Policy Change



seemingly negative, but not statistically significant event for B.C. forest products firms as a whole; (2) the less-diversified B.C. group is impacted slightly, but the diversified B.C. group and non-B.C. firms have no significant gains or losses (Figure 1).

The above analysis is conducted by using multiple regression analysis as well. A system of 11 equations for B.C. firms were run. The Breusch-Pagan lagarange multiplier test statistic for the diagonal covariance matrix for these equations is 239.80. Based on this statistic, the null hypothesis of no contemporaneous correlation across equations is rejected at the 5 percent level. Thus, the multiple regression method gains efficiency in hypothesis testing by accounting the contemporaneous dependence across equations. The results, however, are the same as those of the portfolio approach. Seven of the eleven dummy variables in the 11 equations are negative, and the remaining four are positive (Table 6). But none of them is significantly different from zero at the 10 percent level. Not surprisingly, the null hypotheses that total abnormal return equals zero, and that all of the abnormal returns equals zero cannot be rejected at the 5 percent level (the Wald X^2 test statistics for them have the value of 0.27 and 7.92 with 1 and 10 degrees of freedom, respectively).

4. Conclusions and Discussion

The 1987 changes in forest policy in British Columbia evidently were regarded as a negative, but not statistically significant event for B.C. forest products firms as a whole. The new policy resulted in minor losses for less-diversified B.C. firms. Diversified B.C. firms and other Canadian forest products firms which operate outside of B.C. have not experienced significant gains or losses.

These conclusions seem to contradict media reports[27], but they can be supported by careful reasoning. First, the 5 percent reduction in AAC may not affect the equilibrium of B.C. timber markets very much because B.C. bans log export. The timber that is taken away from big forest

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[27] The Vancouver Sun (1987) reports:

"[I]nvestor's reaction was negative to the B.C. government's plans to reduce the annual harvests of most of the province's forest companies and to increase the price on timber it leaves them.

[T]he Toronto Stock Exchange's pulp and forest products sub-index, dominated by B.C.-based firms, was down 52 points — or about one percent — in early trading. The index recovered somewhat by mid-session and was off 39.09 points to 5,359.69."

The Financial Post (1987) reports:

"'[W]e are dismayed. I mean, very dismayed,' says Michael Apsey, president of the Council of Forest Industry of B.C., the industry associate. The dismay was shared by the stock market. Shares of major B.C. companies — all of which are currently reporting record earnings — declined on the news of the new policy."

Table 6. Parameter Estimates Using Multiple Regression Method

Firms	R_{mt}	Constant	Dummy[a]	R^2
Less-diversified B.C.				
Crestbrook forest Industries	1.5490** (6.5453)	0.0016 (0.9998)	-0.0079 (-1.3635)	0.1299
Doman Industries	1.7127** (4.2288)	-0.0007 (-0.2318)	0.0162 (1.6185)	0.1067
International Forest Products	0.9186** (2.3183)	0.0011 (0.4089)	-0.0102 (-1.0455)	0.0429
Slocan	2.0491** (6.3451)	0.0014 (0.8137)	-0.0057 (-0.9685)	0.2073
Weldwood	0.3544 (1.5091)	0.0004 (0.2620)	-0.0053 (-0.9106)	0.0214
Westar Timber	1.3543** (3.9339)	-0.0010 (-0.3973)	-0.0001 (-0.0118)	0.0895
West Fraser Timber	1.1794** (4.9464)	0.0006 (0.3814)	-0.0023 (-0.3944)	0.1374
Diversified B.C.				
Canfor Corp	1.1031** (4.8870)	0.0006 (0.3586)	0.0029 (0.5250)	0.1299
Canadian Pacific Forest Products	1.4901** (5.3136)	0.0020 (0.9979)	-0.0017 (-0.2521)	0.1537
Macmillan Bloedel	1.4495** (6.0410)	0.0014 (0.8137)	-0.0057 (-0.9685)	0.1978
Scott Paper	0.5795** (3.3689)	-0.0001 (-0.0677)	0.0037 (0.8820)	0.0675

[a] Daily abnormal return.

t statistics in parentheses.
** Significant at the 5 percent level.

products companies will still end up in the B.C. timber markets, and those who lost their AAC can recover at least a portion of it. Indeed, Gillespie (1991) reports that the big firms which cannot bid for timber under Small Business Forest Enterprise Program circumvent the restriction by "surrogate bidding", a practice where a large firm, in return for logs, allegedly provides financial backing, to a small firm who is eligible to bid on the sale.

Second, timber in B.C. may be fully priced with respect to all kinds of tenure. That is, the timber companies pay the same price for the same kind of timber, regardless of how they get it — through tenure, private lands or the open market. This point is supported by Uhler (1991), Sterling Wood Group Inc. *et al.* (1986) and Heaps (1988). Uhler (1991) finds that during the years included in his study (1969 to 1984), timber pricing under forest tenures was not below competitive levels in at least three out of six forest regions in B.C. These forest regions — Vancouver, Rupert and Nelson — together account for 50 to 60 percent of the timber harvested in the province. Sterling Wood Group Inc. *et al.* (1986) show that once differences in logging cost are taken into account, for stands with similar grade and species mixes the prices paid by competitive bidders under the Small Business Forest Enterprise Programs and the prices paid by tenure holders are not significantly different. This is another way of saying that timber is fully priced under all different tenures. If the timber is fully priced, then a reduction in AAC would have no effect on firm's earnings, and therefore no effect on stock prices.

Third, the net present value of the AAC reduction is small. The gross residual value of logs traded in the Vancouver log market, before stumpage or royalty, is $16.95 per cubic meter for all species and all grades in 1987 -1989 (CWC Canadian Western Capital Ltd. 1991). In the same period, the average stumpage price in the Vancouver forest region is $9.30 per cubic metre.

Therefore, one can argue that the maximum net profit for the timber harvesting industry in the Vancouver forest region is about $7.65 per cubic metre. This amount is also, in short-run, the maximum excess price a company would be willing to pay and the maximum excess stumpage price that a forest land owner can get. Given this figure, and assuming that the regional differences in this profit margin are negligible, a five percent AAC reduction to the seven less-diversified B.C. firms, would reduce average net earnings by $1.03 million per year. This amount is not likely to have a significant effect on these companies, which recorded average total sales of over $400 million annually in the 1987 to 1989 period (Price Waterhouse, various years).

Lastly, as mentioned above, the market may have already reacted to the stumpage increase. Taking all of these considerations into accounts, the collection of new requirement, and especially mandatory silviculture at the licensees' expense does not seem to have been sufficient to detract significantly from investors' valuation of B.C. forest product companies.

One implication of these finding is that the marginal value of renewable forest tenures is small or close to zero. This point is related to the argument that timber being fully priced in B.C. While the value of forest tenures as a whole cannot be denied, marginal increases or decreases of tenured forest lands do not appear to have much value to investors. Similarly, Woodbridge and Mackenzie (1992) report that "secure access to fibre" seems to be more important than "secure tenure". In other words, as long as companies can get access to fibre, they are not concerned about whether the timber comes from tenured forest lands or other lands.

While the short-run effects of the forest policy change do not seem to have harmed B.C. forest companies's investors, the long-run effects are less clear. On one hand, the policy change has forced the American counterparts to drop (at least temporarily) their charge that B.C. timber is subsidized. On the other hand, the companies must pay more. The latter may not be a serious problem in times of economic prosperity, but it may prove to be a heavy burden in times of recession.

The results of this chapter should be interpreted with caution. This study only measures the marginal effects of forest policy change, concentrating on the AAC reduction and the shift of silvicultural responsibility. Although the marginal AAC reduction has small effect, the effect of large AAC takeback could be very significant. This study provides no evidence on this issue. Therefore one cannot infer, based on the findings of this chapter, that another 5 or 10 percent AAC reduction will have little impact on investment in the B.C. forest industry. Furthermore, the scenario of the 1987 AAC reduction is different from that of other recent reductions in AAC. In the latter case, the timber has became totally unavailable for the industry. Any further AAC cuts or imposition of costs to the industry may erode investors' confidence, which in turn could have a big impact on the industry which drives B.C.'s economy. Policy-makers do have some room to regulate forest resource users without affecting investment activities in the industry, but it is necessary to understand the dynamic relationship between investment and regulations and to evaluate the effects of regulation before major changes in regulation are imposed.

V. The Effect of Forest Tenure on Land Value: A Hedonic Study

1. Introduction

Private forest lands and Timber Licenses are frequently traded in B.C. Enough observations are available to estimate a hedonic pricing model that captures the effect of forest tenure on land value. This chapter measures and interprets the significance of these forms of tenure for the value of the land. As a by-product, this study also examines the determinants of forest land value in British Columbia, and the role of the allowable cut effect in the decisions of large and integrated firms to purchase forest lands.

The literature on determinants of land value can be found in real estate (e.g., Vrooman 1978; Coulson and Robins 1987) and agriculture (e.g., Hushak and Sedr 1979; Palmquist and Danielson 1989). With the exception of Armstrong (1975) and Washburn (1990), few studies of this kind are found in forestry. Furthermore, the literature apparently contains no research on the effect of institutional instruments on land value in any of these sectors.

The next section describes the data for estimating equation (19). Section 3 discusses the empirical results, and conclusions based on these findings are presented in Section 4.

2. Data[28]

To demonstrate the effect of forest tenures on land value, cross-sectional data have been

[28] The data used in this chapter are available from the author.

collected on transactions of private forest lands and Timber Licenses in the period from 1987 to 1992. This six-year period is long enough to cover a whole business cycle, thereby controlling for change in macroeconomic conditions. The starting year, 1987, has been chosen because major changes in B.C. private forest legislation took place in January of that year. The study area includes the B.C. Coast (Vancouver forest region) and the Southern Interior (Kamloops and Nelson forest region), which together account for some 54 percent of the timber harvested in 1991-1992 and at least half of the productive forest lands in the province. Managed and unmanaged forest lands, defined in Chapter II, are treated as two separate tenures[29].

The data used in this study came from various sources. Information on private forest lands has been mainly provided by British Columbia Assessment Authority (BCAA), which assesses all private forest lands in the province and records the transactions that involve them. There were 1084 transactions in private forest land province-wide during the study period. The use of these transactions is limited to 247 by excluding: (1) all properties that apparently do not have a value (i.e., the values are attached to something else or have yet to be determined); (2) all properties outside the two study regions.

Since the data from BCAA do not include information on the forest inventory, species composition and potential products of each property, a mail-out survey was conducted to determine

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[29] If the lands are outside Tree Farm Licenses, B.C. legislation allows re-classification of these two categories from one to another provided that the holders pay certain tax differences. For example, if holders of managed forest lands find that their lands would be more valuable if classified as unmanaged, they can have them reclassified upon payment of the accumulated tax savings they have enjoyed by having classified the lands as managed forest lands since 1987. Therefore, the difference between managed forest lands outside of Tree Farm Licenses and unmanaged forest lands is limited to taxation and commitment for sustainable forestry practice. However, most managed forest lands used in this study are within Tree Farm Licenses. Therefore unmanaged and managed forest lands are treated as two different types of tenures.

these forest characteristics. Among the 247 properties surveyed, responses from some 115 properties were collected, but only 82 of these (45 from the managed forest lands and 37 from the unmanaged forest lands) are useful. The rest are excluded from the study because the owner either could not, or would not reveal all the information needed for this study. Most of the managed forest lands are incorporated in Tree Farm Licenses, but none of these 82 properties have improvements such as logging facilities and buildings. This circumstance simplifies the data analysis, and helps avoid errors due to the difficulty of estimating the value of the improvements.

Data on Timber Licenses were provided by the Ministry of Forests, Timber License holders and independent appraisers. There were some 170 Timber Licenses traded between 1987 and 1992 in the Coast and Southern Interior, but full sets of information have been obtained only for 24 because of the confidentiality requirements of some Timber License holders. The appraised values of these Timber Licenses were used as market prices. This usage is appropriate since the B.C. Forest Act (Section 50.4) specifically requires that an independent current appraisal be conducted when a Timber License changes hands. Some of these Timber Licenses could be incorporated into Tree Farm Licenses as Schedule "B" lands.

Table 7 describes the variables used in this study. Price per hectare is the dependent variable. While the mean price per hectare for all observations is $3115.80. There is a significant difference among tenures (Table 8). However, any conclusions regarding the effect of tenure on land value can be firmly drawn only after a full analysis of the determinants of land value, since these other factors differ among tenures as well. To facilitate presentation, the twenty variables are categorized into five groups: tenure, forest cover, natural attributes of the lands, location and others, and producer's characteristics.

Table 7. Variable Definitions, Sources and Statistics of Forest Land Transaction Variables

Variable	Mean Value	Standard Deviation	Definition	Sources
PRICE	3115.80	4980.20	Real price of land per hectare as of December, 1992 ($)	BC Assessment Authority (BCAA), Ministry of Forests
PFLm	0.3491	0.4789	Dummy: managed forest land (1 if managed forest land, 0 otherwise)	BCAA, Tenure holders
PFLu	0.4245	0.4966	Dummy: (1 if unmanaged forest land, 0 otherwise)	BCAA, Tenure holders
VOLUME	205.05	188.19	Estimated timber inventory (m^3)	BCAA, Appraisers
D_FIR	28.72	29.24	Percent of Douglas fir	Appraisers, Tenure holders
HB	33.68	24.82	Percent of hemlock and balsam	Appraisers, Tenure holders
CEDAR	16.80	19.45	Percent of cedar	Appraisers, Tenure holders
PRODUCT1	10.09	20.13	Percent of products as peeler and pole	Appraisers, Tenure holders
PRODUCT2	55.85	30.08	Percent of products as sawlog	Appraisers, Tenure holders
SIZE	111.23	254.29	Tract size (hectare)	BCAA, Appraisers
COAST	0.4245	0.4966	Dummy: location (1 if Interior, 0 otherwise)	BCAA, Appraisers
ACCESS1	0.5283	0.5016	Dummy: distance from a mill (1 if between 32-64 km, 0 otherwise)	BCAA, Appraisers
ACCESS2	0.2547	0.4378	Dummy: distance from a mill (1 if greater than 64 km, 0 otherwise)	BCAA, Appraisers

Table 7. continued

Variable	Mean Value	Standard Deviation	Definition	Sources
TOPOG1	0.4340	0.4980	Dummy: average slope (1 if less than 40 degrees, 0 otherwise)	BCAA, Appraisers
TOPOG2	0.4151	0.4951	Dummy: average slope (1 if between 40-60 degrees, 0 otherwise)	BCAA, Appraisers
SOIL_G	28.04	27.26	Percent of good soil quality	BCAA, Appraisers
SOIL_M	45.42	31.87	Percent of medium soil quality	BCAA, Appraisers
SOIL_P	12.26	20.28	Percent of poor soil quality	BCAA, Appraisers
DATE	45.16	21.25	Number of month from transaction date to January, 1987	BCAA
CPI	0.9323	0.0684	Consumer Price Index (December, 1992=1)	Statistics Canada
INT	0.0862	0.0192	Risk-free interest rate (3-month Canadian Treasury Bill rate)	Statistics Canada
PRODUCER	0.4245	0.4966	Dummy: purchaser (1 if large forest firm; 0 otherwise)	Ministry of Forests

Tenure. The three types of tenures considered in this study are converted into two dummy variables (PFLu and PFLm) for analysis. PFLu takes the value of unity if the property is an unmanaged forest land, and the value of zero otherwise. Similarly, PFLm takes the value of unity if the property is managed, and the value of zero otherwise. The Timber License is treated as the base type; therefore, the dummy variables for managed and unmanaged forest lands are of primary

Table 8. Some Statistics on Unmanaged and Managed Forest Lands, Timber Licenses

Variable	Unmanaged Forest Lands		Managed Forest Lands		Timber Licenses	
	Mean Value	Standard Deviation	Mean Value	Standard Deviation	Mean Value	Standard Deviation
PRICE	3768.00	4398.30	3406.30	6193.30	1565.30	2493.00
VOLUME	127.75	111.43	199.58	202.77	334.46	190.92
D_FIR	40.46	34.04	28.97	25.13	10.17	17.34
HB	16.87	20.52	39.49	25.18	48.71	13.58
CEDAR	13.92	22.94	12.28	15.17	29.75	15.32
PRODUCT1	17.57	29.33	4.11	8.41	9.75	14.41
PRODUCT2	43.11	34.98	59.56	29.75	67.37	14.25
SIZE	85.53	204.60	68.55	125.79	230.87	424.08
COAST	0.3243	0.4746	0.4444	0.5025	0.5417	0.5090
ACCESS1	0.5676	0.5023	0.5333	0.5045	0.4583	0.5090
ACCESS2	0.2162	0.4173	0.3778	0.4903	0.0833	0.2823
TOPOG1	0.5135	0.5067	0.5227	0.5052	0.1250	0.3378
TOPOG2	0.4054	0.4977	0.3864	0.4901	0.5000	0.5108
SOIL_G	34.18	31.74	20.38	19.28	32.92	30.07
SOIL_M	44.57	35.70	51.76	29.65	34.83	27.63
SOIL_P	11.30	23.75	12.02	16.92	14.21	21.04
DATE	43.97	18.69	51.20	19.37	35.67	15.67
PRODUCER	0.1081	0.3143	0.7556	0.4346	0.2916	0.4643
Observation	37		45		24	

interest in this study. The variables for both managed and unmanaged forest lands are expected to have significant positive signs since the characteristics of private lands favour the owners more than those of Timber Licenses favour the license holders. The coefficients for PFLu and PFLm are expected to be equal.

Forest Cover. The average volume of timber per hectare on each property is included as a variable (VOLUME), and it is expected to have a positive sign. Four species (Douglas fir, hemlock and balsam, cedar) are singled out in this study in order to measure the effect of species composition on land price. These species account for more than 90 percent of the timber transacted through the Vancouver log market (Zhang and Binkley 1994) and 92 percent of the timber harvested on the Coast in 1991-1992 (Ministry of Forests 1993). Although these species are not so dominant in the interior, they still account for 39 percent of the timber harvested in 1991-1992 (Ministry of Forests 1993). To simplify the analysis, hemlock and balsam are treated as a single species because both have almost exactly the same quality, price, and end-use for the same grade, and in fact, the Ministry of Forests treats them as a single species in stumpage appraisal. This would reduce the analysis to three species variables — D_FIR, HB and CEDAR — which measures the percent of Douglas fir, hemlock and balsam, and cedar, respectively, on each property. The coefficients of these variables indicate the effect of these species on the land price per hectare, compared with the remaining species (a mixture of spruce, pine and hardwood species). The signs of these variables are expected to be related to timber prices by species.

Three forest products — peeler (and pole), sawlog, and pulpwood — are considered in this study. Two potential product variables (PRODUCT1 and PRODUCT2) measure, respectively, the percent of timber inventory that is for the purpose of producing peeler (and pole), and the percent of timber volume that is for producing sawlogs. The coefficients of these variables indicate the effect of the average tree size or potential timber products on the land value, compared to pulpwood. It is expected that both variables have positive signs.

Natural Attributes. The size of each property in hectares is included as a variable (SIZE). The price per hectare should vary inversely with the size of the tract because the market for large tracts of private forest lands is thinner. In other words, few buyers are willing to pay the costs of subdividing the lands. Furthermore, harvest costs vary inversely with the per hectare inventory, although perhaps weakly. Total timber volumes being equal, the value per hectare is inverse to the size of the parcel.

The distance to market is measured as the approximate distance from the property to the closest mill or log dump. Three categories of distance are used[30]. Two dummy variables (ACCESS1 and ACCESS2) are assigned the value of unity if the property is less than 32 kilometres away and between 32-64 kilometres away from the closest mill or log dump, respectively, and zero otherwise. The coefficients for these variables reveal the effect of these distances on land value, compared to the property that is greater than 64 kilometres away from the closest mill or log dump. Positive signs for these variables are expected, with ACCESS1 greater than ACCESS2. Similarly, three categories of topography are incorporated in the property assessment. Two dummy variables (TOPOG1 and TOPOG2) are assigned the value of one if the tract is flat (with an average slope of less than 40 degrees) and steep (with an average slope of between 40-65 degrees), respectively, and zero otherwise. The coefficients of these variables reveal the effect of flat and steep topography on

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[30] Distance to the market, and topographical variables can be treated as continuous variables. However, since data from BCAA record each of them in discrete form, this study follows this practice.

the per hectare value of a property, compared with very steep topography (with an average slope of greater than 65 degrees).

Four categories of soil quality (good, medium, poor, inoperable and non-productive) measure the natural productivity of the land. Three variables are used to take into account the effect of soil quality on the price of land. SOIL_G is a variable that measures the percentage of good soil quality included in a property; SOIL_M is a variable that measures the percent of medium soil quality and SOIL_P is a variable that measures the percent of the poor soil quality. The coefficients of these variables indicate the effect of good, medium and poor soil quality lands on land price compared with the effect of inoperable and non-productive lands. All of the soil quality variables should have positive signs, with SOIL_G greater than SOIL_M, and SOIL_M greater than SOIL_P.

Location and Others. Although three forest regions are included in this study, Kamloops and Nelson are combined as a single region (Southern Interior). A dummy variable (COAST) is assigned to a value of unity for each property in the Coast; all other properties are assigned zero. COAST is a location variable, and is expected to have a positive sign since the Coast is closer to population centres and to markets for forest parcels.

A date variable (DATE) is included to capture the time trend of land price. The monthly Canadian Consumer Producer Index is included as a variable (CPI) to test the effectiveness of forest land as a price hedge during inflation. A variable of risk-free interest rate (INT), which takes the value of the 3-month canadian treasury bill rate, is added to catch the financing cost of purchasing forest lands.

Producer's Characteristics. Finally, a dummy variable (PRODUCER) accounts for the effect of each producer's characteristics. It takes the value of unity if the purchaser of a property is a large integrated forest product firm and zero otherwise. The criterion used here to distinguish large forest product firms from others is the holding of committed cutting rights in the province. The top 20 companies[31], which collectively hold more than 74 percent of the committed annual allowable cut are designated as large firms. A significant positive sign indicates that these companies are willing to pay a higher price to hold more forest lands and timber. The explanation for this result could be the allowable cut effect (Pearse 1965) or economies of scale.

3. Empirical Results

The functional form of the hedonic equation is selected empirically by applying the Box-Cox techniques to the most common functional forms (linear-linear, linear-log, log-linear, and log-log). The log-log form has proven to be preferable[32]. The regression results are given in Table 9.

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[31] These companies are: Macmillan Bloedel, Fletcher Challenge, Canfor, West Fraser/Enso, Weldwood, Doman, Slocan, Westar, Canadian Pacific, Weyerhaeuser, Tolko Industries, Lakeland, Crestbrook, Repap, Ainsworth, Louisiana Pacific, Carrier Lumber, Pope and Talbot, and Lignum.

[32] Two methods are used here to choose the function forms. Both lead to the same conclusion. The first is maximum likelihood method. Spitzer (1982) and Judge *et al.* (1988) show that maximizing the Box-Cox likelihood function is equivalent to minimizing the residual sum of squares for the regression where the dependent variable is divided by its geometric mean prior to transformation. This method is used in Palmquist and Danielson (1989) and Washburn (1990). I divided each dependent variable by its geometric mean and estimated the four functions. The residual sum of squares is 3333 for linear-linear; 216 for linear log; 2400 for log-linear and 181 for the log-log model. Thus the log-log function form which has the smallest residual sum of squares is preferable.

The second method is comparison of R^2. Goldberger (1968) promotes this method. Since the four R^2's of functions which have different dependent variables are not directly comparable, comparable measures have to be proceeded. A log-linear equation exemplifies this method. First, compute the $\hat{Y}_i$'s, the calculated values from log-linear function; take their anti-logs, $\hat{Y}_i^* =$ antilog $\hat{Y}_i$. These are obviously estimates of the absolutes rather than logarithmic values. Second, compute the R^2 between Y_i and $\hat{Y}_i^*$. This is comparable to R^2's of linear-linear and linear-log functions, which

Column 1 of Table 9 is the result of a regression without the variable of PRODUCER. Most of the results for the explanatory variable are reasonable. Out of twenty (20) parameters estimated, sixteen (16) of them have the expected signs. Of those that have counter-intuitive signs, none is statistically significant from zero. Among the parameters with the expected sign, nine (9) are significant at a 90 percent confidence level or better. The following part of this section describes some parameters in detail.

Tenure. The coefficients for unmanaged and managed forest lands indicate that tenure is a significant factor in determining the land price. These parameters are significantly different from zero at the 90 percent confidence level. The regression results imply that the value of Timber License, expressed respectively as a percentage of the average value of managed and unmanaged private forest lands, is 22.6 percent and 34.1 percent. This means that, while all observations have a mean value of $3115.80 per hectare, Timber Licenses have the value of only $704.04-$1063.84 per hectare.

One may argue that these results are surprising, given the fact that everything else being equal, the difference in land price between private forest lands and Timber Licenses is the residual value after harvesting the mature timber. However, on closer examination, the results may be reasonable. First, private forest land owners own other things such as minerals and can use the land for non-timber purposes. In particular, unmanaged forest lands may be more valuable because they can be used in agricultural, recreational and other uses. Managed forest lands may be more valuable

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are the R^2 between $\hat{Y}_i$ and Y_i. The same logic applies to log-log function. I computed the estimated R^2's for log-linear and log-log functions as 0.2437 and 0.5463. Comparing them with the R^2's for log-linear and linear-log functions (0.2614 and 0.4806), it is evident that log-log function is the best.

Therefore the log-log function has been chosen. Notice also the constant price elasticity property of the log-log function.

Table 9. Empirical Results of Log-Log Equation for Forest Land Values

Variable	(1)		(2)	
	Coefficient	T-ratio	Coefficient	T-ratio
Tenure				
PFLu	1.4874	2.7550**	1.6447	2.9926**
PFLm	1.0746	1.8599*	0.9111	1.5190
Forest Cover				
VOLUME	0.0011	1.9900**	0.0009	1.8122**
D_FIR	-0.0641	-0.9410	-0.0478	-0.6947
HB	-0.0066	-0.0814	-0.0140	-0.1732
CEDAR	-0.0459	-0.6686	-0.0491	-0.7191
PRODUCT1	0.0579	0.3243	0.0040	0.0225
PRODUCT2	-0.1181	-0.1235	-0.0244	-0.0956
Natural Attribute				
SIZE	-0.0905	-0.6121	-0.0557	-0.3732
ACCESS1	0.7915	1.8082*	0.8996	2.0250**
ACCESS2	-0.3656	-0.7411	-0.3175	-0.6450
TOPOG1	0.0625	0.1155	0.1595	0.2938
TOPOG2	-0.0960	-0.1995	-0.1083	-0.2260
SOIL_G	0.0543	0.7577	0.0298	0.4060
SOIL_M	0.1999	2.4334**	0.1955	2.3898**
SOIL_P	0.1511	2.9194**	0.1583	2.4448**
Location and Others				
COAST	0.4065	1.0075	0.1992	0.4639

Table 9. continued

Variable	(1)		(2)	
	Coefficient	T-ratio	Coefficient	T-ratio
DATE	-1.2009	-2.1528*	-1.3602	-2.4017**
CPI	12.8220	1.8044*	13.2590	1.8732*
INT	0.8263	0.7517	1.1991	1.0932
INTERCEPT	14.0100	2.9194**	14.9740	3.1017**
PRODUCER			0.6727	1.3580
R^2	0.4408		0.4528	
R^2 -adjusted	0.3093		0.3161	
Observation	106		106	

since the owners enjoy the benefit of allowable cut effect (see below). Second, most Timber Licenses studied here will not expire before 2015. This means that some returns from harvesting the mature timber will not be captured immediately.

The test for identity of the coefficients for PFLu and PFLm, the dummy variables for unmanaged forest lands and managed forest lands, indicates that they are not identical at the 20 percent level (with T-ratio of 0.9034 and 84 degree of freedom). However, when the PRODUCER is added into the equation (column 2 of Table 9), their identity is rejected at 20 percent interval (with T-ratio of 1.4317). This may be because PFLu is picking some effects that were not included in the model, such as potential for development and non-timber uses.

Forest Cover. The value of forest land is strongly related to its forest inventory. The elasticity of the price per hectare of forest land with respect to average per-hectare volume is 0.0011. In other words, for a one percent increase (decrease) in average volume per hectare, the value of forest land per hectare increases (decreases) 0.0011 percent. Translating this information into real terms, a 2.05 cubic meter increase in timber volume (one percent of the mean timber volume) would result in a land value increase of $3.43 (0.0011 percent of the mean land value per hectare)[33]. The relationship between forest land value and species reveals that land value is not affected by species composition. No significant difference among the potential products is found, but the product variables do have the expected signs.

Natural Attributes. Soil quality is found to be significantly related to the land value. The significant positive coefficients of medium and poor soil quality indicate that the value of forest land tends to increase as the percent of medium and poor soil quality on the property increases. The variable for good soil quality has a positive sign, but it is not significantly different from zero. The coefficients for the land size variable are not significantly different from zero. But the variable sign confirms the studies in agricultural, forestry and real estate lands (e.g., Armstrong 1975; Vrooman 1978; Palmquist and Danielson 1989; Washburn 1990) in which the unit land value is found to be negatively related to tract (parcel) size.

The variable that measures the 0-32 km category of distance to mill is significantly different from zero, but the 32-64 category km is not significantly different from the greater than 64 km category. No significant relationship is found between land value and topographical variables.

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[33] This result is surprising given that the average stumpage was 7-10 dollars per cubic meter during the study period. One possible explanation is that some immature trees were reported by some owners.

Location and Other Variables. The coefficient for COAST indicates that the land value is positively related to location, but the per hectare value of forest lands on the Coast is not significantly different from that of the Southern interior once all other factors have been accounted for.

The coefficient for the transaction date indicates that the land value is negatively related to transaction date, and therefore the forest land price is declining over the study period. This trend is perhaps related to the 1990-1992 recession. CPI is significantly different from zero, but INT is not. These results mean that forest land is a good price hedge during inflation, and that the movement of interest rate does not affect the value of forest land very much. The latter may be due to too little movement over the sample period.

Producer's Characteristics. The results in column 2 of Table 9 reflect the addition of the variable of PRODUCER. This addition has little statistical relation to any of the variables other than PFLm. The t-ratio for PFLm is reduced and the variable becomes an insignificant variable at the 10 percent level with this addition. This outcome indicates that there is some collinearity between PFLm and PRODUCER. In fact, 34 out of the 45 managed forest lands are held by the large firms. These results imply that, in combination with the tenure of managed forest lands, the allowable cut effect has affected forest land value in B.C. (Pearse 1965). Large forest products firms do consider the allowable cut effect when they purchasing forest lands, especially when the lands can be added to Tree Farm Licenses.

4. Conclusions

The estimates of this chapter show that the per hectare value of the Timber License is only about 23-34 percent of that of private forest lands and that unmanaged forest lands are slightly more valuable than managed forest lands. This finding complements to the results of the preceding chapter, which asserted that AAC based on lands held under Tree Farm Licenses and Forest Licenses have low marginal values. More importantly, these findings could be applied to the values of lands under other tenures. For example, the characteristics of Forest Licences are not as complete as those of Timber Licenses. If so, lands under Forest Licenses must have a lower value than private forest lands as well.

The high value of private forest lands comes as no surprise, since in almost every aspect, private forest land is the most favourable form of tenure for the holder. Furthermore, the owners of unmanaged forest lands, by avoiding the commitment of sustainable timber production practice, can put a high value on their lands for recreation, fisheries, hunting and other uses. The owners of managed forest lands, on the other hand, benefit from the allowable cut effect if they hold their land in conjunction with Tree Farm License "Schedule B" lands.

VI. The Effect of Forest Tenure on Silvicultural Investment

1. Introduction

Investments in silviculture increase future wood supplies. The role that tenure plays in providing incentives to invest in silviculture, has been the subject of many theoretical studies (e.g., Pearse 1976, 1985, 1993). Previous empirical studies in this area are limited to the interview method (Luckert 1988; Luckert and Haley 1990).

Observed differences in silvicultural expenditure patterns among tenure types may be the result of several factors other than tenure arrangements themselves, including site quality, species composition, size, location and general economic trends. Although recognizing these other factors, Luckert (1988) and Luckert and Haley (1990) deal explicitly only with tenure type and soil quality. Furthermore, these studies are limited to two types of tenures — private lands and Tree Farm Licenses — which are important, but do not represent the majority of forest tenures in British Columbia. There have been no other empirical studies dealing with the relationship between silvicultural investment and tenures in B.C. and elsewhere in Canada, although there are a few similar studies in other sectors, notably in agriculture (e.g., Feder *et al.* 1988).

This chapter presents and discusses an empirical study examining the effect of forest tenure on silvicultural investment. An econometric model, as expressed in equation (13), is used to control all factors that affect silvicultural investment. The results have profound policy implications.

The chapter is organized as follows. The next section describes data used to estimate the silvicultural investment model. Section 3 discusses the empirical results, and Section 4 presents conclusions and policy implications.

2. Data

This study examines four major tenure types: private forest lands within Tree Farm Licenses, Crown lands within Tree Farm Licenses[34], Timber Licenses[35], and Forest Licences. Data on these tenures have been collected in the period from September 15, 1987 to May 15, 1993. The starting date is chosen because it marks the beginning of period of the recent changes in B.C. forest legislation whereby all major tenure holders were given the responsibilities and expense of silvicultural activities[36]. The date with the most recent information available is chosen as the end date. This five and half year period covers an entire business cycle (the boom years of 1988-1989 and the recession year of 1991-1992), and thus controls for changes in macroeconomic conditions.

The study examines silvicultural investment in the four tenure types in three regions in B.C. As in Chapter V, the regions studied include the Coast (Vancouver forest region) and the Southern interior (Kamloops and Nelson forest region). The observation unit of this study is a cutblock, which

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[34] In other words, Tree Farm Licenses excluding private forest lands and Timber Licenses.

[35] Includes Timber Licenses both within and outside Tree Farm Licenses. As indicated in Table 1, roughly half of the timber harvest under Timber Licenses in the province come from Timber Licenses within Tree Farm Licenses. The distribution of Timber Licenses in the sample studied in this thesis is unknown.

[36] Before that, three mechanisms had been used in silviculture: direct government silvicultural investment, licensees' voluntary investment and government reimbursement of approved silvicultural investment undertaken by licensees. Under that scenario, the comparison of actual silvicultural investment among tenures is very difficult since it is hard to distinguish these different types of investment. This is probably one reason that Luckert (1988) and Luckert and Haley (1990) used the interview method rather than actual observed data.

can be seen as a homogeneous unit in terms of the natural land attributes, the location, harvesting activity and species composition. The Ministry of Forests designates each cutblock as a single obligation and its licensee is required to report all pre-harvest silviculture prescription (PHSP) information. In addition, harvesting and silvicultural activities for each cutblock (or obligation) must be reported every four months or on a yearly basis.

Silvicultural investment. There are 28 types of silvicultural activities, or treatments)[37], designated by the Ministry of Forests. The Ministry requires licensees to report their silvicultural activities and their subsequent expenditures[38] in each Forest District[39] every year. If a licensee holds a few cutblocks under more than one type of tenure in a district, and has initiated a silvicultural activity on lands under all tenures within a year, the licensee is allowed to report the total costs of

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[37] These treatments are classified into four groups:

(1) regeneration — planting, replanting, fill planting, natural regeneration, mechanical planting, direct seeding;

(2) surveys — regeneration survey, sit preparation survey and free growing survey;

(3) site preparation — partial slash burning, whole cutblock burning, partial chemical treatment, whole cutblock chemical treatment, guard, partial treatment, mechanical treatment, road rehabilitation;

(4) stand tending — chemical vegetation control, stem clipping, crop covering, fertilization, animal brush control, manual vegetation management, infected tree removal, density control, pruning, seedling protection and spacing.

[38] All expenditures reported in this thesis are licensees' alone and do not include expenditures from federal-provincial Forest Resource Development Agreement (FRDA). This is because FRDA I (1986 - 1990) was focused on restoring backlogs (not satisfactorily restocked lands prior to 1982), and FRDA II (1991 - 1994) is focused on stand tending (spacing, pruning and fertilization). The observations (cutblocks) included in this thesis are not qualified to FRDA I, and the trees on these cutblocks are too young to be qualified for spacing and pruning treatments. Furthermore, fertilization only happened on 7 of the 2311 observations studied here and cannot have a significant effect.

[39] There are 23 forest districts in the study area. They are:

(1) Chilliwack, Campbell River, Duncan, Mid Coast, Port Alberni, Port McNeil, Queen Charlotte, and Squamish in the Vancouver forest region;

(2) Clearwater, Kamloops, Lillooet, Merritt, Pentiction, Salmon Arm and Vernon in the Kamloops forest region;

(3) Arrow, Boundary, Cranbrook, Golden, Kootenay, Invermere, and Revelstoke in the Nelson forest region.

that silvicultural activity as a single figure, while reporting the treatment area under each cutblock separately. Thus the unit cost of silvicultural treatment for a specific cutblock is unknown. To protect the confidentiality of the licensee, the Ministry aggregates both the costs of every silvicultural treatment type and the size of treatment in each district every year before releasing the information to the public.

Given this situation, the investment figure of a silvicultural activity implemented on each cutblock in this study is computed by multiplying the area of the activity undertaken by the licensee and the average unit cost of that same activity in the same district and the same year. The figure is then compounded or deflated to real dollar values in December of 1992 by using the Canadian Consumer Price Index. Adding up all investment figures of every silvicultural activity undertaken generates the total real silvicultural investment for each cutblock. Therefore the total investment figure of a cutblock is the accumulation of investment in all silvicultural activities undertaken on that block after harvesting completion to May 15, 1993. Here, it is assumed that the silvicultural industry in the study area is competitive and that conditions after logging are sufficiently similar so that all licensees incur roughly the same costs for the same silvicultural treatment in a given district, and that there is no systematic difference in the quality (and therefore the cost) of silvicultural activity across types of licenses.

For the present study, 2311 observations have been obtained, each pertaining to a cutblock, and revealing all of the information needed in this study. These cutblocks were logged during the period of September 1987, to December, 1988. Table 10 describes the variables used in this study. The real silvicultural investment per hectare is the dependent variable. The mean investment per hectare for all observations is $750.58, and the sample statistics for investment and other variables

Table 10. Definitions and Statistics of Silvicultural Investment Variables

Variable	Mean Value	Standard Deviation	Definition
INVESTMENT	750.58	622.45	Real silviculture investment per hectare as of Dec., 1992 ($)
PFL	0.0199	0.1397	Dummy: private forest land (1 if private forest land, 0 otherwise
TL	0.1320	0.3385	Dummy: Timber License (1 if Timber License, 0 otherwise)
TFL	0.2579	0.4375	Dummy: Tree Farm License (1 if Tree Farm License, 0 otherwise)
BALSAM	6.2713	14.9342	Percent of balsam regenerated
CEDAR	9.9714	19.2304	Percent of cedar regenerated
D_FIR	5.5534	19.2211	Percent of Douglas fir regenerated
HEMLOCK	13.6573	25.5595	Percent of hemlock regenerated
SPRUCE	22.9104	36.8229	Percent of spruce regenerated
SIZE	29.6861	29.2414	Size of cutblock (hectare)
SOIL_G	0.1238	0.3294	Dummy: soil quality (1 if good, 0 otherwise)
SOIL_M	0.8148	0.3885	Dummy: soil quality (1 if medium, 0 otherwise)
BGC1	0.3872	0.4872	Dummy: biogeoclimatic zone (1 if Coast Douglas Fir or Coast Western Hemlock or Montane Hemlock, 0 otherwise)
BGC2	0.2756	0.4469	Dummy: biogeoclimatic zone (1 if Engelman Spruce-subalpine Fir or Montane Spruce or Sub-boreal Spruce, 0 otherwise)
BGC3	0.0884	0.2836	Dummy: biogeoclimatic zone (1 if Interior Douglas Fir, 0 otherwise)

Table 10. continued

Variable	Mean Value	Standard Deviation	Definition
COAST	0.3981	0.4896	Dummy: location (1 if coast, 0 otherwise)
DATE	56.09	11.27	Number of month from January, 1987 to last silviculture complete date
INT	0.0849	0.0243	Risk-free interest rate (3-month Canadian Treasury Bill rate)
PRODUCER	0.6582	0.4755	Dummy: Producer Characteristics (1 if integrated firm, 0 otherwise)

among the tenures is presented in Table 11.

Tenure type. The four types of tenures are converted to three dummy variables (PFL, TFL and TL) for analysis. PFL takes the value of unity if the property is private forest land within Tree Farm Licenses, and zero otherwise. Similarly, TFL takes the value of unity if the property is Tree Farm License "Schedule B" lands, and zero otherwise; TL takes the value of unity if the property is under a Timber License,and zero otherwise. The Forest License is treated as a base type, and therefore the dummy variables for private forest lands, Tree Farm License and Timber Licenses are of primary interest in this study.

The variable for private forest lands is expected to have a significant positive sign because, as explained earlier, the characteristics of private lands favour the owner more than those of Forest Licenses. The signs of TFL and TL should also be positive, for two reasons. First, the characteristics of both Tree Farm Licenses and Timber Licenses are either less diluted than, or at least equivalent to those of Forest Licenses. Furthermore, Tree Farm Licenses are area-based tenures which may

Table 11. Some Statistics on Private Forest Lands, Timber Licenses, Tree Farm Licenses and Forest Licenses

Variable	Private Lands		Timber License		Tree Farm License		Forest License	
	Mean Value	Standard Deviation	Mean Value	Standard Deviation	Mean Value	Standard Deviation	Mean Value	Standard Deviation
INVESTMENT	839.44	471.26	645.38	572.39	800.69	811.62	745.95	607.22
BALSAM	8.5000	12.9178	11.4066	19.1222	6.6544	15.5626	4.8805	13.1600
CEDAR	18.8478	27.0259	22.8525	25.2338	11.6795	19.9085	6.0455	15.2022
D_FIR	26.0652	36.7897	9.9868	24.6404	5.4647	18.6050	3.9090	16.5475
HEMLOCK	21.0435	21.0259	37.9442	32.9603	17.0772	27.4843	6.4831	18.0449
SPRUCE	4.0435	8.0497	0.1085	27.3075	20.3758	35.3749	27.3519	38.9378
SIZE	31.4652	31.7023	30.6571	27.1463	28.2926	30.6571	27.1463	27.5759
SOIL_G	0.1087	0.3147	0.1013	0.3065	0.1864	0.3897	0.1031	0.3042
SOIL_M	0.8696	0.3405	0.8072	0.3952	0.7671	0.4231	0.8344	0.3718
BGC1	0.9783	0.1474	0.8758	0.3303	0.4193	0.4939	0.2455	0.4305
BGC2	0.0000	0.0000	0.0228	0.1499	0.2662	0.4424	0.3457	0.4758
BGC3	0.000	0.0000	0.0000	0.0000	0.0549	0.2280	0.1256	0.3316
COAST	0.9783	0.1774	0.8758	0.3303	0.4193	0.4938	0.2636	0.4408
DATE	54.52	12.06	57.93	10.04	53.41	12.92	56.97	10.66
PRODUCER	0.9130	0.2849	0.8399	0.3673	0.7520	0.4322	0.5701	0.4952
Observation	46		306		601		1377	

provide an incentive for their holders to invest more than in the case of a volume-based tenure such as a Forest License. On the other hand, this study has included a mixture of Timber Licenses, both within and outsides Tree Farm Licenses. Therefore, the sign of TL is expected to be positive although Timber Licenses outside Tree Farm Licenses have no residual values to the licensees.

Species. Regeneration costs differ among species (Smith 1986). Five species (balsam, cedar, Douglas fir, hemlock and spruce) are singled out in this study to measure the effect of species composition on silvicultural investment. These species account for more than 70 percent of the timber harvested in the province and the second growth crops should roughly be composed of the same proportion. So there are five species variables, BALSAM, CEDAR, D_FIR, HEMLOCK and SPRUCE, which measure the percentage of balsam, cedar, Douglas fir and spruce regenerated on a cutblock, respectively. The coefficients of these variables measure the effect of these species on silvicultural investment per hectare, compared with the remaining species (a mixture of pine, cypress and hardwood species). Since the regeneration costs for these species are not available, the signs of these variables cannot be predicted.

Natural Attributes. The size of each cutblock in hectares is included as a variable (SIZE). Again, the sign of this variable is not obvious because the effect of scale on forest regeneration is unknown. Three categories of soil quality (good, medium and poor) measure the natural productivity of the lands. Two dummy variables (SOIL_G and SOIL_M) are used to account for the effect of soil quality on silvicultural investment. SOIL_G is a variable taking the value of unity if the site class of a cutblock is good, and zero otherwise. SOIL_M is a variable taking the value of unity if the site class of a cutblock is medium, and zero otherwise. The coefficients of these variables indicate the effect of good and medium soil quality lands on silvicultural investment compared with the effect of poor soil quality lands. Both variables should have positive signs.

There are eight biogeoclimatic zones encountered in this study. To simplify the analysis, these zones have been classified into four groups, in consultation with forest ecologists[40], and three variables are assigned (BGC1, BGC2 and BGC3). BGC1 takes the value of unity when the biogeoclimatic zone is either Coastal Douglas Fir, Coastal Western Hemlock, or Montane Hemlock, and zero otherwise. BGC2 takes the value of unity when the biogeoclimatic zone is either Engelman Spruce-Subalpine Fir, Montane Spruce, or Sub-boreal Spruce, and zero otherwise. Similarly, BGC3 takes the value of unity when the biogeoclimatic zone is Interior Douglas Fir, and zero otherwise. The coefficients of these variables measure the effect of these biogeoclimatic types on silvicultural investment, compared with the biogeoclimatic type of Interior Cedar Hemlock[41]. The signs for these variables are not obviously predictable.

Producer's Characteristics and other Variables. Similar to Chapter V, a dummy variable — PRODUCER — is included to take into account the effect of the producer's characteristics. It takes the value of unity if the purchaser of a property is a large integrated forest products firm and zero otherwise. The top 20 companies[42], which collectively hold more than 74 percent of the committed annual allowable cut, are designated as large firms. A significant positive sign will indicate that these companies invest more in silviculture than other firms.

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[40] Professors Philip J. Burton and Gordon Weetman. Personnel Communication. 1993.

[41] Originally the Interior Douglas Fir is treated as the base biogeoclimatic zone. It is recognized later that, since there are no private lands in this base zone, such design may cause statistical error. Therefore, the base biogeoclimatic zone is changed to the Interior Cedar Hemlock. This change affects the results of all biogeoclimatic variables. However, it does not have any noticeable effect on the magnitude of the tenure variables.

[42] See note 31 in Chapter V. Fourteen of these 20 firms happen to be included in this study. They are: Ainsworth, Canadian Pacific, Canfor, Crestbrook, Doman, Fletcher Challenge, Interfor, Macmillan Bloedel, Pope & Tolbot, Slocan, Tolko Industries, Weldwood, Westar and Weyerhaeuser. All of them have area-based tenures and therefore the variable PRODUCER could capture some allowable cut effect as well.

A date variable (DATE) is included to capture the time trend of silvicultural investment. A risk-free interest rate variable (INT), which takes the value of the 3-month canadian treasury bill rate, is added to catch the financing cost of silviculture investment.

Location. Originally a dummy variable (COAST) is assigned a value of unity for each cutblock in the Vancouver forest region and zero otherwise to capture the effect of location on silvicultural investment. This variable is dropped later due to its significant correlation with BGC1. The correlation coefficient between them is 0.9724. This can even be seen in Table 11 by comparing these two variables.

3. Empirical Results

The functional form of equation (20) is selected empirically by applying the Box-Cox techniques to the most common functional forms (linear-linear, linear-log, log-linear, and log-log). The log-linear form is preferable[43]. The regression results are given in Table 12.

Most of the results for the explanatory variable accord with prior expectations. Out of eighteen (18) parameters estimated, sixteen (16) of them are significant at the 90 percent confidence level or better. The following portion of this section describes some parameters in detail. Again, the eighteen variables are categorized into four groups: tenure, species composition, natural attributes, producer's characteristic and others.

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[43] As discussed in note 32 of Chapter V, once the dependent variables have been transformed appropriately, the function form with the smallest residual sum of squares has been chosen. The residual sum of squares 3852 for linear-linear; 3926 for linear log; 2754 for log-linear and 2860 for log-log model. Thus the logarithmic transformation is consequential with respect to the dependent variable, but inconsequential to the independent variables.

Table 12. Empirical Results of Log-Linear Equation on Silvicultural Investment

Variable	Coefficient	T-ratio
Tenure		
PFL	0.5931	3.433**
TFL	0.2425	4.187**
TL	0.1419	1.749*
Species Composition		
BALSAM	-0.0121	-6.476**
CEDAR	0.0046	2.608**
D_FIR	0.0060	3.669**
HEMLOCK	-0.0096	-6.150**
SPRUCE	0.0053	7.0432**
Natural Attribute		
SOIL_G	0.2646	2.283**
SOIL_M	0.3975	4.078**
BGC1	-0.4462	-3.846**
BGC2	-0.2819	-4.148**
BGC3	-0.9736	-10.453**
SIZE	-0.0005	-0.598
Location and Others		
PRODUCER	0.2986	5.678**
DATE	0.0188	3.675**
INT	0.1022	4.386**

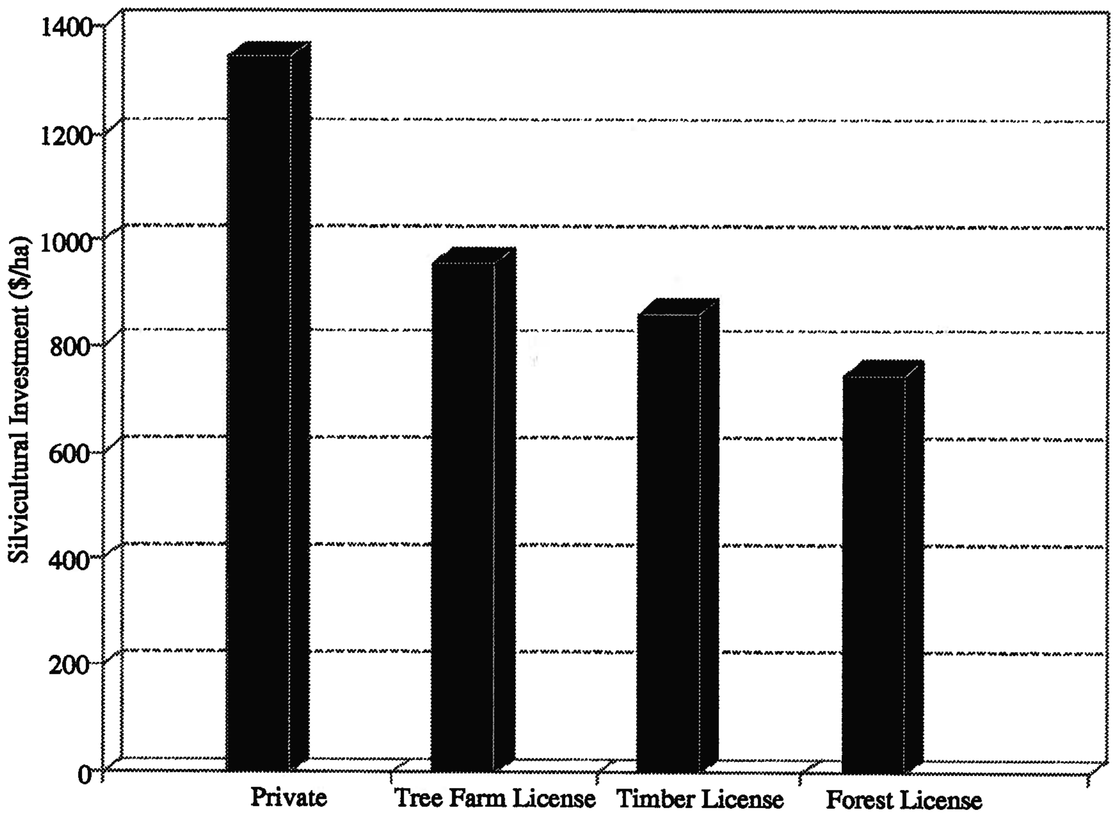
Table 12. continued

Variable	Coefficient	T-ratio
INTERCEPT	3.9780	8.223**
R^2	0.2011	
R^2 -adjusted	0.1951	
Observation	2311	

** Significant at 95 percent level.
* Significant at 90 percent level.

Tenure. The coefficients for PFL, TFL and TL indicate that tenure is a significant factor in determining the level of silvicultural investment. In fact, these parameters are significantly different from zero even at the 99 percent confidence level for PFL and TFL, and at the 92 percent level for TL. The regression results imply that per hectare silvicultural investment under Forest Licenses, expressed as a percentage of the investment in private forest lands within Tree Farm Licenses, Tree Farm License Schedule "B" lands and Timber Licenses, is 55.26, 78.47 and 86.77 percent, respectively. In other words, per hectare silvicultural investment in private forest lands, Tree Farm License Schedule "B" lands and Timber Licenses is 180.96, 127.44 and 115.25 percent, respectively, of the investment in Forest Licenses. Therefore, *ceteris paribus*, at the mean silvicultural investment amount of $745.95 per hectare under Forest Licenses, lands under private ownership, Tree Farm Licenses and Timber Licenses receive $1349.87, $950.64 and $859.71 investment per hectare (in the real dollar values of December, 1992). Figure 2 presents these predicted silvicultural investment using the regression results, at the sample means for all the data, and shows the impact of tenure difference alone.

Figure 2. Silvicultural Investment among Forest Tenures



Species Composition. Silvicultural investment is strongly related to species. The significantly positive relationship between silvicultural investment and cedar, Douglas fir and spruce reveals that licensees invest significantly more in regenerating these species than in a mixture of "other species" (other than balsam, cedar, Douglas fir, hemlock and spruce). This implies that these are more valuable species. In contrast, regenerating balsam and hemlock costs less than these "other species".

Natural Attributes. Soil quality is found to be significantly related to silvicultural investment. The positive coefficients of good and medium soil quality indicate that silvicultural investment tends to increase in good and medium soil quality lands. This finding is justifiable, given that good and medium soil qualities yield higher returns than poor soil quality. The three variables that measure biogeoclimatic types show that silvicultural investment varies in different biogeoclimatic zone. The coefficient for cutblock size variable is negative, but not significantly different from zero.

Producer's Characteristics and Other Variables. The coefficient of PRODUCER is positive, and significantly different from zero at the 95 percent level. This result could be interpreted with reference to the allowable cut effect, and economies of scale in the forest industry. Large and integrated firms that hold most of the area-based tenures can benefit from the allowable cut effect. They may also be efficient enough in generating revenue that they can invest more in silviculture. In addition, they may want to invest more in silviculture to ensure their current and future timber supply, and therefore protect their investment in large forest products manufacturing facilities.

A significant positive relationship is found between silvicultural investment and silvicultural ending date. Therefore, silvicultural investment is increasing over the study period. This trend is perhaps related to the 1992-1993 timber price surge, and the increasing emphasis on silvicultural investment in recent years. The coefficient of INT is positive, and significantly different from zero. This is counter-intuitive, because the investment in silviculture is expected to decrease when real interest rate rises, not increase as indicated here.

4. Conclusions and Discussion

Basic economics postulates that an investment activity must be justified by its return in the future. Silvicultural investment is no exception. Thus, tenure holders' investment decisions will be judged in terms of the future benefits that they expect the investment will bring to them.

The forest tenures in B.C., differ from one another in qualities such as comprehensiveness, duration, security and transferability, thereby defining the future benefits from silvicultural investment that accrue to the holders. Therefore, the tenure characteristics should affect silvicultural investment itself. In particular, the findings of this study show that the per hectare silvicultural investment of Forest Licenses is only about 55 percent of that on private forest lands, 78 percent of that on Tree Farm License schedule "B" lands and 87 percent of that on Timber Licenses, respectively. These findings are broader than those of Luckert (1988) and Luckert and Haley (1990), but consistent with their conclusions about private forest lands and Tree Farm Licenses.

The high silvicultural investment on private forest lands comes as no surprise, since in almost every aspect, private forest lands, as a tenure, favour the owners. The strong positive effect of Tree Farm Licenses and Timber Licenses on per hectare silvicultural investment verifies that the characteristics of these two tenures are favourable to their holders, and that area-based tenures are preferable to volume-based tenures.

These results should not be interpreted as asserting that lands under one tenure are managed "better" from a social point of view than lands under another tenure. Indeed, as Luckert and Haley (1990) observe, "the public and private objectives for management of forest differ and it is impossible to conclude that the intensity of forest management under a tenure (such as Forest License) is sub-optimal." However, it is possible to judge the findings of this study — the adequacy of silvicultural investment under four major types of tenures in B.C. — in the context of public objectives.

A recent study by Vertinsky, Wehrung and Brumelle (1990) shows that the forest industry, the provincial government, and the public all identify the stability of economic wood supply as their highest silvicultural priority. This goal calls for more silvicultural investment. However, as Pearse observed, "the enthusiasm of Canadians for public ownership (of forest lands) is not matched by an enthusiasm for big bureaucracies to manage them." Thus, attracting investment from the private sector seems to be the only choice. This analysis indicates that tenure is one of the most important factors in influencing the private tenure holders' investment decisions. Therefore, the rewards of pursuing the objective of restructuring the current tenure system will be significant.

VII. The Effect of Forest Tenure on the Quality of Forestry Practice

1. Introduction

This chapter investigates whether or not the current tenure system encourages private industry to practise good silviculture on public lands in B.C. No literature has been found, to my knowledge, that deals directly with the relationship between forest tenure and silvicultural performance. There are, however, a few similar studies in other sectors, notably in agriculture (e.g., Feder *et al.* 1988; Anderson and Lueck 1992), which address the relationship between land tenure and productivity (outputs).

This chapter is a further development of Chapter VI. Most data used in this chapter have the same source, definition and simple statistics as in Chapter VI. More importantly, the results of these two chapters are inter-related: forest tenures affect silvicultural investment, the amount of silvicultural investment determines the choice of silvicultural treatments and affects outputs. In addition, forest tenures may directly affect the forest practice and outputs as well.

The chapter is organized as follows. The next section starts with measuring outputs and silvicultural performance in forestry; followed by a brief discussion of the incentives and constraints associated with forest tenures that have determined tenure holders' silvicultural performance. Section 3 and Section 4 respectively describe models and data. Section 5 discusses empirical results, and conclusions and discussion are presented in Section 6.

2. Measuring Output and Silviculture Performance in Forestry

Relating land tenure and silvicultural performance calls for a measurement indicator. The indicator often used in agriculture literature is output or land productivity. It is difficult to have an output indicator in forestry for two reasons. First, there is no market for young stands under tenures other than private lands in B.C. Second, the development of other quantitative indicators is a lengthy process. For example, even indicators such as the achievement of free-to-grow status can only be available after regeneration activities have been undertaken for more than ten years in B.C. Therefore, only short-term readily available output measurements such as the existence of not-satisfactorily restocked lands[44] and the percentage of not satisfactorily restocked lands[45] (as comparing to gross harvested area) are used in this study.

The alternative is to measure the silvicultural activities performed by tenure holders by assuming that different silvicultural inputs lead to different outputs. Silviculture, however, has multiple dimensions. It includes the broad categories of site preparation, reforestation and stand tending, which aggregately consist of 28 officially recorded silvicultural activities[46] in B.C. Measuring each and every silvicultural activity is neither efficient nor necessary. For one thing, these

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[44] Not satisfactorily restocked lands refers to lands without stocking to a prescribed standard. The standard varies from site to site, but a typical rule calls for at least 750 trees per hectare of acceptable species to be established within three years of denudation on the Coast and 5 years in the interior (Pearse, Lang and Todd 1986). It is a general category that the Ministry of Forests uses to describe current forest land status. The appearance of not satisfactorily restocked lands is a gRd output indicator since it reveals the results of human efforts and the nature.

[45] The percentage of not satisfactorily restocked lands reveals the relative proportion of not satisfactorily restocked lands to the cutblock size. Using it as an indicator does not diminish the role of the existence of not satisfactorily restocked lands, since there are only about 10 percent of all cutblocks studied in this thesis have this category and the average proportion for these cut blocks is less than 0.1 or 10 percent. With the remaining 90 percent of cutblocks having the value of zero, the dependent variable itself bias toward zero and may overshadow the effect of any independent variable. Therefore, using this indicator only may not be appropriate to catch the whole picture of the effect of tenure and other variables.

[46] See note 37 in Chapter VI.

activities are, at least partly, reflected in the findings on silviculture investment in Chapter VI. Furthermore, there is some debate about the impacts of certain activities (e.g., broadcast burning and chemical treatment). Third, some treatments such as spacing, pruning and fertilization, are not widely used because there has been too little time to implement these treatments (e.g., spacing and pruning) since the latest legislation change in 1987[47]. Lastly, certain treatments (such as fertilization)[48] are rarely used. Therefore, this study has chosen the reforestation method, i.e., planting or natural regeneration, and the regeneration period (from the end of harvesting to the completion of planting) as two silvicultural performance indicators[49].

What is the role of tenure in silvicultural performance? As in the case of silvicultural investments, tenure provides a framework of incentives and constraints within which its holders operate and make decisions. Everything else being equal, the characteristics of the tenure determine whether tenure holders receive the future returns of silviculture, the quantity of these returns, the amount of their investment and the type of activities they choose. In turn, investment and silvicultural activity determine outputs such as not satisfactorily restocked lands.

The examples discussed in Chapter III make the point clear. The first example looks at two types of tenures. One is secure and lasts is forever; another has a 25-year duration, renewable on an "evergreen" basis, but its security is in doubt. Since they have a stake in future crops, the holders

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[47] See Chapter IV for a discussion about the changes in B.C. legislation in September, 1987.

[48] Fertilization only occurs in seven out of the 2311 cutblocks studied in this chapter.

[49] The legitimacy of choosing reforestation method as an performance indicator is that reforestation is the primary silvicultural costs and the difference between the costs of planting and the costs of natural regeneration is huge. It is hoped that revealing the choice of tenure holders on regeneration method will throw some light on their attitudes in costly activity. This is also the purpose for choosing regeneration period, since licensees who have different attitudes in costly activity may have different length of time to carry the activity.

of the former tenure may invest more and perform better silviculture, thus minimizing not satisfactorily restocked lands, than the holders of the latter tenure. In this simple case, the difference in silviculture investment, performance, and the existence of not satisfactorily restocked lands can be attributed to a characteristic of tenure, security.

The second example looks at area-based tenure versus volume-based tenures. The holders of area-based tenures may recapture some benefits of their silvicultural activities and therefore can quickly regenerate denuded lands. On the other hand, the holders of volume-based tenure, whose only incentive is to minimize their silvicultural costs, may delay regeneration as long as they are able to meet regulatory requirements. Again, everything else being equal, the difference in silvicultural performance in these two types of tenure can be attributed to whether the tenure is area based or volume based. The same logic applies to all of the indicators used in this chapter, namely, these indicators being the appearance of not satisfactorily restocked lands, the regeneration method, and the regeneration period.

3. Models

The models used in this chapter are variations of equation (21) discussed in Chapter III. They can be written in the form of a structural, economic model, based on cutblock (tract) observations:

(24) Occurrence of Not Satisfactorily Restocked Lands = $f(I, C_l, L, C_f, C_p, T_t, T_s)$

(25) Percentage of Not Satisfactorily Restocked Lands = $f(I, C_l, L, C_f, C_p, T_t, T_s)$

(26) Occurrence of Planting = $f(C_l, L, C_f, C_p, T_t, T_s)$

(27) Regeneration Period of Planting = $f(I, C_l, L, C_f, C_p, T_t, T_s)$

Equation (24) states that the existence of not satisfactorily restocked lands is a function of silvicultural investment, time, and all of the variables in equation (13). Equations (25) and (27) have the same independent variables as equation (24), but the dependent variables are, respectively, the percentage of not satisfactorily restocked lands, and the regeneration period of planting. Equation (26) shows the determinants of planting occurrence. It has the same variables as in equation (24) with the exception of the investment variable. This difference prevents the duplication of related variables on both sides of the equation and thus avoids man-made correlation between planting and investment[50].

Equations (24) and (26) are equations with qualitative dependent variables. The logistic regression is used to estimate them[51] [52]. The Box-Cox transformation technique or the maximum-likelihood method is used to find the functional formulation for equations (25) and (27). The regression results of these equations will reveal the contributions of tenure and other factors to silvicultural performance.

Notice, however, that equation (13) can be nested in equations (24), (25) and (27). As a result, a strong relationship between silvicultural investment and the tenure variables in equation (13),

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[50] See Section 2 of Chapter V for discussion of computing the investment figure for each cutblock studied.

[51] The linear logistic function has the form

$$\log(p/1-p) = \alpha + \beta'X$$

where p is the probability of an event occurring, α is the intercept parameter, and β is the vector of slope parameters. So

$$p = \exp(\hat{\alpha} + \hat{\beta}'X)/(1 + \exp(\hat{\alpha} + \hat{\beta}'X))$$

where $\hat{\alpha}$ and $\hat{\beta}$ are estimates of the intercept and slope parameters.

[52] Equations (24) and (26) were also estimated by using the linear probit function. As would be expected, the results are similar to those reported below.

as shown in last chapter, could detract from the influence of the tenure variables in these equations[53]. Therefore the following analysis is done both with and without the investment variable.

4. Data

All independent variables used in this chapter have the same origins, definitions and simple statistics as those of Chapter VI. The definitions and statistics of each dependent variable are presented in Tables 13 and 14. This section only discusses the expected signs of independent variables.

Tenure. It is expected that the variable for private forest lands (PFL) will be significantly negative in equations (24) and (25), and significantly positive in equation (26) and (27), since the characteristics of private lands favour the owners more so than those of Forest Licenses. The signs of TFL and TL should be the same as that of PFL for reasons similar to these given in Chapter VI; the characteristics of both Tree Farm Licenses and Timber Licenses are either stronger than, or at least equivalent to those of Forest Licenses. Furthermore, Tree Farm Licenses and Timber Licenses are area-based tenures which may provide their holders with stronger incentives to improve their performance than volume-based tenures such as Forest Licenses.

Investment. The investment variable assigned is expected to be significantly negative for equations (24) and (25), but positive for equation (27).

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[53] One may argue that estimation of equations (24), (25) and (27) involves two-stage least square regressions. In the first stage, equation (13) is estimated and the predicted investment, $\hat{I}$, is obtained. By using the predicted investment instead of the actual investment in the regression of equations (24), (25) and (27), the second stage reveals if tenure variables have additional effects on outputs. This approach is also tried. The results are indifferent from those reported in this chapter.

Table 13. Definitions and Statistics for Dependent Forest Practice Variables

Variable	Mean Value	Standard Deviation	Definition
NSR	0.0979	0.2972	Dummy: not satisfactorily restocked lands (1 if not satisfactorily restocked occurs, 0 otherwise)
% NSR	6.4952	30.4803	Percent of not satisfactorily restocked lands (NSR/Size)
PLANTING	0.7514	0.4323	Dummy: planting (1 if planting, 0 otherwise)
PERIOD	34.93	12.44	Regeneration period (number of month after harvesting to completion of planting)

Table 14. Some Statistics on Private Forest Lands, Timber Licenses, Tree Farm Licenses and Forest Licenses: Dependent Forest Practice Variables

Variable	Private Lands		Timber Licenses		Tree Farm Licenses		Forest Licenses	
	Mean Value	Standard Deviation	Mean Value	Standard Deviation	Mean Value	Standard Deviation	Mean Value	Standard Deviation
NSR	0.0222	0.1491	0.0915	0.28879	0.0915	0.28858	0.1046	0.3061
% NSR	0.2728	1.8305	4.6134	17.6466	5.2042	20.5029	7.6854	36.2847
PLANTING	0.8889	0.3178	0.7222	0.4486	0.7604	0.4272	0.7443	0.4363
PERIOD	32.95	13.46	37.83	11.29	31.11	14.05	36.10	11.47

Species. The signs of the species variables cannot be predicted.

Natural Attributes. The sign of the size variable is expected to be positive in equation (24) since not satisfactorily restocked lands are more likely to occur in big cutblocks. However, it should be negative in equation (25) since holding the size of not satisfactorily restocked land and everything equal, the percentage of not satisfactorily restocked lands should be negatively related to the cutblock size. Its sign in equation (26) and (27) should also be positive since natural regeneration is unlikely to be successful in large cutblocks. Both soil quality variables should have negative signs in equations (24) and (25), but positive signs in equations (26) and (27). The signs for the biogeoclimatic type variables are less obvious.

Others. The signs of PRODUCER and DATE are not obvious.

5. Empirical Results

5.1 The Occurrence of Not Satisfactorily Restocked Lands

Tenure. Column (1) and column (2) of Table 15 present the logistic regression results of equation (24) with and without silviculture investment as an independent variable, respectively. Private lands contribute negatively to the probability of not satisfactorily restocked land appearance in both cases. The coefficients of TFL and TL are negative but not significantly different from zero at the 20 percent level. This result suggests that private forest ownership has a significant negative effect on the probability of occurrence of not satisfactorily restocked land.

Figure 3 demonstrates the effect of forest tenure on the probability of not satisfactorily restocked land occurrence. This figure is based on the regression results in column (2) of Table 15, and on the assumption that the soil quality is medium, the producer is a large integrated firm, the biogeoclimatic zone variable is BGC1, and all continuous variables take their mean values. Also,

Table 15. Empirical Results for Logistic Equation: Appearance of Not Satisfactorily Restocked Land

Variable	(1)		(2)	
	Coefficient	Wald X^2 ratio	Coefficient	Wald X^2 ratio
Tenure and Investment				
PFL	-1.0521	1.8956*	-1.0829	2.0181*
TFL	-0.0808	0.1822	-0.0932	0.2244
TL	-0.2226	0.7541	-0.2549	0.9244
INVESTMENT	-0.0447	9.8042**		
Species Composition				
BALSAM	0.0077	21.6105**	0.0077	21.5149**
CEDAR	-0.0028	1.4450	-0.0032	1.9556
D_FIR	0.0049	3.6248**	0.0042	2.7703*
HEMLOCK	0.0095	12.6650**	0.0089	11.4460**
SPRUCE	0.0031	3.4468**	0.0030	3.1590**
Natural attribute				
SOIL_G	-1.0749	9.6090**	-1.0550	9.4129**
SOIL_M	-0.7681	9.4084**	-0.7842	9.8731**
BGC1	-0.7917	6.0467**	-0.6304	3.9526**
BGC2	-0.1456	0.3703	-0.1545	0.4296
BGC3	0.9926	14.3300**	1.0257	15.4987**
SIZE	0.1247	3.2807**	0.1282	2.9709**
Others				
PRODUCER	0.1334	0.5935	0.0933	0.2950
DATE	0.2339	0.4581	0.1396	0.1662

Table 15. continued

Variable	(1)		(2)	
	Coefficient	Wald X^2 ratio	Coefficient	Wald X^2 ratio
INTERCEPT	-0.9354	0.4027	-0.9445	0.4150
-2 log L	84.136		75.472	
Score	91.401		79.817	
Observation	2311		2311	

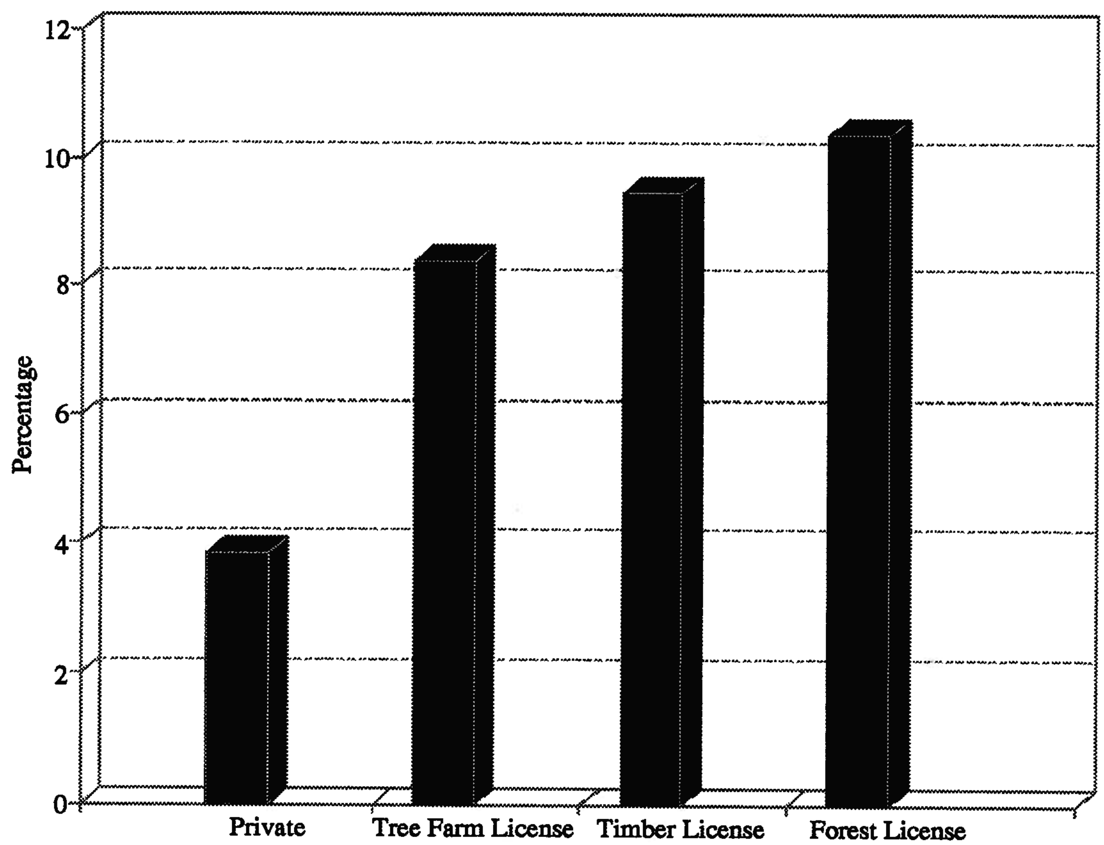
** Significant at the 10 percent level.
* Significant at the 20 percent level.

the logistic equations were transformed to compute the probability of not satisfactorily restocked land occurrence.

Investment. The coefficient of the silvicultural investment variable is negative and significantly different from zero at the 10 percent level. This finding is consistent with common knowledge: increased investment in silviculture is expected to reduce the appearance and amount of not satisfactorily restocked lands. When this variable is dropped from the equation, the effect of the tenure variables (and most other variables) increases (column 2 of Table 15).

Species Composition. The coefficients for the species variables show that, compared to the mixture of "other species", regenerating balsam, Douglas fir, hemlock and spruce contribute positively to the probability of having not satisfactorily restocked lands, but the effect of cedar is not different from that of "other species".

Figure 3. Probability of Not Satisfactorily Restocked Land Occurrence



Natural Attributes. Not surprisingly, good and medium soil quality contribute negatively, and cutblock size contributes positively, to the probability of having not satisfactorily restocked lands. The coefficients for the biogeoclimatic zone variables suggest that the probability of not satisfactorily restocked land occurrence varies in different biogeoclimatic zones.

Others. The coefficient of PRODUCER indicates that the probability of having not satisfactorily restocked lands does not vary among producers, once all factors are accounted for. The coefficient of the DATE variable reveals that the time trend of the probability of not satisfactorily restocked land appearance is static during the study period.

5.2 The Percentage of Not Satisfactorily Restocked Lands

The above analysis does not account for the relationship between the size of not satisfactorily restocked land and cutblock size. To strengthen the results of Table 15, equation (25) is estimated by using linear-log function form in which the continuous independent variables take the form of natural logarithm. The results (Table 16) support those reported in Table 15[54]. As expected, tenure, silviculture investment, size, site class, biogeoclimatic zone, and others all contribute significantly to the percentage of not satisfactorily restocked lands. All variables except CEDAR, SIZE and PRODUCER have the same signs as in Table 15. While the coefficients of CEDAR and PRODUCER are not significant in both cases, change in the sign of the SIZE is reasonable — everything else being equal, the percentage of not satisfactorily restocked lands should get smaller as the cutblock size gets bigger.

5.3 The Occurrence of Planting

Tenure. Table 17 presents the logistic regression results of planting occurrence as expressed in equation (26). PFL is positively related to the logistic probability of planting occurrence at the 10 percent level. The coefficients of TL and TFL are insignificant at the 10 percent level. Therefore, private lands contribute negatively to the probability of planting occurrence. The relationship between tenure and the probability of planting occurrence is presented in Figure 4, where the probabilities of planting occurrence are predicted using the results of Table 17, and assuming that the soil quality

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[54] The low R^2 indicates the lack of fit in the model estimated. This is primarily due to the fact that 90 percent of the cutblocks have zero percent not satisfactorily restocked lands, and therefore the independent variables are zero; and the remaining 10 percent cutblocks have independent variables close to zero. This limit of this regression is overcome by including the preceding regression in this chapter, namely, the regression on the occurrence of not satisfactorily restocked lands.

Table 16. Estimates of Percentage of Not Satisfactorily Restocked Lands

Variable	(1)		(2)	
	Coefficient	T-ratio	Coefficient	T-ratio
Tenure and Investment				
PFL	-0.0682	-1.438*	-0.0729	-1.535*
TFL	-0.0152	-0.969	-0.0161	-1.022
TL	-0.0366	-1.683*	-0.0383	-1.760*
INVESTMENT	-0.0054	-2.795**		
Species Composition				
BALSAM	0.0004	2.552**	0.0004	2.626**
CEDAR	0.0001	0.126	0.0000	0.046
D_FIR	0.0004	1.733*	0.0003	1.495
HEMLOCK	0.0004	1.904*	0.0004	1.835*
SPRUCE	0.0002	1.185	0.0002	1.108
Natural Attribute				
SOIL_G	-0.1066	-3.375**	-0.1062	-3.360**
SOIL_M	-0.1033	-3.879**	-0.1050	-3.940**
BGC1	-0.0454	-1.784*	-0.0342	-1.359
BGC2	-0.0079	-0.423**	-0.0074	-0.393**
BGC3	0.6318	2.502**	0.0693	2.720**
SIZE	-0.0161	-2.589**	-0.0168	-2.703**
Others				
PRODUCER	-0.0036	-0.250	-0.0067	-0.462
DATE	0.0146	0.513	0.0087	0.303

Table 16. continued

Variable	(1)		(2)	
	Coefficient	T-ratio	Coefficient	T-ratio
INTERCEPT	0.3080	2.470**	0.2929	2.348**
R^2	0.0251		0.0218	
R^2 -adjusted	0.0179		0.0159	
Observation	2311		2311	

** Significant at the 10 percent level.
* Significant at the 20 percent level.

is medium, the producer is a large integrated firm, the biogeoclimatic zone variable is BGC1, and all continuous variables take their mean values.

Species Composition. The coefficients for the species variable show that, as comparing to the mixture of "other species", balsam and hemlock contribute negatively, and Douglas fir and spruce contribute positively to the probability of planting at the 10 percent level. These results imply that artificial regeneration is more often used for Douglas fir and spruce than for "other species", and natural regeneration is more often used for balsam and hemlock than "other species". These results are expected since Douglas fir and spruce are the most valuable species.

Natural Attributes. Cutblock size and good soil quality affect positively the probability of planting occurrence. The positive effect of medium soil quality is insignificant at the 10 percent level. The coefficients for the biogeoclimatic zone variables suggest the probability of planting varies in different biogeoclimatic zone.

Table 17. Empirical Results for Logistic Equation: Planting Occurrence

Variable	Coefficient	Wald X^2 ratio
Tenure		
PFL	0.4436	3.1199**
TFL	-0.0080	0.0118
TL	0.0588	0.3503
Species Composition		
BALSAM	-0.0036	29.0322**
CEDAR	0.0011	1.3061
D_FIR	0.0027	6.5860**
HEMLOCK	-0.0032	10.6326**
SPRUCE	0.0018	6.7670**
Natural Attribute		
SOIL_G	0.2841	3.5951**
SOIL_M	0.0641	0.2781
BGC1	-0.1077	0.7935
BGC2	-0.1806	3.9426**
BGC3	-0.9063	65.1497**
SIZE	0.7161	6.3646**
Others		
PRODUCER	-0.0118	0.0297
DATE	-0.3557	6.7462**
INTERCEPT	1.9524	10.6878**
-2 log L	180.144	

Table 17. continued

Score	184.341
Observation	2311

** Significant at the 10 percent level.
* Significant at the 20 percent level.

Others. The coefficient of PRODUCER shows that the large firms and the small firms are indifferent in terms of choosing regeneration methods. The coefficient of the DATE variable reveals that the time trend in planting is declining during the study period.

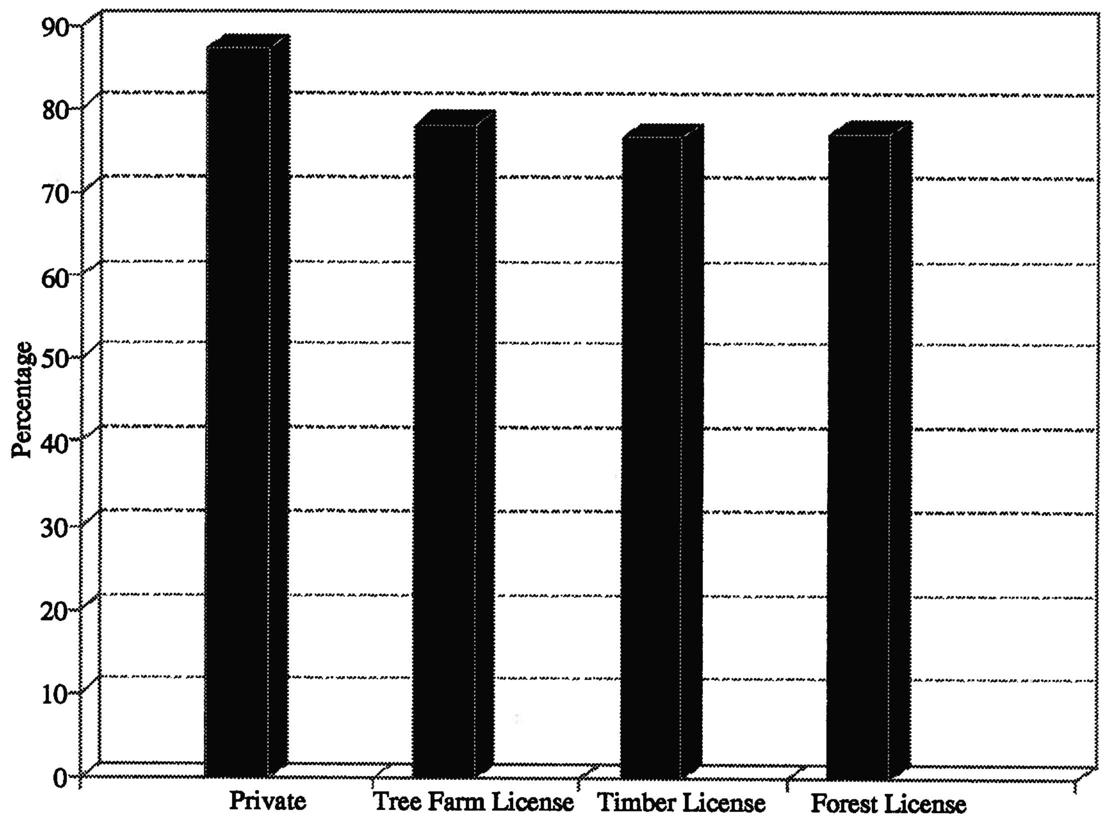
5.4 The Regeneration Period of Planting

Equation (27) is estimated by using 1732 cutblock observations, where tenure holders have chosen to plant rather than naturally regenerate. The functional form of the equation has been selected empirically by applying the Box-Cox technique to the most common functional forms (linear-linear, linear-log, log-linear, and log-log). The linear-linear form is found to be preferable[55]. The regression results are presented in Table 18.

Tenure. The coefficients for the tenure variables indicate that tenure is a significant factor in determining the period of regeneration, irrespective of the inclusion of investment variable. The negative coefficients of PFL and TFL are significantly different from zero at the 5 percent level. However, the negative coefficient of TL is insignificant. The regression results imply that, at mean

[55] The residual sum of squares is 93 for linear-linear; 153 for linear log; 104 for log-linear and 144 for the log-log model.

Figure 4. Probability of Planting Occurrence



regeneration period of some 35 months (Table 13), private lands are regenerated in 32 months and Tree Farm License schedule "B" lands are regenerated in 34 months.

Investment. The coefficient of INVESTMENT is positive and significantly different from zero at the 10 percent level. This finding comes as no surprise: tenure holders prefer to defer costly activities such as planting.

Species Composition. The regeneration period is strongly related to species. The significantly positive coefficients for balsam, Douglas fir and hemlock reveal that it takes longer for

Table 18. Empirical Results for Linear-Linear Equation: Months to Planting

Variable	(1)		(2)	
	Coefficient	T-ratio	Coefficient	T-ratio
Tenure and Investment				
PFL	-3.3393	-3.251**	-3.2571	-3.172**
TFL	-1.3550	-3.935**	-1.3328	-3.859**
TL	-0.5403	-1.117	-0.5402	-1.120
INVESTMENT	0.0004	1.787*		
Species Composition				
BALSAM	0.0449	4.047**	0.0434	3.915**
CEDAR	0.0158	1.526	0.0164	1.587
D_FIR	0.0189	1.927*	0.0203	2.070**
HEMLOCK	0.0471	5.096**	0.0468	5.068**
SPRUCE	0.0041	0.902	0.0054	1.194
Natural Attribute				
SOIL_G	0.0510	0.074	0.1000	0.145
SOIL_M	-0.0604	-1.042	-0.5641	-0.974
BGC1	0.8005	1.158	0.6835	0.993
BGC2	-0.6801	-1.673*	-0.7659	-1.896*
BGC3	1.5695	2.806**	1.4191	2.565**
SIZE	0.0139	2.909**	0.0137	2.878**
Others				
PRODUCER	0.0136	0.043	0.0517	0.165
DATE	0.9052	70.577**	0.9059	70.641**

Table 18. continued

Variable	(1)		(2)	
	Coefficient	T-ratio	Coefficient	T-ratio
INTERCEPT	-16.3190	-17.274**	-16.0846	-17.185**
R^2	0.7351		0.7347	
R^2 -adjusted	0.7331		0.7329	
Observation	1732		1732	

** Significant at the 5 percent level.
* Significant at the 10 percent level.

these species to be regenerated than "other species". The regeneration period for cedar and spruce is similar to "other species".

Natural Attributes. Soil quality is found to be an insignificant factor in determining the regeneration period. This may reflect current provincial regulations, which require that all cutblocks be regenerated regardless of soil quality. The regeneration period varies in different biogeoclimatic zone. The coefficient for the cutblock size variable is positive and significantly different from zero at 10 percent level. This means that the regeneration period is positive related to cutblock size.

Others. The regeneration period is not different among producers. The coefficient for DATE indicates that the length of regeneration period is positively related to the ending date of silvicultural completion, and therefore, the regeneration period is getting longer over the study period.

6. Conclusions and Discussion

The estimates of this chapter show that:

(1) not satisfactorily restocked lands are less likely to occur on private lands than on Crown lands under Tree Farm Licenses, Timber Licenses and Forest Licenses;

(2) where not satisfactorily restocked lands occur on private lands and Timber Licenses, the proportion of these lands to the total cutblock size is smaller than the proportion for Tree Farm License Schedule "B" lands and Forest Licenses;

(3) artificial regeneration is more frequently used by private land owners than the licensees of Tree Farm License Schedule "B" lands, Timber License and Forest License; and

(4) if planting is chosen as the regeneration method, the regeneration period for private lands is shorter than the periods for Tree Farm License Schedule "B" lands, Timber Licenses and Forest Licenses; and Tree Farm License Schedule "B" lands have a shorter regeneration period than lands under Timber Licenses and Forest Licenses.

The findings confirm that the characteristics of tenure affects the tenure holder's silvicultural performance. When a tenure is comprehensive, secure, transferable and long-term, such as the case of private lands, their holders shows a stronger interest in the future crop. Through investing more and choosing the most effective methods, they tend to eliminate not satisfactorily restocked lands. They apparently use costly and thus maybe more effective method (planting) to regenerate denuded forest lands. Furthermore, they regenerate cutblocks more quickly and avoid opportunity costs of prolonging the regeneration period.

On the contrary, if a tenure is not comprehensive, is insecure, is short-term and has limits on transferability such as Forest License, their holders may not benefit much from their silvicultural activities. Thus, the only incentive left to them is to meet the requirements of regulations with minimum cost. In fact, they can become so concerned about minimizing their costs that their actions can lead to an increase (at least temporarily) in not satisfactorily restocked lands. They are likely to avoid using more expensive methods, such as planting, to regenerate the lands. And, likewise, in an effort to avoid costs, they may postpone regeneration activities.

One can argue that all of the not satisfactorily restocked lands will ultimately be eliminated by the licensees at their own expense. Moreover, licensees must meet the requirement of free to grow status within a certain period of time. However, the occurrence of not satisfactorily restocked lands gives rise to opportunity costs, because the benefits of future crops are postponed. Delays in regenerating denuded forest lands represent such a loss to the public as well.

It is important to note that one should not infer from this that planting is better than natural regeneration. Given that planting costs more than natural regeneration, the fact that holders of some tenures consistently and deliberately avoid planting, merely implies that the characteristics of these tenures do not provide enough incentives for them to invest.

The findings of this and previous chapters reveal that property institutions do make a difference in land value and forest management. These results and the policy implications are summarised and discussed in the concluding chapter.

VIII. Summary and Conclusions

1. Summary and Conclusions

This study has investigated the role of tenure in determining forest land value and forest management. It attempts to describe these relationships through a detailed empirical study of actual tenure holder behaviour, an approach which has not been applied to the area of forest tenure. The primary results of the analysis can be summarised in the following paragraphs.

First, forest tenures in B.C. fall along the entire spectrum of "property". They are similar in exclusiveness, but vary considerably in other characteristics, namely comprehensiveness, duration, security, transferability and benefits conferred. The development of the model, based on the traditional theory of capital and a simplified version of forest tenures, predicts that forest tenure has a significant impact on land value and forest management.

Second, the event study of the forest policy change in 1987 shows that the marginal value of cutting rights under some forest tenures (Tree Farm License, Forest License, Major Timber Sale License and Timber Sale Harvesting License) is small. Explanations for this finding include factors such as existing log export restrictions, the earlier market anticipation, the insignificance of the net loss due to annual allowable cut reductions compared to the total assets of medium and large companies, and the plausible scenario that timber is fully priced for all tenures. However, no evidence is provided here on the total value of these tenures or the cutting rights under them.

Third, the estimation of forest land value reveals that private lands are significantly more valuable than Timber Licenses. This is because private forest lands, as a tenure, include the residual value of the bare land, and provide for more flexible use of the land and current stand of timber. Moreover, the owners of unmanaged forest lands are able to put a high value on their lands for recreational, agricultural and other non-timber uses, and owners of managed forest lands can enjoy the benefits of the allowable cut effect. Likewise, since all of the characteristics of Timber Licenses are less truncated than those of Forest Licenses, one would expect that private lands are more valuable than Forest Licenses, but the data are not available to demonstrate this.

Fourth, private lands, Tree Farm Licenses and Timber Licenses receive more investment than Forest Licenses. It is evident that there is a direct relationship between forest tenure and silvicultural investment. Silvicultural investment tends to be high when a tenure is comprehensive, long-term, secure and when all of the benefits of future crops are conferred to its holders. The opposite is true when a tenure is short-term, insecure and few benefits are left for its holders.

Therefore, greater investment in silviculture on private lands can be attributed to the comprehensiveness, security and perpetuity of private ownership, which allow the owners to gain all of the benefits of future crops after property taxes. Tree Farm Licenses have the advantage of being long-term and area-based, which could give their holders a sense of security in silvicultural investment. The result for Timber Licenses is less easy to explain. However, it can be explained, at least in part, by the fact that about half of Timber Licenses are within Tree Farm Licenses and will eventually become part of Tree Farm Licenses.

Fifth, the nature of forest tenures affects outputs. Specifically, not-satisfactorily-restocked lands are less likely to occur on private lands than on Forest Licenses, and even if they appear on private lands, their proportions to the total harvest area are smaller than those of Forest Licenses. Little difference among Tree Farm Licenses, Timber Licenses and Forest Licenses is found in outputs.

Similarly, forest tenure affects the performance of its holder. Costly silvicultural treatments such as artificial reforestation, are more often used by private forest owners than the holders of Forest Licenses. If planting is chosen as the regeneration method, the regeneration period for private forest land is shorter than those for Tree Farm Licenses, Timber Licenses and Forest Licenses; likewise, Tree Farm Licenses have a shorter regeneration period than Timber Licenses and Forest Licenses. The results can only be explained by the fact that private land owners (and to a lesser extent, Tree Farm License holders) have the necessary security and benefits conferred in their property. Again, the incentives and constraints of tenure affect the performance of tenure holders.

In summary, this study suggests four key conclusions.

(1) The value of private forest lands is higher than that of Crown lands under other tenures.

(2) Silvicultural investment behaviour is related to the characteristics of the property rights. The stronger and more complete a tenure, the more silvicultural investment.

(3) The outputs of land depends on tenure characteristics. When the characteristics of a tenure are less attenuated, the outputs will be greater.

(4) The behaviour of tenure holder can be predicted from their tenure characteristics. When a tenure is stronger and more complete, its holder will invest more and have better

silvicultural performance.

2. Consistency of Results with Theory of Property: Contribution of This Study

The theory of property suggests that property is a bundle of rights through which the holder can enjoy the benefits of an asset; each right has its characteristics, and differences in the characteristics of property rights have profound economic consequences. The more "complete" the characteristics, the more complete the property right, and thus the more valuable the property itself. Property rights also govern the incentives for holders to invest and perform, which in turn determine economic outcome. Any restrictions on full private rights are likely to blunt a property holder's incentives to invest, and the ultimate result will be lower output than there would be in the absence of restrictions.

The findings of this thesis are consistent with the theory. Forest tenures which are less "complete" than private ownership have lower values; the holders have weak incentives to invest more than the minimum requirements of regulations, and, as a result, the output of these lands is lower than the output of private lands. It is evident that the structure of property rights affects both the relative prices of inputs and the allocative decisions of the holders, and these alterations can be interpreted as adjustments of a given production function. Property rights also dictates which production function and technology the holder chooses.

3. Policy Implications

Before discussing the policy implications of this study, it is important to note the complexity of the issues surrounding forest tenure. First, the various tenure characteristics are not independent. That is, changing one characteristic modifies the others as well. The interdependency of tenure characteristics is best exemplified by a look at the dimension of economic benefit conferred, which is virtually affected by all other characteristics. Another example is belief in security, which can be affected by duration, transferability, and area- or volume-based tenure arrangements. Therefore, designing an optimal tenure is a difficult task.

The second, more serious, problem is to find a social utility function and then find the best public-private intersect, both of which influence the optimal specification of characteristics. The problem associated with finding a social utility function is well documented in economic textbooks. To choose the best public-private intersect could be exemplified by flexibility, referring to the extent to which the specifications of a tenure can be changed. Governments, as landlords, have been attempting to maintain the flexibility of tenures in order to cope with rising public demands on forest resources. In fact, it is one of the main motivations behind the of creation of volume-based tenures. However, as I have shown earlier, volume-based tenures have limitations in attracting private silvicultural investment.

A related issue is the transaction costs. The lack of private silvicultural investment in Forest Licenses does not necessarily mean that it is in society's best interests to take actions towards a more completely defined property rights. The transaction costs must be considered and weighted against the benefits of changing any tenure.

Despite these complexities inherent in tenure policy, decision-makers must choose a course of action regarding the structure of tenure policy. The findings of this study could provide some insights for future policy directions.

The most important implication of this study is that, in order to attract more investment in the forest industry, and to generate stronger incentives for forest users to perform good silviculture, more complete forms of forest tenure should be designed.

Tenure should be comprehensive, but this does not mean that forest companies need to have the rights to all resource values on forest lands. As long as exclusivity prevails for each resource interest, the must advantageous balance among users can be achieved as long as every interest is represented by someone who can bargain with others when conflicts arise (Pearse 1988, 1993).

The balance between duration (and renewability) and flexibility is also important. A longer term tenure is warranted if it does not jeopardize the necessary flexibility of the government. To take full advantage of market mechanisms to ensure that forest resources are used efficiently, forest tenures must be transferable.

Second, area-based tenure is more attractive to private investment than volume-based tenure, and improves tenure holders' silvicultural performance. This implication is drawn from the comparison of silvicultural investment and the quality of forest practice between Tree Farm License and Forest License. Everything else being equal, area-based tenure gives holders more security and an incentive to manage. One way to change this may be to modify the current Tree Farm Licenses and to redesign some, if not all, Forest Licenses along the lines of Tree Farm Licenses. In fact, International Forest Products Limited has recently proposed a "Supply Block Management Unit" to convert chart areas of a Forest License into, in effect, area-based tenure[56].

Third, lack of equity in future crops prevents benefits and costs from being internalised by tenure holders and leaves them with little incentives to invest and to manage. This lack of equity could be achieved by replacing the current stumpage system with some revenue device that does not vary according to the timber produced, such as initial, lump-sum charge for the forest tenure or a fixed land rent.

Hitherto, no comment has been made about the characteristic of property referred earlier — the economic benefit conferred to the holder. Everything else being equal, the more economic benefits left to the holders, the more they will invest in silviculture. In order to change this important characteristic one may immediately pay attention to the stumpage system. Luckert and Haley (1989) argue that, although the current stumpage system in B.C. makes some indirect allowance for basic silviculture, it aims at extracting all the rents for the public owner, and therefore leaves no reward to those who produce more forest growth. It thus fails to attract much investment in intensive silviculture (Luckert and Haley 1989). A cropsharing system, which leaves a share of the rents to the licensees, would mitigate this problem. Therefore, replacing the current stumpage system with cropsharing system could provide some economic incentive for improved management.

Likewise, if tenure holders are fully compensated when their rights are terminated, they will regard their holdings as more secure. The issues surrounding compensation are discussed extensively in Schwindt (1992), who argues that when termination occurs, the forest property rights should not be compensated, but the costs of tenure holders should be reimbursed. The results of this study

[56] Clark S. Binkley. 1994. Personnel Communication.

support the principle of compensation.

One way to advance these objectives involves selling the rights to timber production on forest lands, but retaining public ownership of the land itself. These arrangements fall just short of private ownership of land, but strengthen the economic benefits conferred to the holders, and provide them with the necessary economic incentives. This approach has been initiated by the New Zealand government (New Zealand Forestry Corporation 1989), and certainly suggests an alternative to the public forest tenure system in British Columbia.

The characteristics of property rights affects land value, silvicultural investment, and outputs. Simply knowing that the tenures such as Forest Licenses attract less silvicultural investment than other types of tenure does not necessarily imply that these tenures should be abolished or changed. However, this thesis has demonstrated that the potential benefits of pursuing this objective, to particularly to the B.C. government which owns more than 95 percent of forest lands, are huge.

4. Further Study

This study has drawn attention to the need for research in several related issues. One is the transaction costs associated with different types of tenures. Forest tenure change can only achieve beneficial results if the net gains outweigh the transaction costs. A second is to examine the political feasibility or public acceptance of tenure change: an investigation that relates more closer to political science than to economics. Without enough political will or public support, any tenure change is unlikely to be successful. A third is the environmental issues associated with forest tenures. The general perception is that property rights for non-timber interests are weak. This thesis does not explicitly deal with this issue. Further study is warranted in designing the property rights for these uses.

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