Contractual Structure in British Columbia's Silviculture Sector:

A Transaction Cost Economic Analysis

by

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A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF

THE REQUIREMENTS FOR THE DEGREE OF

DOCTOR OF PHILOSOPHY

in

THE FACULTY OF GRADUATE STUDIES

(Department of Forest Resources Management)

We accept this thesis as conforming
to the required standard

THE UNIVERSITY OF BRITISH COLUMBIA

November 1997

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Vancouver, Canada

Date Dec. 3, 1997

DE-6 (2/88)

Abstract

This dissertation investigates the effects of institutional reforms in British Columbia's silviculture sector. Based on transaction cost economics, the institutional restructuring in BC's silviculture sector, especially since 1987, is argued to have effected the contractual relationships for silvicultural performances in response to the need to economize on transaction costs. Research emphasis is on forest companies' choice of contractual forms between contracting out and in-house operation.

An analytical framework is developed through the presentation of a theory of contractual choices and the identification of a set of transaction cost attributes and firm characteristics. Hypothesis testing is performed by means of probit and ordered probit models, using survey data. Empirical results confirm the general validity of transaction costs theory that firms pick contractual forms in accordance with the attributes of silvicultural activities and firm-specific characteristics.

Separate regression analyses have also been conducted to examine the determinants of forest companies' choice of payment schemes such as piece wages and time rates and the determinants of silvicultural contractors' performances. Changes in the structure of silvicultural costs during the period 1987 - 1996 have also been examined through a case study of a major forest company that operates on the BC Coast.

The empirical results confirm that contractual forms tend to align with transaction attributes and firm characteristics so that some costs of transacting can be saved. The research findings suggest that neither pure market-based outsourcing nor vertically integrated in-house forms necessarily prevail. Ultimately, the choice of governance modes is dictated by the nature of the transactions involved.

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Acknowledgment

Completing a Ph.D. program is a process of faculty development and skills enhancement in preparing oneself for a life-long pursuit of knowledge with rigor and determination. First and foremost, I wish to thank Professor G.C. van Kooten for his mentorship throughout my program. I am indebted to him for his guidance in the choice of a dissertation topic, his help with careful research design, and his support in funding arrangements. I wish to thank Professor David Haley for his valuable insight in BC's forest policy issues and for his suggestion on adopting a transaction cost economics approach to the analysis of BC's silvicultural institutions. I am grateful to him for his guidance as my acting research supervisor during Professor van Kooten's sabbatical leave. I wish to thank Professor Ilan Vertinsky for his penetrating vision on the "big picture of paradigms", his stimulating thoughts on the dynamics of social institutions, and his provision of generous financial assistance by involving me in a number of research projects. I wish to thank Dr. Jennifer Wohl for her help with econometric techniques and presentation skills. I wish to thank Dr. Bill Wilson for his keen interest in and warm encouragement for my research. I am thankful to my research supervisory committee for its collective wisdom. I would like to thank Professor William F. Hyde, Professor Richard R. Barichello and Professor Gordon F. Weetman for their constructive criticism and helpful suggestions on ways to strengthen my arguments. I would also like to thank Professor William Stanbury for his willingness to share his scholarly experience and for his advice on building up "multiple portfolios" in pursuing career goals.

Many people have helped me in one way or another. I wish to acknowledge my fellow graduate students at UBC's Forest Economics and Policy Analysis Research Unit (FEPA) for their interactions as well as their friendship. I am thankful to Mabel Yee for her readiness to help and for her diligence that has turned FEPA into a fun workplace.

Finally, I thank my parents for their love, understanding and confidence. I thank my wife, Sulan Dai, for her love, patience and perseverance in going through, together with me, the high and low moments of this process.

Chapter One

Institutional Changes in British Columbia's Silviculture Sector

1.1 Introduction to BC's Silviculture Sector

British Columbia is Canada's westernmost province. It covers 96 million hectares and has a population of 3.7 million (Statistics Canada 1997). As of the mid 1990s, forest land accounts for 64% of BC's total area (Natural Resources Canada 1996).

For one and a half centuries, the forest resource base has served as the cornerstone of the BC economy. However, the patterns of forest resource utilization have undergone changes over time. Initially, forests were harvested in a 'mining' fashion (Pearse 1976). Concerns for forest conservation did not emerge until the beginning of the twentieth century. Changes in forest structure and in species composition have taken place due, in part, to the enhancement in utilization standards that are driven by demand and technological change encouraged by public policy. Aside from the driving force of the sustained-yield policy that was adopted on the basis of the Sloan Commission Report (1945), relative scarcity of forest resources, concerns for production costs and heightened awareness of environmental issues contributed to the emergence of a distinct silviculture sector.

In BC, silvicultural activities first appeared in the late 1920s, marked by the establishment of the first production forest nursery at Green Timbers in Surrey (Young 1989a). The past seven decades may be divided into four stages: (i) pre-1950, initiation period; (ii) 1950 - 1978, framework-evolving period; (iii) 1979-1987, backlog reforestation period; and (iv) from 1987 onwards, basic silviculture period (Knight 1990).[1] The evolution of silvicultural programs is characterized by a progression from heavy reliance on natural regeneration (until quite recently two thirds of BC's cut-over sites were naturally regenerated) to conscientious human interventions in reforestation and planned forest renewals. In terms of activity intensity, the trend has

[1] The concept of basic silviculture emerged in 1979 with the new Forest Act. According to B.C. Reg. 385/81, 'basic silviculture' is officially defined as 'surveying, planting, direct seeding, brushing and weeding and site preparation for regeneration'. Since 1987 when major licensees were formally required to be responsible for basic silviculture on Crown land, the attainment of free-to-grow status has become a mandatory obligation.

been a gradual transition from simple task-based operations to increasingly complex outcome-oriented programs.

Given the predominance of public ownership of BC's forest land (94%), the relatively short history of the development of silvicultural programs bears out a prominent feature, namely, the necessity of integrating private initiatives into the undertaking of production and management activities on public properties. The choice to retain Crown ownership of forest lands while allocating the rights of timber harvesting to individuals via a variety of leasing and licensing arrangements seems to have worked effectively only to the extent of timber removals (Pearse 1988). The difficulty of having cut-over sites rapidly and appropriately regenerated had been a central concern to policy makers up to the late 1970s, and institutional restructuring to promote silviculture has been a key element in the overall reform of the Province's forest policy sector since the 1980s.

There seems to have been four major trends in the evolution of BC's silviculture sector. First, beginning with seedling production, silvicultural activities proceeded from planting merely for the purpose of reforestation of harvested sites towards forest renewal-oriented timberland management with greater emphasis on the enhancement of multiple forest values. After several decades of slow progress, this process has accelerated over the last twenty years. Second, the institutional structure has evolved from a Forest Service-centred mode to a multi-strata system whose centre of gravity has moved towards forest tenure holders. For instance, in the 1950s, responsibility for forest regeneration became that of the holders of Tree Farm Licences (TFLs). During the 1960s, gradual transfer of responsibilities to licensees occurred in the Public Sustained Yield Units. The 1970s saw the implementation of the "credit against stumpage" system. By the late 1980s, full responsibility for basic silviculture, both physical and financial, had been transferred from the Forest Service to major licensees, except for operations under the Small Business Forest Enterprise Program.[2] Third, in parallel, financial obligations for basic silviculture have gradually shifted from the Forest Service to major licensees. The trajectory began with the government supply of seedlings for reforestation, free of charge, to private forest land owners in the 1950s; it progressed to a "stumpage offset" system (based on approved costs) that was initially adopted in 1964 and became "credit against stumpage" in the form of "Section 88" of the Forest Act (British Columbia Legislature 1979); and culminated in 1987 with mandatory financial obligation for basic silviculture residing with major licensees. Lastly, quality standards have risen steadily in an increasingly regulatory environment. Examples include the requirement of commitment to a free-to-grow status (initially introduced in 1979), pre-harvest silviculture prescription (PHSP) (formally introduced in 1987) that subsequently was replaced by silviculture prescription (SP), a five-year silviculture plan (officially introduced in 1995), and other Forest Practices Code-related requirements (phased in from 1995 onwards).

The first trend is concerned with the growth patterns, in terms of both scope and scale, of silvicultural programs. The second trend is concerned with the evolution of institutional structures for physical operations. The third trend is concerned with the financial arrangements necessary for carrying out silvicultural activities, while the final trend is concerned with regulatory aspects of silvicultural operations. Specifically, silviculture prescription is, conceptually, a good idea because it ensures the important position of silviculture, because cutting cannot proceed until a silviculture plan is in place. Literally, silviculture prescription becomes a key task that can have system-wide effects, the delay of which may hinder or jeopardize progress on cutting operations.

The evolution of historical driving forces behind institutional changes provides a context for the analysis of concrete silvicultural activities. Table 1.1 provides a chronology of the trends and other major events that shape the Province's silviculture sector.

1.2 Evolving Patterns and Paradigm

As a result of a series of reforms in the past two decades, and especially since 1987, the institutional structure of BC's silviculture sector now has the following features:

(1) the BC Ministry of Forests (MOF) is bound by legislation to administer the Province's silvicultural programs on Crown land, and relevant legislation includes the Forest Act (RS 1979, Chapter 140), the British Columbia Forest Renewal Act (SBC 1994, Chapter 3) and, above all, the all-encompassing Forest Practices Code of British Columbia Act (SBC 1995, Chapter 4)[3];

[2] Major licensees are those that hold major licences such as tree farm licence, forest licence, timber licence and so forth.

[3] The Forest Practices Code consists of the Act, Regulations, Standards and Guidelines.

(2) the major licensees are required by law to undertake basic silviculture to the free-to-grow stage after timber harvest,[4] and their silvicultural performances must adhere to pre-harvesting silviculture prescriptions and comply with established standards;

(3) government involvement in actual silvicultural operations has been reduced sharply with only two undertakings left—the delegation of management authority to Forest Renewal BC (Table 1.1) and a program-based undertaking known as the Small Business Forest Enterprise Program;

(4) the majority of the planting material production facilities has been privatized, with some 90% of the seedlings used for planting each year supplied by some 40 commercial and industry nurseries, with the MOF owning only three nurseries; and

(5) reforestation contractors implement the majority of silvicultural activities for forest companies and the MOF.

What is the nature of the trends in BC's silviculture sector? There are at least four dimensions. The widening scope of silvicultural operations, which range from seedling production to fertilizing and surveying, is testimony to a transition from old-growth to second-growth harvesting and management. Figure 1.1 shows the scope of expanded silvicultural programs. In terms of scale, the increase in the number of seedlings planted is indicative of an accelerated growth and reflects changing policies, and this feature was most pronounced in the latter part of the 1980s (see Figure 1.2).

The expansion of silvicultural programs necessarily brings about changes in institutional arrangements. As far as physical arrangements are concerned, at first the Provincial Forest Service was the only player in performing reforestation tasks on Crown land. Beginning in the 1970s, the single-player model gradually gave way to an umbrella-shaped structure. Consequently, the Forest Service moved towards acting as a focal point in engaging forest companies, silviculture contractors and workers for the performance of silvicultural activities. As a result of the policy changes of 1987, a stratified structure has emerged that realigns the relationship among the Forest Service, companies, contractors and silviculture workers in a vertically connected manner (see Figure 1.3).

[4] Free-to-grow stands refer to those that meet stocking, height, and/or height growth rate standards and are judged to be essentially free from competing vegetation.

The development of silviculture and changing relationships among an increasing number of players have had financial implications. The situation is that basic silviculture is now paid for by major licensees, and incremental silviculture has been financed largely by specially earmarked programs, such as the Canada-British Columbia Forest Resource Development Agreement (FRDA) during the period 1985 - 1996 and by Forest Renewal BC (FRBC) in the foreseeable future. Given this, licensees are expected to perform silvicultural activities by taking funding sources and other factors into consideration.

The above trends are open to different interpretations. One way is to view them from an institutional perspective. Evidently, the emergence and growth of BC's silviculture sector have brought about or responded to changes in institutional structures. As the scope and scale of activities exceeded the capacity of the Forest Service, actions were necessary in decentralizing physical delivery of silvicultural programs at the operational level. The privatization of eight government nurseries in 1988 provided additional evidence. However, in the meantime, decentralization has taken place under intensified legislative regulations and administrative controls.

The outcome is a specialization of productive functions and vertical integration of management relationships.[5] One outstanding feature is that an agency relationship has become more visible. Conceptually, the Ministry of Forests, major licensees and silviculture contractors are engaged with one another in a two-strata contractual structure, with the MOF and the licensees forming the upper-level "principal-agent" relationship, and the licensees and contractors engaged in the lower-level relationship. In consequence of the series of institutional reforms in BC's silviculture sector over the past decade or so, the MOF has now been relieved of responsibilities for direct involvement in physical operations (except in SBFEP) to become more specialized in administering and monitoring silvicultural programs. Meanwhile, the major licensees have become more specialized in managing forest operations in a manner that unifies harvesting and silviculture planning, leaving much of the physical silvicultural work to silviculture contractors.

In essence, BC's institutional reforms have brought about two fundamental changes. One is a change in the institutional environment and the other a realignment in contractual relationships. While the former is indicated by the emergence of a new legislative and policy framework that has taken into account public

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[5] In transaction cost economics literature, the term 'vertical integration' refers to a hierarchical alignment of contractual relationships. When the relationships are less organized, the term 'vertical coordination' is used. The case of BC is probably somewhere in between.

aspirations for enhanced silvicultural products and practices, the latter finds expression in the establishment of a new relationship in concrete silvicultural performances.

1.3 Research Problem

According to Williamson (1996), changes in the institutional environment trigger 'shifts' in production and organizational parameters, giving rise to a need to redesign governance structures.[6] Typically, the choice of governance structures in arranging silvicultural operations in BC has been dichotomous in the post-1987 period. Some silvicultural activities are performed by forest companies in-house through their internal hierarchical structures, but some other activities are contracted out to specialized silviculture contractors. While the latter represents market-oriented contractual arrangements, the former falls into the category of vertical integration. Of course, a variety of "hybrid" and "intermediate" forms exist over the spectrum of contractual modalities.

Reforms in the institutional structure concerning basic silviculture (as a separate undertaking to incremental silviculture) constitutes the core of the context of this research. Since 1987, a series of reforms have unfolded and these reforms have significant implications for governance choices by which silvicultural work is organized, resulting in changes in the cost structures and incentive schemes of individual operations. Based on the patterns of the institutional evolution identified above and the characterization of BC's silviculture sector, several questions are posed.

1) Why has restructuring happened in the institutional framework of the silviculture sector in a manner characterized by decentralization of activities under a tightened regulatory atmosphere?
2) Given the changes in the institutional environment, why do governance structures differ in the sense that firms choose the mode of vertical integration for some silvicultural activities while electing to relegate responsibilities to independent contractors in other activities via market oriented contractual arrangements? That is, why are some silvicultural activities performed "in-house" while others are

[6] According to Palay (1984, p.265), the term 'governance' refers to the institutional framework in which contracts are initiated, negotiated, monitored, adapted, enforced, and terminated. The term was first used in this context by Williamson (1979).

contracted out? What firm and activity characteristics cause some forest companies to perform an activity in-house while another company contracts it out?

3) What is the rationale behind the private sector taking certain actions in order to meet basic silviculture obligations and to what extent do these actions successfully match the attributes of the chosen governance structures?

In terms of emphasis, the first question is concerned with overall changes in the institutional structure and environment, and it is addressed by a theoretical analysis in Chapter 3. The other two questions are dealt with separately in the empirical part of the dissertation. Considering that this research emphasizes the contractual relationships that are involved in silvicultural activities, silvicultural planning and other professional aspects are outside the scope of the dissertation.

1.4 Outline of Study

The second and third chapters are concerned with theory. Chapter 2 outlines the theoretical basis of the dissertation, namely, institutional economics. The main developments of institutional economics and arguments of representative schools of thoughts are reviewed. After laying out the relevance of institutional economics to BC's silviculture sector, focus is narrowed down to that branch of institutional economics known as transaction cost economics (TCE). Justification is provided for choosing the transaction cost approach as the theoretical framework of the research. Chapter 3 provides a theoretical treatment of the research problem. It is hypothesized that the nature of institutional reforms since 1987 is to economize on transaction costs in the choice of appropriate organizational and contractual modes. Then, the research methodology and analytical model are presented.

Chapter 4 provides a profile of the BC silviculture industry. The Ministry of Forests, the major licensees as well as silviculture contractors are characterized based on the results of surveys and interviews. Chapter 5 has four components. First, a case study is presented of a major forest company that operates in the coastal region of the Province. The company's management strategies, choice of contractual arrangements, cost structures, and efficiency of silvicultural operations are examined.[7] Next, an econometric study of the contractual decision of forest companies is presented. Transaction cost economics is applied to the analysis of forest companies' choice of whether to contract out silvicultural activities or do them in-house. Then, the determinants of payment schemes that forest companies use are analyzed by means of regression techniques. Finally, BC's silviculture contracting industry is analyzed econometrically using survey data.

The conclusions of the study follow in Chapter 6. The restructuring of the institutional framework and contractual arrangements in BC's silviculture sector and the relevance of the TCE approach are summarized, and policy implications are discussed.

Table 1.1 Chronology of Major Events and Policies Regarding BC's Silviculture

1912	Passage of BC's first Forest Act; creation of the Forest Branch
1923	Amendments to the Forest Act, introducing seed tree regulations
1925	Establishment of Forest Reserve Account to provide fund for planting
1927	Initiation of experimental harvesting in favour of reforestation
1930	Establishment of BC's first production nursery at Green Timbers in Surrey
1932	Planting of logged-over land on West Thurlow Island
1936	Beginning of operational planting by the Forest Branch
1937	Mulholland's appeal for more efforts in reforestation
1938	Huge forest fire at Campbell River, destroying 31 000 hectares of forests; in response, the Forest Branch accelerated reforestation program by planting 4 050 hectares each year and this policy marked the beginning of production planting in BC
1938	Tree planting initiated by predecessor companies of MacMillan Bloedel
1945	Release of first Sloan Royal Commission report
1946	Establishment of Silviculture Fund
1947	Expansion of nursery capacity on the Coast and first production from the Duncan nursery
1950	Supply by government of free seedlings for replanting of denuded privately owned forest land
1953	Denuded private forest land subject to Forest Service examination and planting of NSR private forest lands becoming mandatory
1956	release of second second Sloan Royal Commission report, urging for artificial regeneration in the Interior; building of a seed extraction plant at Duncan; initiation of seed registration program
1958	Organization of the Plus Tree Board; commencement of genetically improved seed production; pilot plantations in the Interior; establishment of small nurseries at Ranger Stations in the central Interior
1964	Forest Act amended to permit payment as compensation for post-logging silvicultural treatments by stumpage offset or by funds appropriated by the Legislature
1967	First production of seedlings from a nursery at Red Rock, close to Prince George; swelling of planting program beyond the Forest Service in-service capacity, and planting contracts being advertised for competitive bidding, marking the beginning of the separation of silviculture as a distinct industry from the forest industry in BC

[7] In this dissertation, the term 'efficiency' is used to denote management efficiency in an economic sense, without reference to any technical or biological efficiency.

1971 Interior exceeded Coast in artificial regeneration for the first time in BC's history
1972 Forest Act amendment, urging all tenure holders to be responsible for post-logging reforestation
1975 Initiation of the biogeoclimatic ecosystem classification project, which was not completed until 1994, and this system has provided the foundation for silvicultural decision making
1976 Release of Pearse Royal Commission report
1978 Passage of a new Forest Act, Ministry of Forests Act, and Range Act, the above three Acts providing a new framework for the management, protection and conservation of BC forest and range resources, replacing the Forest Act of 1912 and the Grazing Act of 1919
Timber Sale Harvesting Licence replaced by newly created Forest Licence; FL together with TFL and Timber Licence holders being required to submit a management and working plan with explicit regeneration commitment
1979 Intensive Forest Management Subsidiary Agreement was signed between federal and provincial governments as a cooperative support to silviculture. It was expected to terminate on March 31, 1984, but was extended for one additional year and expired on March 31, 1985
1980 Credit to Stumpage Regulation, under Forest Act (Section 88), BC Regulation 433/80, Order in Council 2132, was approved and ordered. Section 88 of the Forest Act became the principal means of financing forest management activities undertaken by licence holders. It allowed the Ministry to reimberse licensees for approved activities, such as planting, by deducting the cost of activities from the stumpage the licensee would otherwise pay to the government
1980/81 White Paper on the Growing of Tree Seedlings, a significant policy decision concerning nurseries in that: (i) production from Ministry nurseries will be constrained to about 100 million seedlings per year; (ii) all production above this level required to meet the five-year program goals will be achieved through the development and expansion of private nurseries, and (iii) the Ministry will pay for the cost of producing seedlings in private nurseries that are used to restock Crown land. As a result of this policy, in 1980-81 the Ministry approved four nurseries to be developed by the forest industry (licensees), and 7 commercial nurseries were allocated production
1981/82 Duncan Seed Centre facility became inadequate to meet future program needs, so planning for a new facility was begun during the year
1983/84 Shifting of more forest management responsibilities to holders of tree farm licences was proposed in a discussion paper
1984-85 To improve cost-effectiveness, a large 2+0 container seedling program was initiated since some sites required larger planting stock, which could compete successfully with other vegetaion Seedlings of this type were intended to replace more costly transplanted seedlings on brushy sites
1985 The *Five-Year Forest and Range Resource Program, 1985-1990* proposed substantial increase of planting to reach 200 million seedlings per year
Provincial and federal governments signed the first Canada-British Columbia Forest Resource Development Agreement (FRDA I), $300 million, which emphasized the regeneration of 738000 hectares of good and medium sites of accessible forest land denuded prior to 1982
1986 The Forest Stand Management Fund was established to fund silviculture and related activities to enhance the Provincial forest resource. Matching contributions to this fund are anticipated from the federal government, forest industry, municipalities and forest sector trade unions
A new seed centre was established at Surrey, replacing the one at Duncan
A Memorandum of Understanding between Ministry of Forests and Lands and Ministry of Health on Minimum Standards for Silviculture Camps was reached
Canada signed with USA a softwood Memorandum of Understanding (MOU) in which the Canadian government proposed to lift the US 15% duty and establish a 15% export tax on all softwood lumber exports to the U.S. It was agreed that this tax could be eliminated if provincial governments took "replacement measures" to raise stumpage fees to the equivalent level of the export tax
1987 BC government announced major policy changes via amendments to Forest Act, i.e., Bill 70:
- cost and responsibility for basic silviculture up to a free-to-grow tree crop was shifted to the industry (on Timber Sale Licences the Crown continues to carry out the silviculture work with funding from the Small Business Forest Enterprise Account)
- a new pricing system, namely, the comparative value stumpage pricing system, was introduced, and an increase in stumpage was implemented

- the TFL program was proposed to expand from 28% to about 66% of the Provincial AAC to provide industry with more tenure security
- 5% of major licensees' timber harvesting rights were reallocated under the SBFEP
Pre-Harvest Silviculture Prescription was implemented and major licensees were obliged to prepare PHSPs for approval prior to harvesting

1988 Small Business Forest Enterprise Program and its Account were established
Introduction of a silviculture regulation, which outlined the contents for a PHSP and the requirements to meet basic silviculture obligations
Privatization of eight government nurseries, with the Crown retaining three only

1990 Initiation of the Silvicultural System Program to investigate alternatives to conventional clearcutting and to identify their ecological, operational and socio-economic implications and opportunities

1991 FRDA II was signed—$200 million for four years, covering the fiscal period 1991-92 to 1994-95, and the primary objectives of the agreement are to conduct incremental silviculture (spacing, pruning, fertilization) and to fund initiatives in communications, extension, research, small-scale forestry, product and market development and economic and social analysis

1991 Release of Forest Resources Commission's report *The Future of Our Forests* that contains recommendations on silviculture and many other forest related aspects

1992 Establishment of Commission on Resources and Environment (CORE)
National Forest Strategy and Canada Forest Accord, the provincial, territorial and federal governments, as well as industry, labour, First Nations and environmental groups signed the Canada Forest Accord, committing to the concept of sustainable forestry
Announcement by the BC government a Protected Areas Strategy, the goal being to achieve 12% of the Province under protection by the year 2000

1994 Passage of three pieces of legislation:
- Forest Renewal Act
- Forest Practices Code of British Columbia Act
- Forest Land Reserves Act

Silviculture Regulation replaced by the Silviculture Practices Regulation, which established requirements for administrative penalties, improved soil conservation and maximum densities for all conifer species
Forest Renewal BC Plan was announced in April 1994. Forest Renewal BC, a new Crown agency, was established in the same year by the BC Forest Renewal Act. Forest Renewal BC's funding is derived from increases in stumpage and royalties paid by companies to harvest timber on Crown land. On May 1, 1994, stumpage rates were increased to begin generating this revenue

1996 The Forest Practices Code Act came into effect

1996 Bill 12 was adopted, giving first priority to replaced forest workers in silviculture work on Crown land

1997 On June 19, Premier Glen Clark announced the Jobs & Timber Accord, aiming at creating 39,800 new jobs by 2001; 5,000 of these jobs are expected to come from forest renewals

Chapter Two

Institutional Economics and Its Relevance to BC's Silviculture Sector

Theoretically, this research is grounded in the new institutional economics, particularly that branch known as 'transaction cost economics'. In this chapter, an overview of the development of institutional economics is first provided. Then, the school of transaction cost economics is highlighted. Finally, the relevance of institutional economics to the study of BC's silviculture sector is examined.

2.1 Brief Overview of Institutional Economics

The philosophical framework of this dissertation is derived from transaction cost economics, which is a branch of the new institutional economics (NIE). Institutions refer to the humanly devised constraints that shape human interaction (North 1990). More specifically, North (1984, p.8) defines institutions as "a set of constraints on behavior in the form of rules and regulations, a set of procedures to detect deviations from the rules and regulations and, finally, a set of moral, ethical behavioral norms which define the contours that constrain the way in which the rules and regulations are specified and enforcement is carried out."[8]

Broadly speaking, NIE has arisen out of two major sources of influence. One is the line of institutionalism and the other is from within mainstream economics.[9] The publication of John R. Commons' *Institutional Economics* in 1934 marked the formation of institutional economics as a distinct school of thought. However, institutional economics did not make significant headway until after the 1940s thanks to the contributions of Clarence E. Ayers, who is regarded as the one ushering in the era of neo-institutional economics (Gruchy 1972). In contrast to conventional microeconomics theory, which emphasizes the human profit motive and the desire for monetary gains, the institutional economic approach

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8 There is a distinction between North's 'institutions' and commonly perceived 'policy institutions'. The former refers to a wide range of societal arrangements whereas the latter is focused more on institutionalized establishments and instruments that serve the purpose of achieving some conceived social objectives or policy goals. This research is specifically concerned with the organizational and contractual aspects of some institutional arrangements in BC's silviculture sector.

9 The origin of institutional economics goes back to Thorstein B. Veblen who is widely viewed as the 'founder of American institutionalism'.

pays greater attention to the role of technology, based on the belief that the basic dynamic force in economics is technology or the accumulation of technical knowledge (Gordon 1980).

Fundamentally, NIE descended out of both institutional economics and neoclassical economics. On the one hand, most of the new institutional economists refuse to be recognized as descendants of the older institutional economics approach represented by Veblen, Commons and Ayres on account of major differences in philosophical views and methodologies (Hutchison 1984). On the other hand, they have been unhappy with the neoclassical economic paradigm due to disagreements with its fundamental assumptions (Eggertsson 1990; Pejovich 1995). The term 'new institutional economics' indicates that economists of this school take economics as 'a science of institutions', but, in the meantime, they wish to distinguish themselves from institutionalists by emphasizing that this economic approach is still a 'science of choices', but operating at a different level in a different environment.

With diverse research agendas and emphases, the main components of NIE include: (a) the historical economics approach represented by North (1994, 1991, 1990);[10] (b) the property rights approach advanced by Alchian (1961, 1965, 1973 [with Demsetz]) and Demsetz (1967);[11] and the industrial organization and transaction cost approach (Williamson 1996, 1985, 1979; Coase 1972, 1960, 1937; Arrow 1969).[12] Other approaches such as those based on information, the agency problem and so forth may also be brought under the general heading of institutional economics.

2.2 Transaction Cost Economics

As a result of a seminal paper by Williamson (1979), the notion of transaction costs has gained increasing recognition, with many developments in the new institutional economics centering around this

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[10] According to North (1994), institutions provide the incentive structure of an economy. As that structure evolves, it shapes the direction of economic change towards growth, stagnation or decline. North argues that institutions evolve incrementally and connect the past with the present and the future. History is largely a story of institutional evolution.

[11] Property rights refer to relations among individuals, and property rights specify the norm of behavior with respect to scarce resources. In other words, property rights consist of a bundle of characteristics that specify incentives.

[12] Coase's 1937 paper indicates that, "without transaction costs, the firm has no role to play"; in comparison, his 1960 paper, "the Problem of Social Cost" indicates that, "without transaction costs, law has no role to play."

concept. This has enabled the development of a distinct school of thought known as 'transaction cost economics' (TCE).

Standing on the ground that Coase broke in 1937, Williamson and others view TCE as an extension of the neoclassical economic paradigm with a clear mission of probing into the nature of the firm.[13] Based on an earlier reference by Arrow (1969, p.48) to transaction costs as the "costs of running the economic system", more recently, scholars define transaction costs as the costs of all resources required to transfer property rights from one economic agent to another. They include the costs of discovering exchange opportunities, negotiating contracts, monitoring and enforcing implementation, and maintaining and protecting the institutional structure (Pejovich 1995, p.84).[14]

Among the factors that affect the levels of transaction costs associated with institutional modes, bounded rationality and opportunism have been identified as two key behavioral assumptions that form the very basis of transaction cost analysis (Williamson 1985, 1981). Williamson has repeatedly argued that the new institutional economics is preoccupied with the origin, incidence and ramifications of transaction costs. Cheung (1989) echoes Williamson by insisting that the relevance of the organization of economic activities hinges on the existence, the level and the types of transaction costs. Thus, rallying around the concept of transaction costs, TCE scholars propose that economic institutions operate to minimize transaction costs at various levels through hierarchical arrangements, sequencial arrangements, contracts, and so on. According to Coase (1937), firms exist as an efficient mode of economic organization to take advantage of the lower levels of transaction costs because many costs are saved in the processes of institutional restructuring that reduce the costs of information and opportunistic behavior.

The TCE reasoning insists that firms behave in a transaction cost economizing manner so that the choice of governance modes regarding specific activities conform with transaction characteristics. For instance, market oriented contracting usually prevails when nonspecific investments are involved. As asset specificity increases, market arrangements tend to give way to bilateral modes, and in the case of idiosyncratic

[13] Williamson (1981) recognizes the contribution by both Coase and Commons to the initiation of the transaction-cost concept. Williamson (1985, pp.4-7) also acknowledges the important contributions from legal scholars such as Karl Llewellyn and from organization scholars like Chester Barnard with his 1938 book *The Functions of the Executive*.

investments that occur at frequent intervals, unified governance will be chosen (Williamson 1985, p.79). More recently, it has been recognized that, in addition to Coase's insight, lateral integration may be comparable to vertical integration in transaction cost economizing, and the choice of governance structures depends on the nature of transactions and circumstances (Groenewegen 1996). Ultimately, TCE is concerned with the incorporation of institutional factors as explanatory variables. Nonetheless, economic efficiency is upheld as the most important explanatory variable for understanding and justifying the presence of markets and/or hierarchies (Williamson 1996).

In its early stage of development, TCE was frequently a target of criticism for its tautological convenience (see Fischer 1977). However, the developments of TCE over the last two decades have proved the vitality and usefulness of the approach for effectively comparing alternative organizational forms (Masten 1996). Progress in the development of methodologies and techniques for applying the transaction cost logic have been particularly noticeable, with studies covering a wide range of sectors, from automobile to airlines and from natural gas to national defense. To a large degree, the increase in the number of empirical studies lies in the adaptability of TCE problem formulations to qualitative choice models. By the mid-1990s, because of its established theoretical framework and its analytical capacity in handling a variety of real-world problems, TCE had grown beyond the stage of conceptualization. Table 2.1 provides an abbreviated literature review of the major TCE empirical studies. Evidently, most of the empirical work is on rather idiosyncratic industries such as ship-building (Masten, Meehan and Snyder 1991). Probably, the study on the tuna industry (Gallick 1984) is more parallel to silviculture than the others.

2.3 Relevance of Transaction Cost Economics to BC's Silviculture Sector

Silvicultural activity is, by and large, an economic activity. Silvicultural projects have traditionally been analysized as investment decision-making problems (Sedjo 1984). The selection and evaluation of silvicultural projects are dictated by the principle of economic efficiency, and funds are allocated to investment alternatives that promise streams of net benefits over the specified project life. Rooted in the optimum rotation theory of Faustmann (1849), which is characterized by a determination to maximize land rent in timber

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[14] Professor David Haley summarizes the scope of transaction cost economics into an acronym—ICE, i.e.,

production, this capital budgeting approach has dominated the economic analyses of stand-level management for well over a century.

In recent decades, the limitations of the conventional approach in guiding forest planning and management have been increasingly recognized. Efforts aimed at augmenting the Faustmann approach have been made along at least three lines. First, the appeal for incorporating nontimber values into standard economic analysis has expanded the scope of the Faustmann model to account for a wider range of forest-based non-timber products and services (Hartman 1976; Calish, Fight and Teeguarden 1978). Second, the elevation of the unit of analysis from the stand level to the forest level has given rise to debates on whether zoning can serve as a viable solution for reconciling conflicts between dominant and multiple uses of forest land (Vincent and Binkley 1993; Sahajananthan 1995). And third, the popularization of the concept of sustainable forestry has resulted in reorienting the objectives of silvicultural operations towards broad perspectives of ecosystem management with attention to inter-regional and inter-generational considerations (O'Hara and Oliver 1992). All this implies a shift from private sector planning to public sector planning characterized by public intervention.

Along with the above developments, institutional economists have criticized the conventional model for its disregard of institutional dynamics. For instance, the property rights (PR) approach insists that economic behaviour is influenced by differences in the structure of the property rights underlying the relationships among economic agents (Alchian and Demsetz 1973; Demsetz 1967). Based on the belief that economic agents respond to incentives in their performance of economic activities, and that incentive schemes vary from one property rights structure to another, the efficiency of economic activities is amenable to analysis via the examination of property rights compositions for their incentive implications. Since property rights differ in the dimensions that may be measured by a set of identifiable attributes, in applying the PR approach to the analysis of forest tenures in BC, forest economists first identified the principal forest tenure types and their main attributes. The purpose was to determine the characteristics and magnitude of incentives. Then, they examined the effects of specific tenures on the formation of behaviour patterns at the level of individual firms.

I for information, C for contracting, and E for enforcement.

Finally, they made inferences about the implications of the tenure arrangements for silvicultural investment at the industry level (see Haley and Luckert 1990; Luckert 1988; Luckert and Haley 1993, 1994; Zhang 1996).

Emphatically, the PR approach operates at the level of forest tenures and is largely concerned with the incentive implications of various property rights structures. Consider the following question: "What are the changes in economic incentives and how do they influence the behaviour of the economic agents involved?" In the context of this question, the PR approach is certainly a fruitful avenue of enquiry. However, because the PR approach depends on analyzing the several dimensions that include exclusiveness, duration, transferability and so forth (Haley and Luckert 1986), and since BC's forest tenure structures have not changed nearly as much as the contractual relationships among the players, investigation into the effects of forest tenures on silvicultural investment and performance may be difficult. In order to look into the governance structures of forest companies with respect to silvicultural arrangements, the transaction cost approach has clear advantages because it is capable of being applied to analysis of silvicultural contracts. Specifically, the TCE approach is characterized by a contracting orientation with transactions as the unit of analysis, and the TCE approach is concerned with the transaction cost implications of different governance structures (Williamson 1985, p.24).

Silvicultural programs comprise activities that actually can be viewed as distinct transactions. Since governance structures act as an institutional framework whose specific attributes guide transactions in a predictive way (Masten 1996), analysis of BC's silviculture sector reduces to an understanding of the nature and workings of the organizational forms involved. Given that transaction attributes are largely identifiable, in light of the reasoning of transaction cost economizing, it is pertinent for investigation of the efficiency of silvicultural programs to proceed by examining the extent to which existing silvicultural governance structures match the attributes of transactions.

Logically, since the reorganization of economic activities must serve the purpose of and should result in the reduction of transaction costs, silvicultural institutional changes are amenable to analysis through the employment of the TCE approach. Intuitively, BC's institutional reforms have been such that some transaction costs may increase (e.g., the costs of enforcement and monitoring on the part of the BC Ministry of Forests), but other costs may be saved due to new opportunities in lowering negotiation and information costs. This occurs for two reasons: (1) forestry knowledge is largely location-specific, and the closer decision making is to the grass-root level, the more likely that useful knowledge can become available; and (2) the closer the ties between management and operators, the more likely that opportunistic behaviour can be held in check.

Given the nature and characteristics of institutional changes in BC's forestry sector, the TCE approach is not only applicable but is also believed to possess obvious advantages over several other analytical approaches. For instance, in addressing the issue of the implications of BC's institutional reforms for the efficiency of silvicultural activities, what the conventional approach can offer is the use of benefit-cost analysis that seeks to express all activities in dollar terms to enable comparisons of benefits and costs. Due to the drawbacks mentioned earlier, the best that this approach is capable of delivering is a rough approximation under rigid assumptions.

To summarize, the employment of transaction cost economics as the analytical framework for this research is justified on the following grounds. First and foremost, this research is concerned with the economics of institutions. BC's silvicultural restructuring since 1987 has consisted of a series of institutional reforms that have brought about, among other things, changes in the relationships among economic agents. Second, TCE provides a theoretical framework of analysis for examining the economic implications of the institutional reforms in the silviculture sector. Suppose one wants to find answers to questions such as: "Why have the institutional reforms involved restructuring of organizational arrangements, and how has such restructuring taken place?" We can investigate the rationale behind the choice of a certain organizational form in terms of transaction cost logic. Hence, governance choices can be evaluated in terms of transaction cost economizing capacities. And third, being an interdisciplinary undertaking, TCE is essentially concerned with efficiency and this feature ensures the validity of many analytical techniques of standard economics in the investigation of institutional problems. Alternatively, one may employ some other analytical approaches such as a political economy model. However, the political economy approach is believed to be too simple for the problem under investigation, because the focus of this research is on contractual relations rather than power or union issues *per se*.

Finally, the TCE approach is, by and large, an extension of the neoclassical economic approach. Instead of replacing the conventional wisdom, it provides augmentations by drawing attention to organizational modes with emphasis on contractual relations. It argues, in essence, that the costs of transacting should be incorporated into the analysis of the total costs of economic activities.[15] By directing investigators' attention to the fact that governance structures tend to align with transaction attributes so that some costs of transacting may be saved on the whole, the TCE logic implies that neither pure market-based institutions nor vertically integrated firms necessarily prevail. The choice is, ultimately, dictated by the nature of the transactions involved.

Table 2.1 List of Empirical Studies of Transaction Cost Economics

Author	Sector
Stuart D. Frank & Dennis R. Henderson (1992)	Food industry
R. Glenn Hubbard & Robert J. Weiner (1991)	Natural gas industry
Scott E. Masten (1984)	Aerospace industry
Erin Anderson & David C. Schmittlein (1984)	Electronics industry
Scott E. Masten, James W. Meehan, Jr., & Edward A. Snyder (1989)	Auto industry
Scott E. Masten, James W. Meehan, Jr., & Edward A. Snyder (1991)	Naval ship-building
Keith J. Crocker & Kenneth J. Reynolds (1993)	Air force engine
Paul L. Joskow (1987)	Coal markets
Paul L. Joskow (1985)	Coal supply
Paul L. Joskow (1988)	General
Kirk Monteverde & David J. Teece (1982a)	Auto industry
Kirk Monteverde & David J. Teece (1982b)	Auto industry
Scott E. Masten & Keith J. Crocker (1985)	Natural gas industry
Keith J. Crocker & Scott E. Masten (1991)	Natural gas industry
Keith J. Crocker & Scott E. Masten (1988)	Natural gas industry
Sumit K. Majumdar & Venkatram Ramaswamy (1994)	Multiple industries
George John & Barton A. Weitz (1988)	Industrial firms
John M. Barron & John R. Umbeck (1984)	Petroleum industry
Laurence T. Phillips (1991)	Airline, railroad
Thomas M. Palay (1984)	Rail carriers
Russell Pittman (1991)	Railroads
Victor P. Goldberg & John R. Erickson (1987)	Petroleum coke
Edward C. Gallick (1984)	Tuna industry
John Stuckey (1983)	Aluminum industry

[15] Professor David Haley has drawn my attention to the analogy that 'neoclassical economics' assumes an economic 'machine' that is frictionless; as a result it can lead to erroneous conclusions, just as an assumption of a frictionless physical world leads to serious errors in mechanics. Transaction costs provide friction—they are the 'sand in the works'. Include transaction costs in neoclassical models and you will have a much more realistic interpretation of the economic 'machine'.

Chapter Three

Modeling the In-house versus Outsourcing Choice

This chapter consists of three parts. First, I examine a forest company's choice between an in-house arrangement or outsourcing contracts for the performance of silvicultural activities. Then, the methodology of applying the theory to empirical analysis is outlined. Finally, a model for empirically validating the theory is developed.

3.1 Theory of Silviculture Contracting

Transaction cost theorists have reached a consensus that economic activities are organized to match the attributes of the activities undertaken and the characteristics of the agents so as to minimize transaction costs (Williamson 1996, 1985). However, the problem of categorizing and quantifying transaction costs is a matter of intense debate in the TCE literature. Contributions by Klein, Crawford and Alchian (1978), Alchian (1984), Williamson (1983, 1979), Joskow (1988, 1987) and Masten, Meehan and Snyder (1991) recognize and confirm "specificity, frequency and uncertainty" as key dimensions that characterize transaction costs. The most comprehensive explication is found in Williamson (1985): (i) governance choices are a function of the specificity of physical and human assets, and contractual relations; (ii) frequency is a crucial aspect in the examination of transactions; and (iii) uncertainty refers to the different capacities of alternative governance structures to respond effectively to disturbances in the institutional and physical environment.

One of the objectives of this research is to improve our understanding of contractual arrangements for silvicultural activities in BC. A specific task is to identify the parameters that affect the choice of contractual forms. In farm management, three contractual forms are common—fixed wage, rental and share contracts (Eswaran and Kotwal 1985). Likewise, as far as the BC silviculture sector is concerned, the major licensee basically has three options regarding the manner in which the harvested site can be treated with silvicultural activities. First, he could do it in-house by directly hiring labor and providing both management and supervision herself.[16] This is equivalent to the fixed wage contract in farm management. Alternatively, he could contract out the silvicultural work for a fixed lump sum payment. In this outsourcing contract, the silviculture contractor is responsible for hiring labor and providing supervision. This is the rental contract. Finally, the licensee and contractor could make a share contract in which the former provides management and the latter supervision, and the output is shared at a mutually agreed point in time. But, since BC's forest tenure system does not provide grounds for the sharing of silvicultural outcome, consideration of share contracts is not relevant for this research.

Beginning with the production function, let us posit that silvicultural activities entail the use of four inputs: (1) material, *K*, which is an aggregate of such physical inputs as fixed capital, tools, seedlings, and so forth; (2) effort, *E*, that comprises labor, *L*, and supervision, *S*, or the time spent supervising the labor; (3) land, *H*; and (4) management, *M*. The efficiency of silvicultural performance is crucially dependent on the quality of management decisions. For instance, the choice of species to be planted, selection of inputs and timely procurement are essential for successful silviculture. In BC, the silviculture prescription deals with many of these management aspects, and the management responsibilities lie with the major licensee. While the amounts of hired labor and material inputs are easily observable, the levels of supervision and management are not. This feature introduces the moral hazard problem of shirking. It is assumed that licensees have superior abilities in management, while contractors have an advantage in supervising the implementation of specific activities.

Let effort $E = g(L, S)$, where g is linearly homogeneous, increasing and concave in L and S. Silvicultural output is given as:

(3.1) $$Q = f(K, L, H, S, M)$$

where Q is an output level;

f is a production function that is linearly homogeneous, and increasing and concave in its arguments;

[16] Licence holders can be a person, a company or an institution. Here, licensees are personified.

K is material such as machinery, tools, seedlings, etc.;

L is hired labor;

H is land;

S is the time spent supervising labor; and

M is management.

It is assumed that silviculture contractors are without any type of forest tenures. It is further assumed that a contract is a one-period contract although contractual relationships tend to be of a long-term nature.

The above expression differs from traditional production function by explicitly including management and supervision as two input factors. From this new expression, it is clear that total cost may be expressed as an aggregate of all variable costs in the short run. Transaction cost economics is explicitly concerned with the source of costs that arise from areas other than production factors. In the case of silviculture contracting, it is the levels of labor supervision and program management that directly account for the incidence and level of transaction costs. In other words,

$$TC = vS + wM \tag{3.2}$$

where TC is transaction cost, and v and w are the factor prices of supervision and management, respectively.

Here, it is assumed, for simplicity, that the production function involves two transaction cost factors only, namely, S and M. In order to determine the response of transaction cost-minimizing firms to the changes of exogenous variables, comparative static techniques may be used. It can be shown that, for a transaction cost-minimizing firm, the decision variables, S and M, are a function of three parameters—the two factor prices and the output level. With two input factors and for a given output level, an increase in the price of one factor increases employment of the other input. In other words, when one factor becomes more expensive, a firm will use less of this factor and more of the other factor instead. However, the response of the firm to a shift in the level of output is indeterminate.

The transaction cost minimization problem is to minimize transaction costs subject to a production constraint. The objective is:

$$\text{(3.3)} \quad \text{Minimize} \quad TC = v\,S + w\,M$$

$$\text{subject to} \quad Q = f(K, L, H, S, M)$$

The optimization problem is:

$$\text{(3.4)} \quad L = v\,S + w\,M + \lambda\,[Q - f(K, L, H, S, M)]$$

where *L* is a Lagrangian function, and λ is the Lagrangian multiplier.

Differentiating *L* with respect to *S*, *M* and λ yields the first-order conditions for a minimum:

$$\text{(3.5)} \quad L_s = v - \lambda f_s = 0$$

$$\text{(3.6)} \quad L_m = w - \lambda f_m = 0$$

$$\text{(3.7)} \quad L_\lambda = Q - f(\bullet) = 0$$

The sufficient second-order condition for an interior minimum is that the bordered hessian determinant be negative semi-definite:

$$\text{(3.8)} \quad \Diamond = \begin{vmatrix} -\lambda f_{ss} & -\lambda f_{sm} & -f_s \\ -\lambda f_{ms} & -\lambda f_{mm} & -f_m \\ -f_s & -f_m & 0 \end{vmatrix} < 0$$

Hence, *S*, *M*, and λ can be solved in terms of the parameters, *v*, *w*, and Q_0, yielding:

$$\text{(3.9)} \quad S = S^*(v, w, Q_0)$$

$$\text{(3.10)} \quad M = M^*(v, w, Q_0)$$

$$\text{(3.11)} \quad \lambda = \lambda^*(v, w, Q_0)$$

Equations (3.9) - (3.11) represent the factor demand functions when output is held constant at Q_0. Given transaction cost minimization, we have, by substituting (3.9) - (3.11) into (3.2),

$$(3.12) \qquad TC^* = v\, S^*(v, w, Q_0) + w\, M^*(v, w, Q_0)$$

This is the indirect transaction cost function. Then, comparative statics techniques can be used to understand the response of a transaction-cost minimizing firm to changes in the parameters it faces. By substituting (3.9), (3.10) and (3.11) into (3.5), (3.6) and (3.7), respectively, we get:

$$(3.13) \qquad v - \lambda^*(v, w, Q_0)\, f_s\, (S^*(v, w, Q_0)) \equiv 0$$

$$(3.14) \qquad w - \lambda^*(v, w, Q_0)\, f_m\, (M^*(v, w, Q_0)) \equiv 0$$

$$(3.15) \qquad Q - f\, (S^*(v, w, Q_0), M^*(v, w, Q_0)) \equiv 0$$

Now, totally differentiate the three identities (3.13) - (3.15) with respect to factor prices *v* and *w* and solve for the relevant partial derivatives. For the case of the supervisory factor, *S*, (i.e., its price *v*), we get:

$$(3.16) \qquad 1 - \lambda^* f_{ss}\, \partial S^*/\partial v - \lambda^* f_{sm}\, \partial M^*/\partial v - f_s\, \partial\lambda^*/\partial v \equiv 0$$

$$(3.17) \qquad - \lambda^* f_{ms}\, \partial S^*/\partial v - \lambda^* f_{mm}\, \partial M^*/\partial v - f_m\, \partial\lambda^*/\partial v \equiv 0$$

$$(3.18) \qquad - f_s\, \partial S^*/\partial v - f_m\, \partial M^*/\partial v \equiv 0$$

In matrix notation, this becomes:

$$(3.19) \qquad \begin{vmatrix} -\lambda^* f_{ss} & -\lambda^* f_{sm} & -f_s \\ -\lambda^* f_{ms} & -\lambda^* f_{mm} & -f_m \\ -f_s & -f_m & 0 \end{vmatrix} \begin{vmatrix} \partial S^*/\partial v \\ \partial M^*/\partial v \\ \partial\lambda^*/\partial v \end{vmatrix} = \begin{vmatrix} -1 \\ 0 \\ 0 \end{vmatrix}$$

Using Cramer's rule:

$$(3.20) \qquad \partial S^*/\partial v = \begin{vmatrix} -1 & -\lambda^* f_{sm} & -f_s \\ 0 & -\lambda^* f_{mm} & -f_m \\ 0 & -f_m & 0 \end{vmatrix} = -\Delta 11/\Diamond$$

Likewise,

$$(3.21) \qquad \partial M^*/\partial v = -\Delta 12/\Diamond$$

and

$$(3.22) \qquad \partial \lambda^*/\partial v = -\Delta 13/\Diamond$$

where Δ_{ij} is the cofactor of the element in the *i*th row and *j*th column of the determinant, $\Diamond$. Since the denominators, $\Diamond$, are all negative (in order to satisfy the second-order conditions for minimization), therefore,

$$(3.23) \qquad \Delta 11 = \begin{vmatrix} -\lambda^* f_{mm} & -f_m \\ -f_m & 0 \end{vmatrix} = f_m^2 > 0$$

$$\Longrightarrow \quad \partial S^*/\partial v < 0$$

Also,

$$(3.24) \qquad \Delta 12 = -f_s f_m < 0$$

$$\Longrightarrow \quad \partial M^*/\partial v > 0$$

And,

$$(3.25) \qquad \Delta 13 = \lambda^* (f_{ms} f_m - f_{mm} f_s) \quad > \text{or} < 0$$

$\Longrightarrow \quad \partial\lambda^*/\partial v$ is indeterminate.

In like manner,

$$(3.26) \qquad \partial S^*/\partial w > 0$$

$$(3.27) \qquad \partial M^*/\partial w < 0$$

$$(3.28) \qquad \partial\lambda^*/\partial w > \text{or} < 0.$$

The above comparative statics analysis provides useful information about the relationships between the factors and their prices, and about the effects of incremental changes, both own effects and cross effects. Detailed rules regarding comparative statics analysis can be found in Chiang (1984) and Silberberg (1978). Clearly, the own effects are negative and cross effects are positive. However, the indeterminacy of effects of changes in output level on the use of factors may cause some difficulty. In the case of BC, silvicultural activities have increased considerably since the 1980s. Other than the knowledge that firms tend to respond to changes in transaction cost factor prices by substituting less costly factors, we do not have definitive conclusions about firms' responses to the increase in the level of silvicultural activities.

Of course, some insights may be gained from further analysis of the relationships among the parameters and the decision variables by assuming a specific cost function. For instance, using the specification of a Cobb-Douglas cost function, transaction costs may be expressed as:

$$(3.29) \qquad TC = Q \ (v^{\alpha} w^{\beta})$$

The above equation shows that transaction costs can be expressed as a function of output, Q, and the factor prices of supervision and management, v and w. Using Shephard's lemma, the factor demand functions for supervision, S, and for management, M, are:

(3.30) $$S = \alpha(\frac{w}{v})^{\beta} Q$$

and

(3.31) $$M = \beta(\frac{v}{w})^{\alpha} Q$$

Substituting (3.30) and (3.31) into (3.2) and rearranging, transaction costs, *TC*, may be expressed as:

(3.32) $$TC = B\ Q^{1/\alpha+\beta}\ \ w^{\beta/\alpha+\beta}\ \ v^{\alpha/\alpha+\beta}$$

In the above equation, *B* is a constant that depends on α and β. It turns out that the exponents of the factor prices in the Cobb-Douglas cost function reflect the share of each input in accounting for the total transaction costs, and the factor equalizing rule results in:

(3.33) $$\frac{v\,M}{\alpha} = \frac{w\,S}{\beta}$$

Ordinarily, minimization of transaction costs does not alter the shares of the input prices, but, institutional changes can affect the shares. Assuming that the production function is a constant-returns-to-scale type, the elasticity of substitution between the two input factors is simply the shares:

(3.34) $$e_{TC,\,v} = \frac{\alpha}{\alpha+\beta}$$

and,

(3.35) $$e_{TC,\,w} = \frac{\beta}{\alpha+\beta}$$

Eswaran and Kotwal (1985) demonstrated the applicability of the above reasoning in the context of farm management. In spite of its usefulness to understanding BC's silviculture contracting, the question remains unanswered as to why firms have made certain contractual choices in their organization and performance of silvicultural activities.

Since the several commonly used variables in transaction cost economics are physical specificity, human specificity, frequency, uncertainty and complexity, based on TCE logic, a theory of the choice of contractual forms is proposed as follows:

> Silvicultural activities that tend to be performed in-house are those that are complex to manage, have a low degree of seasonality, and involve highly specific physical assets, and require high levels of human skills; contracting out occurs otherwise.

TCE suggests that it is possible to identify distinctive features of silvicultural activities. The most salient features that distinguish silvicultural activities from other (forestry) activities include:

(a) Seasonality. The timing and coordination of activities are critical for labor, planting materials, and so on, with the window of opportunity in terms of timely performance being narrower for basic silviculture than for incremental silviculture due to potential losses and damages.

(b) Temporal and sequential dependence. Often one activity has to be completed before another can take place, so, a great deal of planning is required in order to achieve desirable results. As a rule of thumb, silvicultural activities are carried out in a sequential order, and they are tied to harvesting operations in the case of basic silviculture.

(c) The difficulty of defining a tangible 'final product'.

This basic distinction underscores a number of differences that persist in production processes and in the assets employed in the silviculture sector. First, the equipment and tools used in many silvicultural activities are not idiosyncratic in that they are not specific to a particular activity. In the case of basic silviculture, physical assets are generally unspecialized, inexpensive and tend to be much less relationship specific, and are not site or location specific. As a matter of fact, most of the physical assets used tend to be portable and mobile to permit employment at various locations.

Second, regarding human assets, except for a few activities, the skills, knowledge and experience required of planters and spacers do not demand extended apprenticeships, and, generally speaking, the skills are not specialized to forestry.

Third, uncertainty results in unpredictability (Williamson 1979). In BC, large forest companies are better able to cope with uncertain situations. Hence, the likelihood of integration is expected to increase with increasing uncertainty, given nontrivial asset specificity (Anderson and Schmittlein 1984, p.387).

Finally, differences in the types of silvicultural activities influence the circumstances that give rise to opportunism and that determine the level of organization costs. TCE arguments regarding the role of relationship-specific investments suggest that both human and physical capital specificity should raise the costs of market organization, but the nature of silviculture may make physical asset specificity less important in silviculture than in other applications. Silviculture mainly involves organizing and coordinating a variety of relatively low-technology, labor-intensive activities. The requirement for highly technical, engineering-intensive activities takes place at the stage of preparing pre-harvest silviculture prescriptions, which invariably are handled by company employees, often with registered professional forester (RPF) status.

To sum up, the several major propositions are:

(1) The greater the total value of company-specific assets, the greater the likelihood of vertical integration in the form of an internally oriented vertical arrangement. According to this logic, since tree planting is not distinctive and asset specificity is low, therefore, outsourcing via market contracts is common for tree planting.

(2) Basic silviculture tends to be performed by contractors whereas incremental silviculture may be implemented in-house, or through special contractual arrangements.

(3) Since desirability of integration (or coordination) increases as work load increases, we expect to see more 'special arrangements' as more activities of higher-level silviculture increase.

(4) Firm size is an important factor. Large companies are able to achieve economies of scale in acquiring and utilizing management skills, so, scale economies are likely to play an important role in virtually all integration decisions. Since large firms have greater ability to aggregate inputs, large-sized forest companies tend to maintain their own silviculture crews or directly hire silviculture workers.

In summary, the choice of contractual forms depends on the types of activities, characteristics of licensees, contractors and workers. Activities that tend to be contracted out are those with the following features: high degree of seasonality in work scheduling, high degree of seasonality in labor demand (e.g., college students looking for summer jobs), and high intensity of work (e.g., tree planting is quite demanding physically). In contrast, activities that tend to be performed in-house are those that are less seasonal and require greater care and knowledge of production or a higher level of training. Apparently, major licensees have a greater advantage in hiring directly for these jobs. Based on various guidebooks of the Forest Practices Code and interviews with selected silviculture managers of several companies, a number of propositions about the attributes of major silvicultural activities are advanced. In Table 3.1, the lexical categories of low, moderate and high are used for illustrative purposes. If converted to a 5-point scale, "low" probably corresponds to < 2.5, "moderate" for 2.6 - 3.5, and "high" for > 3.5.

Formally, the general hypotheses of the research are as follows:

H_1: Silvicultural activities requiring standard physical assets tend to be contracted out.

H_2: Activities requiring low levels of human skills and training tend to be contracted out.

H_3: Activities with a reasonable degree of certainty of predictable results tend to be contracted out.

H_4: Relatively straightforward activities, such as single activities of basic silviculture, characterized by a high degree of seasonality, tend to be contracted out.

H_5: Larger forest companies tend to carry out more silvicultural activities in-house.

It should be noted that the above theorizing explicitly abstracts from risk considerations. This is not to say that risk factors are nonexistent in silvicultural contracts. However, due to the fact that risk is a crucial factor that determines share contracts, and farm-management-type share contracts are rare in BC's silviculture sector, it is believed that ignoring the risk factor in this research is justified.

3.2 Methodology

The previous section presents the general hypotheses related to the particulars of silviculture. It is believed that the problem of BC's silvicultural institutional restructuring provides an appropriate opportunity to test the applicability of the above TCE analytical framework. Focus will be placed on the governance structures of forest companies because of the pivotal role that the companies have to play in the new contractual relationships with the regulating government agency at the top of the hierachy and the implementing group of silviculture contractors at the bottom. In view of TCE's emphasis on the dimensions of specificity, uncertainty and frequency, one will expect that a forest company ordinarily wishes to exercise greater control over an activity by vertically integrating it within its hierarchical structure if that activity requires specific physical investment, specialized human input, and location-specific considerations. The problem is then reduced to testing the hypothesis that companies economize on transaction costs by choosing to undertake some silvicultural activities internally and to contract out some others to independent contractors.

The empirical part of this research consists of a case study and several econometric analyses. The data used for empirical analyses come from mail surveys and structured interviews. In view of the nature of the silvicultural activities involved in the study and the way that they are organized, respondents are categorized as (1) seed orchards, (2) tree nurseries, (3) forest companies and (4) public institutions (BC Ministry of Forests, Greater Vancouver Water District and other government and quasi-government agencies).

3.3 Model

The conceptual model incorporates the crucial features of silviculture contracting. Analytically, it has the following structure:

$$(3.36)\qquad G^* = G^1, \text{ if } C^1 < C^2$$
$$= G^2, \text{ if } C^1 \geq C^2$$

where G^* is the preferred alternative actually chosen; G^1 and G^2 represent a pair of alternative institutional arrangements; and C^1 and C^2 are the corresponding costs of governing transactions under these institutional arrangements. Since the choice of governance modes is determined by the category and actual levels of transaction costs, transaction costs can be related to the observable transaction characteristics and governance attributes as follows:

$$(3.37) \qquad C^1 = p(\beta^1 X^1) + e^1$$

and

$$(3.38) \qquad C^2 = p(\beta^2 X^2) + e^2,$$

where X is a matrix of observable firm characteristics and governance attributes that affect organization costs; p is a measure of transaction cost, β is a parameter vector; and e is an independently and identically distributed error term. This formulation is based on Masten (1996), Majumdar and Ramaswamy (1994) and Masten, Meehan and Snyder (1989).

The above conceptual model is constructed for analytical purposes only. The actual hypothesis testing requires an econometric model that is presented in Chapter 5. Here we note that a probit model is appropriate, with the dependent variable being the dichotomous choice between outsourcing and in-house. As the dependent variable may be further classified into three choices, i.e., contracting out, combination of outsourcing and in-house operations and purely in-house mode, and these three contractual choices follow an order in terms of transaction cost implications, an ordered probit model is also warranted.

Table 3.1 Proposition of Attributes of Major Silvicultural Activities

Silvicultural activities	Physical specificity	Human specificity	Uncertainty	Frequency
Cone collection				
- from seed orchard	low	moderate	high	high
- from wild	moderate	low	high	low
Seedling production	high	low	low	high
Surveying	low	high	moderate	high
Site preparation	high	high	moderate	high
Planting	low	low	low	high
Spacing	low	moderate	low	high
Thinning	moderate	moderate	low	low
Pruning	low	moderate	high	low
Fertilizing	moderate	moderate	high	low

Chapter Four

Organization and Contractual Arrangements of BC's Silviculture Sector

Given an understanding of the institutional environment of BC's silviculture sector, this chapter provides a profile of institutional changes at the operational level, namely, the changes in the way silvicultural activities are organized, particularly in contractual relationships and arrangements. The chapter proceeds as follows. First, the general forms of contractual relationships in BC's silviculture sector are outlined. Second, the Province's silviculture contracting force and its main characteristics and management approaches are described. The results of a survey of silviculture contractors are analyzed statistically. Third, a profile of the silvicultural arrangements at the level of the BC Forest Service is provided, with emphasis on the organization of silvicultural activities under the Small Business Forest Enterprise Program. Fourth, seed orchards and forest nurseries are described. Fifth, a profile of the organization and arrangements of silvicultural activities by forest companies is presented, and the results of surveys conducted among forest companies are analyzed statistically. Finally, the organization and contractual arrangements are summarized for the entire Province, and findings are discussed in the context of transaction cost logic.

4.1 Contractual Relationships in BC's Silviculture Sector

In BC, silviculture is a sub-sector that does not dominate the overall forestry sector although, in recent years, silviculture has increased in importance relative to other sub-sectors. Due to the fact that, up until the 1970s, the main thrust of forest management and technology in BC was in the area of harvesting, silviculture had been submerged in a multitude of other relationships, making it a challenging task to clearly identify the interconnectedness of silviculture and other sub-sectors.

During the past several decades, the main feature of institutional restructuring in BC's silviculture sector has been an alteration in contractual relationships. Initially, when BC's silvicultural programs were confined to nursery work and small-scale tree planting, the Provincial Forest Service directly hired individuals to perform silviculture on Crown land. Towards the end of the 1960s, with the expansion in the scale and scope of operations, the handling of an increasing amount of work became more and more costly.

So, instead of directly hiring workers on an individual basis, the government began to assume the role of a 'principal' with the emergent silviculture contractors as 'agents' (see Brinkman 1991 for background information). The rationale for such arrangements may be interpreted as an effort to minimize transaction costs, because silviculture contractors possessed the right type of specialized skills and knowledge required for the task. More importantly, they were in a better position to organize individual workers, so it was more logical for them to act as a level of management between the workers and the Forest Service. As a result, transaction costs were saved by the Forest Service thanks to the reduction in the costs of contract negotiation and physical enforcement. Of course, this assumes that contractors were more successful than the Forest Service in minimizing the problem of moral hazard.

The policy change that took place in 1987 opened the door for new arrangements. The then existing relationship of the BC Ministry of Forests-independent contractors-silviculture workers was now to include officially the major licensees, so the new relationships have become the MOF-major licensees-contractors-workers.[17] The reason for this new relationship had much to do with the rapid growth in the amount and type of silvicultural work and the changes in the expectations of the quality of silvicultural activities. The Ministry of Forests found it increasingly costly to stick to the old contractual arrangements. Hence, a new layer of principal-agent was inserted in the silviculture contracting system. As shown in Figure 1.3, the new hierarchical rearrangement vertically integrated major licensees into the silviculture contractual system. The rationale for this change was threefold. First, from the standpoint of forest management, it provided a basis for the incorporation of basic silviculture as an integral component of a forest management system and for the adoption of new planning processes that require forest regeneration to take place as a sequential operation immediately following harvesting operations. Second, from an administrative and organizational point of view, the policy decentralized silvicultural decision making without altering the fundamental structures of the existing forest tenure system in the Province. It effectively anchored the major licensees in the integrated forest management system in a compulsory fashion. The role of the MOF became regulatory, administrative and punitive. Finally, from an economic

[17] Bear in mind the fact that major licensees had used the services of silviculture contractors back in the 1970s for forest regeneration, although many of the costs were reimbursed by the Forest Service under the 'ledger cost' system.

point of view, the new approach resulted in the improvement of economic efficiency by minimizing the transaction costs that were associated with the organization of silvicultural operations, i.e., through designing decentralized contractual relationships in such a way that the costs of contract negotiation, enforcement and information collection might be lowered.

In essence, the contractual relationships in BC's silviculture sector are agency relationships. With the emergence and expansion of silvicultural activities, the possibility of gains to specialization gave rise to a relationship in which agents act on behalf of a principal due to comparative advantage. Conceptually, the several tiers of relationships in regard to silvicultural activities may be characterized as follows. The MOF may be viewed as the first-level principal and major licensees the second-level principal.[18] Likewise, the licensee is best described as the first-level agent and the silviculture contractor the second-level agent. Thus, the principal-agent structure is, more comprehensively, a two-strata relationship with the MOF-major licensee comprising the first layer and the licensee-contractor forming the second layer. Due to the existence of the Small Business Forest Enterprise Program (SBFEP), the MOF also deals with silviculture contractors. However, this layer of relationship is subsidiary in nature because SBFEP only accounts for some 13% of the Province's allowable annual cut, or AAC (BC Ministry of Forests 1996a, p.31). Of course, in absolute terms, this still represents a large area for treatment each year.

For the sake of distinction and brevity, we may call the MOF "the major principal" (MAP) and the major licensee "the minor principal" (MIP). In like manner, we can label the licensee "the major agent" (MAG) and the contractor "the minor agent" (MIA). At the first layer of relationship between the MOF and major licensees, the policy instruments used are mainly legislative and administrative in nature (although contracts in the form of licensing documents are an important instrument), for instance, the Forest Practices Code, pre-harvest silviculture prescriptions as well as AAC. Modeling of interactions at this level is likely to be conceptual and qualitative rather than quantitative.

From the above categorization, it is obvious that the second-layer relationship is essential because silvicultural operations hinge on the major licensee, who acts in a dual role as both a principal and an agent.

[18] It may be argued that the Ministry of Forests is an agent operating on behalf of the BC residents, who collectively are the ultimate principal. This point is not pursued in this research and, therefore, MOF is viewed as the paramount principal insofar as BC's public forest lands are concerned.

In consequence, the licensee plays a central role in this institutional arrangement. Figure 4.1 provides a full description of the multi-tiered relationship in BC's silviculture contractual system.

Conventionally, economists tend to approach principal-agent problems by investigating incentive schemes and alignment of objectives between the principal and the agent (Sappington 1991; Stiglitz 1975; Ross 1973). It is worth noting that, at the interface between major licensees and contractors, asymmetric information emerges as a problem. But, due to the fact that licensees replace the MOF as the principal in dealing with the silviculture contractors, the problem of information asymmetry is forced downward. The more the problem of information asymmetry is forced to a lower level decision making, the more advantageous the MOF's position is. This is because a licensee tends to be more knowledgeable than the MOF about site-specific silvicultural activities, and an agent's opportunistic behavior is more likely to be held in check. It is in the interests of the licensee to make sure that the agent behaves, because this is a condition for the licensee to satisfy a higher-level requirement that the government (higher-level principal) demands.

The usual principal-agent approach tends to ignore the categorization and subsequent analysis of transaction costs, and the expected solution to an agency problem usually hinges on rigid assumptions about risk attitudes of the principal and the agent (Laffont 1989; Hart and Holmström 1987). In this research, however, the principal-agent formulation is constructed only to the extent of characterizing, at a conceptual level, the institutional and contractual reforms in BC's silviculture sector. In the sections below, emphasis is given to investigation of contractual arrangements at the level of itemized silvicultural activities in order that transaction cost hypotheses can be empirically tested.

4.2 Profile of BC's Silviculture Contracting

The data required in this research come from several sources. The MOF's annual reports and annualized Five-Year Forest and Range Resource Programs, the *1994 Range Resource Programs and Forest, Range & Recreation Resource Analysis*, the relevant guidebooks of the Forest Practices Code, and other relevant public documents have been consulted for the purpose of documenting policy changes and institutional restructuring. Numerical data have been retrieved from the MOF Forest Practices Branch data base ISIS (Integrated Silviculture Information System). The primary sources of essential data for empirical analysis, however, are the surveys that I have conducted on the following sub-sectors: seed orchards, forest nurseries, major licensees and silviculture contractors (questionnaires can be found in Appendix I). A summary of the survey responses is provided in Table 4.1. In addition, structured interviews have also been conducted. Detailed explanations are provided in sections below.

Table 4.1 Summary of Data Source, Category and Focus

	Surveys		
Sub-sector	Questionnaires sent out	Number of returns	Response rate (%)
Seed orchard	16	13	81.3
Forest nursery	43	34	79.1
Major licensees	117	103	88.0
Silviculture contractors	139	52	37.4
Overall	**315**	**202**	**64.1**

4.2.1 Workforce of BC's Silviculture Contractors

Sources differ considerably in regard to the number of silviculture contractors in BC. According to the latest *Canadian Silviculture Directory*, there are 212 contractors in the Province (Table 4.2). While the Western Silviculture Contractors' Association (WSCA) reports a total of 62 full members and some 20 associate supplier members as of early 1997, it is widely believed that the number of silviculture contractors is upwards of 500 (Groves 1996). However, active contractors are fewer in number. For instance, over the past two years, the MOF Vancouver Forest Region has issued a list that includes some four dozen contractors who have recently held tree planting contracts with the MOF (BC Ministry of Forests 1996b).

Table 4.2 BC's Silviculture Contracting Force

Category	Number[a]
Silviculture suppliers	122
Forest nurseries	13
Planting and general contractors	56
Site preparation contractors	1
Spacing contractors	4
Brushing and weeding contractors	5
Pruning contractors	4
Commercial thinning contractors	1
Watershed restoration and erosion control	4
Woodlot management contractors	2
Total	212

Source: "Canadian Silviculture Directory," *Canadian Silviculture Magazine*, Winter 1997, vol. 5, no.1.
[a] The total number of contractors in the table contains some double counting due to the fact that a certain number of contractors are involved in multiple activities. In terms of contracting firms, the number is 150.

As is clear from Table 4.2, BC's silviculture contracting covers the full spectrum of silvicultural operations. Results of a survey of BC silviculture contractors reveal more details (see Table 4.3). When examining both Tables 4.2 and 4.3, three features are discernible. First, contractors tend to concentrate in basic silviculture such as planting, brushing and weeding. Second, contractors that are engaged in incremental silviculture are limited in number. Finally, stewardship contracting, which is end-results based and involves multiple phases and multiple activities, is virtually non-existent.

Table 4.3 Scope and Extent of Participation in Silvicultural Activities, 1997

(% of contractors performing)

Activity	WSCA member	Not WSCA member	Entire group	Pre-1987 contractor	Post-1987 contractor	Pre-1987 WSCA member	Post-1987 WSCA member
Cone collection	15.4	26.9	21.2	32.1	8.3	17.6	11.1
Site preparation	19.2	19.2	19.2	14.3	25.0	11.8	33.3
Planting	73.1	34.6	53.8	67.9	37.5	88.2	44.4
Brushing & weeding	76.9	50.0	63.5	67.9	58.3	76.5	77.8
Pest & disease control	15.4	23.1	19.2	21.4	16.7	23.5	0.0
Spacing	50.0	50.0	50.0	60.7	37.5	64.7	22.2
Pruning	34.6	38.5	36.5	42.9	29.2	41.2	22.2
Thinning	34.6	30.8	32.7	35.7	29.2	41.2	22.2
Fertilizing	15.4	3.8	9.6	14.3	4.2	23.5	0.0
Surveying	26.9	57.7	42.3	46.4	37.5	35.3	11.1

Survey results reveal a considerable variance among BC's silviculture contractors. From Table 4.4, based on a survey of 52 contractors (37.4% of 139 contractors contacted), the average period of operations is 11 years, with WSCA members averaging 12.4 years and non-members 9.6 years. The silviculture contracting force is relatively young (Figure 4.2). For instance, the majority of the contractors surveyed have been in the silviculture business for less than 15 years, and two larger groups being 6 - 10 years and 11 - 15 years, representing 37% and 29%, respectively, of the surveyed contracting community. The overall young age of the contracting force is due to the emergence of a large number of contractors in the past decade. Many of the contractors have elected not to become WSCA members.

Table 4.4 Management of Silviculture Contracting in BC, 1997[a]

Category	WSCA member	Not WSCA member	Entire group	Pre-1987 contractor	Post-1987 contractor	Pre-1987 WSCA member	Post-1987 WSCA member
Number of managers	5	3.9	4.5	5	3.8	5.3	4.4
Workers hired in 1996	127	49	88	136	32	170	48
Returned workers (%)	66.3	49.2	56.8	60.8	54.5	68	63.1
Worker-manager ratio	26	11	19	26	9	36	8
Payment scheme (%)[b]							
- hourly wages	26.9	76.9	51.9	53.6	50	35.3	11.1
- piece wages	80.8	53.8	67.3	82.1	50	94.1	55.6
- base wage + bonus	11.5	15.4	13.5	17.9	8.3	11.8	11.1
- other (salary, etc.)	26.9	7.7	17.3	14.3	12.5	23.5	33.3
Contract length (days)							
- basic silviculture	66 - 67	73 - 88	69 - 77	67	79	55	94
- incr. silviculture	72 - 77	81	76 - 79	77	78	61	105
Ratio of workers to supervisor (proportions in brackets)	1-5 (11.5%) 6-10 (53.8%) 11-15 (34.6%)	1-5 (46.2%) 6-10 (34.1%) 11-15 (19.2%)	1-5 (28.8%) 6-10 (44.2%) 11-15 (26.9%)	1-5 (10.5%) 6-10 (63.2%) 11-15 (26.3%)	1-5 (45.8%) 6-10 (37.5%) 11-15 (16.7%)	1-5 (5.9%) 6-10 (58.8%) 11-15 (35.3%)	1-5 (22.2%) 6-10 (44.4%) 11-15 (33.3%)
Preference for[c]							
- Forest Service	15.4%	15.4%	15.4%	17.9%	12.5%	17.6%	11.1%
- Forest companies	100%	92%	96%	96%	96%	100%	100%

[a] Weighted average of individual contracting firms surveyed.
[b] Percentage of contractors using the method.
[c] Percentage of contractors making the indication.

Survey results also confirm that BC's silviculture contractors have a noticeable variance in the scope of activities and management approaches. According to Table 4.3, the intensity of engagement in silvicultural activities is as follows (in a descending order): brushing and weeding, planting, spacing and surveying. Comparisons between WSCA members and non-members do not provide indications that member-contractors necessarily involve themselves more fully than non-members in silvicultural work. Except for planting, brushing and weeding, and fertilizing, WSCA members do not seem to have any advantages over non-members. Experience seems to be an important determinant in the scope of silvicultural operations. As shown in Table 4.3, contractors with more years of experience, regardless of WSCA membership, demonstrate a greater degree of involvement in virtually all activities.

In order to understand the quality of performance and management efficiency, the survey included questions concerning contract length, payment scheme, size of employment, rate of returned workers and level of management. Table 4.4 shows that, compared with non-members, WSCA members tend to hire more workers and enjoy higher management efficiency (from a technical rather than economic standpoint) in terms of the percentage of returned workers and ratio of workers to supervisors. Many contractors not only adopt piece wages but other payment schemes like base wage plus bonus, and so on. However, comparatively speaking, although non-members also use piece rates, the hourly wage system is more commonly used by this sub-group. One reason for this difference is that, since WSCA members tend to be in operation for more years, they have more experience with different sorts of incentive schemes. In this respect, many new contractors lack experience and, therefore, they need to use the hourly wage system for a certain period in order to gain knowledge. Management efficiency is clearly positively related with experience, and this is most noticeable when comparing the survey results for the pre-1987 and post-1987 sub-groups.

For the sake of comparison, BC's silviculture contracting in the 1980s is described in Table 4.5, based on two directories assembled by the Pacific Reforestation Workers Association. It is clear that, over the past decade, the Province's silviculture contracting industry has grown beyond the tree-planting dominant stage into an era of more diversified activities. Evidence is found in the average number of workers hired by a contractor (55 in 1987, 104 in 1989 and 88 in 1996), in the worker-supervisor ratio (13 in 1987 and 8 in 1996) and the average length of working season (11 weeks for tree planting in 1987 and up to 15 weeks for basic and incremental silviculture in 1996). However, the competitiveness of the industry persists. Several pressing issues include: (a) the concern for employment security, (b) the conflict between displaced union workers and mobile silviculture workers, and (c) the coordination among various government agencies, the forest industry and independent contractors regarding silviculture contracts. Given the trend in the last 10 years, it is likely that BC's silviculture contracting industry will continue to consolidate and localize towards more permanent silviculture workforce.

In summary, BC's silviculture contracting industry has been in existence for some thirty years. Statistical analysis shows the following. (1) Silviculture contractors, especially the larger ones who have been in operation for a relatively long period, concentrate their efforts in basic silviculture activities such as planting and brushing and weeding. (2) Contrary to expectation, contracting experience does not necessarily mean more contract days. (3) There is no evidence indicating that WSCA members win more contracts and/or obtain more secure silvicultural work.

Table 4.5 Statistics on BC's Silviculture Contracting in the 1980s

Item	Mean	Standard deviation	Minimum	Maximum
1987 (N = 40)				
Workers hired	55	55	4	300
Number of crews	3.3	4.1	1	23
Crew size	20	10	4	40
Worker-supervisor ratio	13	8	4	40
Number of trees contracted (million)	1.95	2.43	0.02	10
Season length (weeks)	10.9	5.5	2	22
Pay for average planter ($/day)	154.45	24.78	90	225
Proportion of bid paid to workers (%)	56	7	50	100
Camp fee ($/day)	14.23	4.93	20	20
1989 (N = 42)				
Workers hired	104	122	2	500
Number of crews	4.6	5.0	1	21
Crew size	24	12	2	60
Returned workers (%)	80	19	40	100
Number of trees contracted (million)	3.26	2.99	0	12
Work hours per day	9.0	0.9	7.0	11
Camp fee ($/day)	12.62	7.13	0	20
Number of rest days-work days ratio	0.23	0.08	0.14	0.4

Source: Compiled from *Screef*, Pacific Reforestation Workers Association, Summer 1987 and Spring 1989.

4.2.2 Profile of the BC Ministry of Forests' Silviculture Contracting

According to the 1988 amendment to the BC Forest Act (B.C. Reg. 265/88; O.C. 1326/88), the MOF has a mandate to get involved in silviculture contracting under the Small Business Forest Enterprise Program. Currently, the MOF maintains direct contact with silviculture contractors through SBFEP, which involves some 13% of AAC. According to Raymer (1997), the number of silviculture contracts averages some 15,000 per annum over the last several years. This number more than doubles that in the 1980s. Due to the increase in the number of contracts, decision making has been decentralized to the Forest District level. At present, managers of the 43 Forest Districts are the final authority approving contracts. In 1986, the maximum contract size that the MOF Forest Districts could tender by selective invitation was raised from $10,000 to $25,000. Contracts under $25,000 are now handled by direct awarding by the Forest District manager; contracts between $25,000 and $150,000 are tendered to at least three selected contractors; and contracts over $150,000 are advertised for open bidding. At present, the MOF is involved in the management of Forest Renewal BC (FRBC) silvicultural projects (from a technical standpoint), Industry Outstanding (IO) contracts (from a financial standpoint) and Ministry Outstanding (MO) contracts (from a physical implementation standpoint). When it comes to contract monitoring and enforcement of technical standards, the MOF's Forest Practices Branch (formerly known as Silviculture Branch) has played an important role.[19]

Upon request from the author, the MOF Forest Practices Branch provided assistance in retrieving a data set from its data base called Integrated Silviculture Information System (ISIS). According to ISIS, contracting with the MOF for silvicultural activities on BC's Crown land is undertaken by three categories of performers, namely, Forest District offices of the MOF, large forest companies and small firms. Small firms that comprise independent contractors and lumber mills are by far the largest group because they are responsible for over 85% of the MOF administered silvicultural contracts. Even if major licensees win contracts from the MOF under the Industry Outstanding category, or from FRBC sources, they are likely to sub-contract the actual work to independent contractors (Raymer 1997). Except for the contracts executed by the MOF's Forest District offices, the majority of the contracts occur in the Interior. For instance, some 83% of the small firms' contracts are in the Interior, while nearly 80% of the large companies' contracts are in the Interior.

As far as individual activities are concerned, the top four are (in decreasing order): surveying, planting, spacing and brushing. These four activities account for 73% of the total number of projects (see Table 4.6). Table 4.7 indicates that, over the three years 1995 - 1997, there has been an increase in brushing and site preparation, a decrease in spacing contracts and stabilization in planting and surveying contracts. The reason that the number of projects for 1995 was considerably lower than for 1996 and 1997 is because ISIS was first introduced in 1995 as a reporting system.

[19] At the beginning of 1997, organizational restructuring took place within the Silviculture Branch. As a result, the branch has become the Forest Practices Branch. Silvicultural contracts are the responsibility of the Forest Site Management Section, which is one of the seven sections of the branch. For detailed information on structural change of the branch, see BC Ministry of Forests 1997b, pamphlet 967FFPB143--02/97 QP# 19999.

Table 4.6 Silvicultural Contracts Funded by MOF, by Performer

	MOF		Large firm		Small firm		Total		
Activity	Coast	Interior	Coast	Interior	Coast	Interior	Coast	Interior	Total
Brushing		1	17	37	34	249	51	287	338
Direct seeding						1		1	1
Fertilizing					7	4	7	4	11
Five-year plan				1				1	1
Juvenile spacing		2	7	21	66	340	73	363	436
Pest control				2	11	8	11	10	21
Planting	1	3	8	48	93	327	102	378	480
Pruning				1	29	51	29	52	81
Roads					1	3	1	3	4
Multiple activity				1	2	69	2	70	72
Site preparation	3	19	2	25	16	207	21	251	272
Stand tending			4	9	27	149	31	158	189
Surveys	54	13	19	63	69	314	142	390	532
Total	58	38	57	208	355	1722	470	1968	2438

Source: Integrated Silviculture Information System (ISIS), data maintained by the Forest Practices Branch, BC Ministry of Forests.

Table 4.7 Silvicultural Contracts Funded by MOF, by Year

Activity	1995		1996		1997		Total	
	Contracts	%	Contracts	%	Contracts	%	Contracts	%
Brushing	12	5.3	184	13.6	154	18.1	350	14..4
Juvenile spacing	48	21.2	257	19.1	123	14.5	428	17.6
Planting	36	15.9	290	21.5	170	20.0	416	17.1
Site preparation	16	7.1	164	12.2	89	10.5	269	11.1
Surveys	59	26.1	282	20.9	185	21.8	526	21.7
Other	55	24.3	172	12.8	130	15.2	357	14.7
Total	226	100.0	1349	100.0	851	100.0	2426	100.0

Source: Integrated Silviculture Information System (ISIS), data maintained by the Forest Practices Branch, BC Ministry of Forests.

4.2.3 Profile of BC's Seed Orchards and Forest Nurseries

Seed Orchard

BC's seed orchard program arose from a perception of timber shortages and a desire to secure a supply of high-quality seeds. As a result of an expansion in artificial regeneration, mainly by planting, an increase in demand for high quality seedlings to reduce timber shortfall generated an enthusiasm for developing genetically improved seed produced in seed orchards (Hanson 1985).

The first seed orchard was established on the BC Coast in 1963 at Campbell River. During the 1960s and 1970s, 25 orchards were established on the Coast by the Forest Service and the forest industry, and with the exception of one Sitka spruce (*Picea sitchensis* (Bong.) Carr.) orchard and one western hemlock (*Tsuga heterophylla* (Raf.) Sarg.) orchard, the rest focused on Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco). In 1974, a seed production section was set up in the Reforestation Division of the BC Forest Service. Two mandates of the seed production section were: (i) to establish first phase seed production orchards either by grafting of scions or use of seedlings from selected high quality parent trees to produce regular supplies of seed with high germinative vigour and wide adaptability; and (ii) to establish second-phase seed orchards from progeny tested breeds of proven superior genetic quality. These two objectives were designed to progressively—over the next 20 to 40 years—reduce dependence on chance collection from wild stands (BC Forest Service 1974, p.34).

To improve coordination within the joint government/industry tree improvement efforts, two cooperative programs were formed: the Coastal Tree Improvement Council (CTIC) and the Interior Tree Improvement Council (ITIC). These two councils were formed in 1979 and 1981, respectively, to coordinate government and industry projects. They have also been responsible for making recommendations to the Provincial Chief Forester regarding program objectives, strategies, agency involvement, and allocation of workload and research needs for future tree improvement in BC. For instance, as a result of a CTIC recommendation, 10 of the initial coastal orchards were either abandoned or withdrawn from intensive management because they were found to be located in an unfavourable environment. Companies participating in the management of orchards were reimbursed for costs incurred through credits-to-stumpage under Section 88(1) of the Forest Act (RS 1979, Chapter 140). The objectives of the Councils were twofold: (1) to establish programs to increase the levels of genetic gain through testing and breeding, and (2) to produce sufficient orchard seed (incorporating the highest available level of genetic improvement) to meet specific goals established for each species. Meanwhile, private orchards have been in existence to produce seed primarily for private forest lands, and they have been managed and financed without government support.

Orchard planning is based on 37 seed orchard planning zones. These boundaries represent a compromise between biogeoclimatic zones and subzone boundaries and administrative boundaries. Each planning zone has a projected long-term seed need based on planting requirements for each species. The trend for the period between the late 1960s and mid 1980s was to establish and intensively manage seed orchards to produce seed of superior genetic quality for the major reforestation species. As of 1992, the total area of seed orchards covered 200 hectares, with the MOF managing slightly more than half of the area. Geographically, the MOF has placed greater emphasis on the Interior whereas the industry concentrates its efforts on the Coast. Specifically, one third of the MOF's orchard area is in the Interior, but the industry has 82% of its orchards in the coastal region (BC Ministry of Forests 1992). This is because most of the major forest companies are concentrated on the Coast, while Weyerhaeuser Canada Ltd. and Vernon Seed Orchard Company Ltd. are the two major agencies engaged in seed orchard development in the Interior.

Some seed orchards are located adjacent to nurseries, others in clusters close to a nursery that serves as a headquarters for administrative and maintenance purposes. This feature finds explanation in scale economy and capital justification. The fact that staff and facilities of seed orchards are often attached to nurseries may also be explained by transaction cost economizing, because such an arrangement enables joint use of facilities and equipment and facilitates pooling human resources in favor of direct consultation on matters of propagation.

Most cone harvesting in seed orchards is done with the aid of ladders. In some orchards, hydraulically operated lifts used in the fruit industry are utilized in seed orchards. These units have a slow ground speed but are versatile in that they can be used for conducting orchard surveys and enable pruning, pest control and pollination as well as cone harvesting (Konishi 1985). So, the physical specificity is considered low.

As far as human skill is concerned, cone production may be broken into two parts. While cone harvesting itself does not require much skill and training, a great deal of expertise is necessary for things such as pollen handling, cone induction, pest control, and so on.

For the survey on seed orchards, a response rate of 81% (13 out of 16) was obtained (Table 4.1). Generally speaking, the forest industry's seed orchards are 10 years older (mean age of 24 years) than the MOF orchards (14 years). The average growing area for all seed orchards is 21.1 hectares. The orchards have produced cones, on average, for nine years. In aggregate, cone production ranges from 853 to 1,298 hectolitres per annum across the Province, with the average being 66 - 100 hectolitres per orchard.

The 13 orchards reported a total of 26 permanent employees, so the average per orchard is just two people. The number of professional and administrative personnel totals 10 for the 13 orchards, that is, just under one full-time equivalent per orchard. Hiring of seasonal workers is commonly in the range of half a dozen or less (see Table 4.8). It is found that 77% of the seed orchards hire seasonal workers to harvest cones. Three orchards (23% of total) use their own permanent staff to harvest cones, and they are all MOF's seed orchards. As far as payment schemes are concerned, time rate is universally used with seasonal workers who are hired at each and every seed orchard in the Province. Survey results indicate that 77% of the orchards use their technical staff for supervising seasonal workers, while the rest (23%) rely on a combination of technical staff and hired people for supervisory work.

Table 4.8 Seed Orchard Management in British Columbia

Number of seasonal workers hired per year		
Number of seasonal workers	Number of orchards	Frequency (%)
0	1	7.7
1 - 3	3	23.1
4 - 6	4	30.8
7 - 10	1	7.7
> 10	3	23.1
Period of employment for seasonal workers		
Number of weeks	Number of orchards	Frequency (%)
< 5	3	23.1
5 - 8	3	23.1
9 - 12	1	7.7
> 12	6	46.2
Percentage of cones harvested by seasonal workers		
Percentage	Number of orchards	Frequency (%)
≤ 25	3	23.1
26 - 50	1	7.7
51 - 75	0	0
76 - 100	9	69.2
Ratio of seasonal workers to supervisors		
Number of workers	Number of orchards	Frequency (%)
< 4	3	23.1
4 - 6	5	38.5
7 - 10	4	30.8
> 10	1	7.7

Regarding training, 92% of the orchards provide some training, with 69% of those training their seasonal workers for less than half a day. Longer training (0.5 - 1 days) occurs at only 31% of the seed orchards. No seed orchard provides training in excess of one day.

Expert opinion on the several identifiable characteristics of seed orchard management was solicited. On a 5-point rating scale, from 1 to 5, with 1 meaning low and 5 being high, the average is as follows:

- frequency of production	4.1
- management complexity	3.2
- specificity of equipment and tools	2.7
- level of technical skill for cone collection	2.4.

The above information means that cone production is relatively frequent in seed orchards; management of seed orchards is moderately complex; physical specificity of equipment and tools is moderate; and the level of technical skills required for cone harvesting is relatively low.

Forest Nursery

BC's forest nursery sector was born in 1926 with the establishement of a small experimental facility on the outskirts of Victoria. The Province's first nursery for production purposes was established at Green Timbers near Vancouver in 1930 (Young 1989a). However, expansion in nursery capacity did not begin until the early 1960s (Young 1989b) because, up to the 1950s, only some of the most highly productive sites in the most accessible areas were considered for restocking (Sloan 1956). For instance, in 1946, some 1.2 million seedlings were produced. Ten years later, in 1955, approximately seven million seedlings were available for planting in BC, the majority being planted on the Coast. In 1961, seedling production was still approximately the same. However, two years later, seedling production doubled. In 1963, BC had three major nurseries, producing 12.5 million trees for planting. With this rate of production and a planting density of 400 trees per acre, only 31,000 acres could be planted per year.[20] By 1964, 23 million seedlings were produced. The estimated 1965 nursery capacity for seedlings in the Province

[20] 2.471 acres = 1 hectare.

reached 25 million (Sedlack 1965). At that time, nursery stock production was financed entirely by the government.

Since the late 1960s, regeneration accelerated in speed, exerting increasing pressure on BC's seedling production capacity. For instance, sowing requests for 1979 totaled 111 million seedlings, 11 million more than the nurseries could grow. The new situation forced the newly created Ministry of Forests to explore the possibility of involving private nurseries to meet the increased demand for seedlings (Grant 1979, p.19). Quickly, more than one dozen commercial and forest industry nurseries were established.

Nursery management represents the greatest concentration of technology and investment in the forest growth cycle and rivals wood processing in capital and labor intensity (Gordon 1984). The nursery production cycle is short relative to many other forestry operations. Since nurseries are the first custodians of seed-orchard seeds, they have received increasing attention from silviculture managers. Nurseries present a unique opportunity to multiply the effects of technology and research on wood yields (Gordon 1984). After several years of debate and preparation, the Provincial government decided to sell nine Ministry of Forests and Lands' nurseries.[21] Located in several different regions, the nurseries for sale included the land, buildings and equipment needed for seedling production, and each was staffed by fully trained and experienced personnel.

Expressions of interest were solicited from the general public, but the Ministry made it clear at the outset that the government reserved the right to negotiate an agreement directly with affected employees in the event a satisfactory proposal was received from those employees. If no acceptable employee proposals were identified, the normal public bidding process would apply. In any event, the government would favor proposals that emphasized job creation and job protection.

In the middle of 1988, six of the nine nurseries were purchased by an employee group headed by one of the Ministry's top managers.[22] The six nurseries involved a total of 100 jobs, with 47 of them being

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[21] On November 12, 1987, the *Vancouver Sun* (B9) carried an advertisement 'An invitation to apply for the purchase of 9 BC Forest Service nurseries'. The nurseries produced 100 million seedlings a year—half the seedlings needed for reforestation by the industry. The other 50% was supplied by private suppliers. Before privatization, there were 11 government nurseries. The government wanted to retain the Surrey Nursery and the Skimikin Nursery in Salmon Arm for research and to provide seedlings for reforestation of lands directly under the Ministry's control.

[22] See *Vancouver Sun*, July 23, 1988, B8.

regular full-time jobs. The employees paid $5 million for the nurseries and they would give the government $3.9 million worth of seedlings and service charges over the next five years. The new company signed a four-year contract with the Ministry for seedling production and a five-year contract for seedling storage. At around the same time, two other nurseries were also privatized. However, Green Timbers—BC's very first forest nursery was withdrawn from the privatization process primarily due to public outcry (Merrel 1997).

Prior to October 1987, the MOF was financially responsible for growing almost all of the seedlings planted on BC's Crown land. In consequence of the changes in the responsibility for funding reforestation in the Province, the administration of contracts, seedling morphological and physiological quality, nursery culture, pest management, shipping and cold storage became important to all licensees as well as nurseries due to changes in the supplier-customer relationship. In December 1987, the Forest Act was amemded (Bill 70) to require major licensees to carry out basic silviculture, at their own expense, beginning October 1, 1987 (British Columbia Government 1988a; BC Ministry of Forests 1988, p.15). The policy change, among other things, created a forest industry funded seedling market (Brazier 1991).

Since the early 1980s, production of forest planting stock in containers has increased rapidly in BC. Currently, of the some 220 million seedlings raised each year, over 90% are container grown. The principal species are spruces [white spruce (*Picea glaauca* (Moench) Voss), Engelmann spruce (*Picea engelmannii* Parry *ex* Engelm.), sitka spruce (*Picea sitchensis* (Bong.) Carr.)], lodgepole pine (*Pinus contorta* Dougl.ex Loud.), Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco), western redcedar (*Thuja plicata* Donn *ex* D. Don *in* Lamb.), hemlock [western hemlock (*Tsuga heterophylla* (Raf.) Sarg. and mountain hemlock (*Tsuga mertensiana* (Bong.) Carr.)], true firs (*Abies* spp.) and miscellaneous species including Ponderosa pine (*Pinus ponderosa* Dougl. *ex* P. & C. Lawson), western larch (*Larix occidentalis* Nutt.) and yellow-cedar (*Chamaecyparis nootkatensis* (D.Don) Spach). A list of tree species and their scientific names can be found in Appendix III.

Container-grown plants are removed from their growing trays at the nursery, culled according to morphological standards, which include the presence of a plantable root system, packaged for cold storage, shipped and field planted. The change in 1987 from a single government buyer to a multiplicity of purchasers has resulted in a true market-driven forest seedling industry. The market demands have increased the number of stock types from eight in 1986 (Brazier 1991) to 35 in 1993 (Scagel *et al.* 1993). In terms of stock types sown during the late 1980s and early 1990s, 1+0 containers rose to dominate the market, 2+0 containers showed some decline, bare-root continued to decline, and transplants increased.[23] There has been a general trend from using smaller stock types to larger ones. For instance, PSB 211A has declined from 19% of the total sowing requests in 1987 down to 5% in 1993; but in the meantime, PSB 415's have increased from 4% to 28% (Scagel 1993). Table 4.9 shows the steady growing trend to larger-sized container seedlings.

Table 4.9 Trends in Stock Type Sowing Request for British Columbia 1987 - 1993[a]

(in 1,000s of seedlings)

Stock type[b]	Cavity	1987	1988	1989	1990	1991	1992	1993	Total
211A	240	36518	62072	59158	38639	26807	15552	11969	250715
310A	160						101	29	130
310B	160					1413	1428	805	3646
312	198							254	254
313A	198	70128	74226	92515	51892	31791	23615	7815	351982
313B	160	43399	57289	72251	76772	66409	63954	62600	442674
313C	160					2	645	815	1462
313D	160					2	296	201	499
315	160						2		2
323A	160			8	20	3	5		36
410	112					1516	5392	11861	18769
415A	112				1789	222	129	17	2166
415B	112	8509	18787	35575	45933	40473	62862	52551	264690
415C	91				850	376	686	497	2409
415D	77				2439	2945	5225	8810	19419
515A	60							20	20
615A	45	27	92	347	265	406	445	561	2143
615B	28						20	81	101
Other[c]		32480	28051	38866	23065	20172	14935	13820	171389
Total		191061	240517	298742	249917	210520	233871	224789	1649417

[a] Compiled from Scagel *et al.* 1993.

[b] Stock type listed here are plug styroblock container seedlings.

[c] Other stock types include bareroot, plug transplanted bareroot, container rooted cutting, plug copper treated, and container paper pot.

[23] Plug styroblock (PSB) is a commonly used container stock type. For a given species, a stock type name is comprised of nursery culture and growing seasons. For instance, 1+0 means one-year-old seedling, i.e., one year in container and 0 year in transplanting stage. For container seedlings, PSB211A, PSB313A, PSB415B, PSB615A and so on refer to the cavity diameter, depth (in centimeters) and number of cavities per block. Frequently used styroblocks are PSB313B, PSB415B and PSB415D, with 160, 112 and 77 cavities per block, respectively. A standard styroblock measures 13 inches wide and 25 inches long.

In summary, BC's nursery capacity presently exceeds demand. Three trends have been visible over the past 10 to 15 years: container seedlings have replaced bare-root seedlings; larger stock types have increased in proportions; and nursery production has shifted into greenhouses. These changes and Bill 70 fostered new facilities to meet the customer requirements of an increased number of clients (Brazier 1991).

The survey on forest nurseries produced a response rate of 79%. As noted in Table 4.10, of the 34 nurseries that replied to the survey, four are MOF nurseries, six are of forest companies (i.e., Scott Paper Ltd., MacMillan Bloedel Ltd., Pacific Forest Products Ltd., Riverside Forest Products Ltd., and Weyerhaeuser of Canada Ltd.), and the remaining 24 are all commercial ones.[24] The MOF nursery at Cowichan Lake Research Station is not included in statistical calculations due to its research nature. Of the commercial nurseries, seven are managed by Pacific Reforestation Technologies (PRT), and they were among the eight nurseries privatized in 1988. Obviously, the MOF and commercial nurseries are larger in both acreage and production capacity than the ones under the major forest companies. Table 4.16 shows that only half a dozen forest companies have their own nurseries. This is because many firms have too small planting programs to justify establishment of a separate forest nursery (Barker 1997). The number of years in operation averages between 14 and 17, which corresponds with the time when the MOF decided to encourage private efforts in seedling production.

Table 4.10 Forest Nurseries in British Columbia, by Category

Nursery category	Number	Average years in operation	Average size (ha)	Total capacity (million)	Mean annual capacity (million)
MOF	4	36	340	36	12
Industry	6	15	14.6	29	4.8
Commercial	24	14	30.1	240	10
Overall	34	17	64	305	9

The three MOF production nurseries currently produce 25 million seedlings. Since the MOF is currently responsible for making available 45 million seedlings, some 20 million seedlings are purchased from private growers. The selection of private nurseries is done on a rating basis handled by a nursery

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[24] The BC Ministry of Forests has identified two categories of private nurseries. Private tree seedling nurseries under contract to the Ministry, for direct payment of seedlings destined for Crown land, are

contract review board, and the formula consists of a weighted average of 60% for seedling quality and 40% for production and delivery ability as well as contract prices (Merrel 1997).

The MOF has the greatest availability of permanent staff and technical personnel (Table 4.11), and the MOF nurseries do not hire seasonal workers as intensely as private nurseries. However, regardless of nursery categories, temporary workers are invariably hired for labor-intensive jobs such as thinning, weeding, lifting and packing (Table 4.12). For contracting out, the MOF nurseries tend to outsource activities such as seedling lifting, nursery maintenance, and so on. Several industry nurseries also contract out some activities, but the commercial nurseries do not contract out at all.

Table 4.11 Forest Nursery Management in British Columbia

Nursery category	Permanent employees	Technical staff	Intensity of seasonal hiring (in %)		
			< 10	11 - 20	> 20
MOF	10	9.3	33.3	33.3	33.3
Industry	6	2.4	16.7	16.7	66.7
Commercial	9	4.7	8.3	25.0	66.7
Overall	8	4.7	12.1	24.2	63.6

Table 4.12 Seasonal Worker Employment in Performing Nursery Activities

(measured in %)

Nursery category	Sowing	Stock growing	Thinning	Weeding	Lifting & packing	Other[a]
MOF	33	33	67	67	100	33
Industry	67	33	83	83	100	33
Commercial	71	25	96	96	96	29
Overall	67	27	91	91	97	30

[a] Other includes transplanting, pest control, moving and clean-up.

Normally, the period of employment for seasonal workers is around 3 - 6 months (Table 4.13). With a few exceptions, almost all seasonal workers are from local communities. Some exceptions occur with the forest industry nurseries. As far as unionization is concerned, the MOF nurseries are 100% unionized; industry nurseries are largely unionized; among the commercial nurseries, the PRT group is primarily unionized because they were government nurseries before 1988. However, among the non-PRT group, unionization is not a factor, except for Pelton Reforestation Ltd. whose seasonal workers are all

categorized as commercial nurseries. Private nurseries operated by forest companies that harvest on Crown land are called industry nurseries.

unionized. Time rate is the predominant payment method for seasonal workers. However, some one third of the nurseries have also adopted a piece rate system or production bonus schemes, but majority of these are in the PRT group.

Table 4.13 Period of Employment for Seasonal Workers

(in %)

Nursery category	< 3 months	3 - 6 months	6 - 9 months
MOF	0	100	0
Industry	17	67	17
Commercial	38	50	13
Overall	30	58	12

Due to their relatively greater availability of permanent and technical staff, the MOF nurseries can afford to let one person supervise fewer seasonal workers; the ratio of supervisor to workers is considerably lower in both commercial and forest industry nurseries. Table 4.14 provides more details about this comparison.

Table 4.14 Supervision of Seasonal Workers, by Category

Nursery category	Responsibility (in %)		Number of seasonal workers being supervised (%)		
	Technical staff	Tech. + hired people	< 10	11 - 20	> 20
MOF	33	67	67	0	33
Industry	83	17	17	33	50
Commercial	75	25	21	63	17
Overall	73	27	24	52	24

As far as training is concerned, up to 90% of the nurseries provide some form of training to seasonal workers. Although training typically lasts half a day at the beginning of every employment season, private nurseries spend comparatively a little longer on training than the MOF nurseries (Table 4.15).

Table 4.15 Length of Training at Forest Nurseries in BC

(in %)

Nursery category	< 0.5 day	0.5 - 1 day	> 1 day
MOF	100	0	0
Industry	50	33	17
Commercial	42	46	13
Overall	48	39	12

The characteristics of nursery management are summarized below, using a 5-point rating scale, with 1 being low and 5 being high:

- frequency of seasonal hiring 3.8
- management complexity 2.8
- specificity of equipment and tools 2.8
- level of human skills for nursery work 2.3.

To interpret, nursery work is labor-intensive, requiring low level of skills. The level of management complexity is moderate and the specificity of physical asset is intermediate.

Table 4.16 Silvicultural Profile of BC's Major Forest Companies

Forest company	Seed orchard	Forest nursery	Time silviculture division set up	AAC (million m^3)
Canadian Forest Products Ltd.	yes	no	1990s	4.8
International Forest Products Ltd.	no	no	1970s	3.5
MacMillan Bloedel Ltd.	yes	yes	1960s	5.2
Northwood Pulp & Timber Ltd.	no	no	1990s	> 3
Pacific Forest Products Ltd.	yes	yes	1960s	1.6
Riverside Forest Products Ltd.	yes	yes	1980s	> 2
Slocan Forest Products Ltd.	no	no	1980s	1.7
TimberWest	yes	no	1980s	4.2
Weldwood of Canada Ltd.	yes	yes	1970s	4.1
Western Forest Products Ltd.	yes	no	1950s	2.5
West Fraser Mills Ltd.	no	no	1970s	3.9
Weyerhaeuser Canada Ltd.	no	yes	1990s	> 1.5

4.2.4 Profile of the Forest Industry's Silviculture Contracting

Given the nature of institutional reforms in the BC silviculture sector, it is logical that major licensees ought to be the focus of this study. First of all, a list of forest companies was put together, based on the MOF annual reports and by correspondence with the Council of Forest Industries of British Columbia (COFI) and its associate members. A total of 117 questionnaires were sent out, each accompanied by a cover letter explaining the purpose of the survey (see Appendix I). The response rate was 88%.

Survey results indicate that 44% of the major licensees have separate silviculture divisions. The earliest such divisions appeared in the 1950s. However, most firms that chose to have separate silviculture divisions did not do so until the 1980s and the 1990s (see Figure 4.3). In terms of geographic distribution of forest companies, the number of firms (either companies or their divisions) operating on the Coast represents 40%.

Measured by AAC, a large number of the companies are relatively small in size because only 45% of the respondents have AAC in excess of half a million m^3. Besides, 59% of the respondents indicate that they have some form of area-based tenures such as TFL or private land, but a considerable number of licensees (41%) do not have any area-based tenures, having only volume-based Forest Licences. Hence, they may not have adequate incentive for silvicultural investment (Luckert and Haley 1993; Zhang 1994). The Province's large forest companies have all established separate silviculture divisions (Table 4.16).

As far as availability of personnel and its professional quality is concerned, the majority of the licensees have very few permanent silviculture staff. The survey results indicate that only 14% of the licensees (forest companies or their divisions) have more than 10 permanent silviculture staff each. Those companies that have more than two RPFs or administrative staff merely account for 30% of all firms surveyed.

Forest companies generally do not directly hire a large number of seasonal workers. Only 37% of the licensees directly hire 10 seasonal workers or more each year. For those companies that directly hire seasonal workers, the length of work period is relatively short. Only 46% of the respondents provide longer than three months of silviculture work to directly hired workers. Most forest companies in the Province provide less than three months of seasonal work to silviculture workers. Only one third of the respondents report that they have basic silviculture contracts longer than three months. Nevertheless, 65% of the major licensees surveyed report that incremental silviculture work is available at their operations. Usually, monitoring of individual performance is done in two forms, either by managers of a firm or by hired checkers and evaluators. Directly hired silviculture workers are paid an hourly rate (41%), a piece rate (25%), or a salary (34%).

Up to 93% of the respondents indicated that they had a "preferred contractor", with only 35% indicating that they relied on "low bid". It appears that silviculture contracting is quite competitive. As much as 79% of the respondents reported that 4 - 7 contractors were available to them whereas 17% of the companies said that there were less than three contractors available in their respective area; two companies even reported that they each had more than seven contractors to choose from.

As for the question on the proportion of contractors from the local community, survey results show that there is some mobility among silviculture contractors in that one third of the companies used less than 30% of the contractors from the local community, and another one third relied on between 30% and 70% of contractors from the local community.

Prior to sending out the questionnaires, five determinants for selecting contractors were identified—low bid, good reputation, successful relationship in the past, whether the contractor was unionized, and employment for the local community. It turns out that companies put a great deal of weight on previous experience and reputation as their criteria for selecting contractors. Table 4.17 provides the ranking.

Table 4.17 Ranking of Determinants for Silviculture Contractor Selection

Determinants	Percentage indicated
Successful relationship in the past	91.3
Good reputation	77.7
Employment for local community	61.2
Low bid	52.4
Union issue	4.9

Contract negotiation seems moderately complex, as indicated by the average measurement of 2.4 on a five-point rating scale. An escape clause that allows contracting parties to terminate the agreement or re-construct one is usually included in silvicultural contracts. Negotiation or re-negotiation, which is built into contracts on an annual basis, is quite common. Some three fifths of the companies have provisions of this kind in their contracts. Forty percent of the companies choose to negotiate with their partners on an *ad hoc* basis. In other words, negotiation of contract terms takes place upon request from one of the parties. In case of disputes, negotiation is the predominant form (96%), arbitration is uncommon (7%), and litigation is rare (3%). The latter two means of handling disputes are only reported by several large forest companies that operate on the Coast.

As far as contractual forms are concerned, silvicultural activities are either contracted out or performed in-house within the corporate structure. Some firms adopt both forms at the same time. Table 4.18 summarizes the results in proportions by activity. The four transaction cost attributes of major silvicultural activities are presented in Table 4.19.

Table 4.18 Silvicultural Performance in BC, by Contractual Form (in %)

Activity	In-house	Contracting out	Both
Cone collection	14.3	77.4	8.3
Seedling production	8.5	78.0	13.4
Site preparation	23.1	52.7	24.2
Planting	12.7	61.8	23.5
Brushing and weeding	6.1	77.6	16.3
Spacing	8.5	80.5	11.0
Pruning	7.0	87.7	5.3
Thinning	7.0	88.4	4.7
Fertilizing	8.8	85.3	5.9
Surveying	36.1	24.7	39.2

Table 4.19 Transaction Cost Attributes of Silvicultural Activities

Activity	Technical skill	Frequency	Uncertainty	Physical specificity
Cone collection	2.3	2.2	2.2	2.9
Seedling production	4.5	4.5	1.8	3.9
Site preparation	3.8	4.0	2.0	3.0
Planting	3.5	4.8	1.9	3.0
Brushing and weeding	2.9	3.8	2.4	2.6
Spacing	3.2	3.0	2.1	2.3
Pruning	2.7	1.9	1.9	3.1
Thinning	3.4	1.9	2.3	2.6
Fertilizing	3.1	1.5	2.5	3.1
Surveying	4.4	4.8	1.9	2.2

Given the micro-analytic nature of the study, it is necessary to acquire greater details than that asked in a mail-out questionnaire. Hence, interviews serve the purpose of soliciting required information. For practical reasons, managers at the intermediate and operational level were chosen as key informants. The managers or superintendents of one seed orchard and of three nurseries were interviewed, as were the corporate managers for silvicultural operations in seven forest companies or institutions. Formal interview protocol and procedures were established in advance. Each interview lasted approximately 30 - 40 minutes.

Interviewees were contacted by phone or fax in advance and informed about the topic and scope of questions. During an interview, with prior permission from the interviewee, a tape recorder was used. After the interview, upon request, interviewees were provided with a summary of the interview to enable them to verify their responses and make necessary amendments. Should an interviewee set any conditions on the use of his/her responses, every effort was made to honour the specific requests. The list of interviewees is shown in Appendix II.

To provide additional information for comparative purposes, Table 4.20 assembles some silvicultural cost data for stand establishment. The costs of seedlings during 1986 and 1991 are shown in Table 4.21. Scagel *et al.* (1993) report that the current production costs range between $0.18 and $0.68 per seedling, which does not include storage and transportation costs.[25] This is in conformity with the growing costs estimated by Pelton Reforestation Limited. Pelton (1996) reveals that pine seedlings average, at present, eight cents per square inch of cavity space, which is equivalent to some $25 per styroblock (Table 4.22).

To summarize, in this chapter, I have profiled BC's silviculture industry, covering the silviculture contracting community, the MOF responsibilities, seed orchards, forest nurseries and major licensees. Emphasis is placed on the description of contractual arrangements, with particular reference to management practices, payment methods and organizational forms. Much of the information presented is descriptive in nature. In-depth analysis and empirically testing the hypothesis of in-house operations versus contracting out are the subject of the next chapter.

[25] According to Scagel et al. (1993), storage costs about three cents per seedling and transportation costs average one cent per seedling.

Table 4.20 Proportional Costs of Stand Establishment

Activity	$/1000 seedlings	$/ha	cents/seedling	% of total cost
Cone collection	3.00	3.45	0.3	0.5
Seed processing	0.42	0.48	0.04	0.1
Nursery	175.00	201.25	17.5	29.7
Site preparation	166.90	191.93	16.7	28.4
Planting	242.60	279.00	24.3	41.3
Total	587.92	676.11	58.8	100.0

Source: Wallinger (1985, p.137). Stocking density is based on 1,150 seedlings per hectare. All species, all stock types, all methods, and including production overhead, but excluding administration.

Table 4.21 Value of Seedlings Sown in BC 1986 - 1991

Sowing year	Number of trees (millions)	$ Dollars (millions)	Cost/tree (cents)
1986	243.8	41.9	17.2
1987	191.1	30.7	16.1
1988	240.6	38.0	15.8
1989	298.9	49.4	16.5
1990	249.9	42.9	17.2
1991	213.1	35.8	16.8

Source: Brazier (1991, p.39). The value of seedlings sown during the period was based on the current Ministry's commercial prices, which tended to lag behind the current market, hence, were suspected to be slightly higher than the actual current market prices (Brazier 1991).

Table 4.22 Prices for Major Stock Types of Pine Seedlings

Stock type	Cavity	Cavity size (square inches)	Unit price ($)	Sale price per styroblock ($)
211A	240	1.4	0.10	24.00
313B	160	2.0	0.16	25.60
415B/410	112	3.0	0.23	25.76
415D	77	4.0	0.31	23.87
615A	45	7.5	0.56	25.20

Source: Pelton (1996).

Chapter Five

Empirical Studies

An empirical analysis of the survey data is provided in this chapter. It consists of four sections. The first section provides a case study of a major forest company in the coastal region of the Province. Both descriptive and regression analyses are employed. The second section is an econometric study of forest companies' contractual choice between contracting out and in-house operation. The theory and hypotheses of Chapter 3 are tested using probit and ordered probit methods. In the third section, I consider the payment schemes that forest companies use for hired seasonal workers. Again, probit and ordered probit methods are used to test the relationship between identified independent variables and choice variables, such as piece wages, hourly rates and salary. The last section analyzes the determinants underlying silviculture contractors' performances.

5.1 Corporate Strategy and Performance in Silviculture: A Case Study

Since the policy change in late 1987, major forest licensees have been made responsible for basic silviculture up to free-to-grow status following harvesting on Crown land. In order to assess the impacts of government policies on BC's forest industry with regard to silviculture, a major forest company that mainly operates in the coastal area of BC has been selected for a case study. Data on silvicultural activities, which were performed during the period from 1987 to 1996, were obtained. Much of the study serves the purpose of providing a profile of a major licensee by statistical means. The inclusion of the case study is to contribute to the overall design of the research. In view of the request of the company to remain anonymous for confidentiality reasons, in this study, the company is referred to as the "F Company Ltd.", or simply the *Company*.

5.1.1 Background Information

Comprising seven operations primarily on the BC Coast, F Company Ltd. has an AAC of over three million m^3. It has four TFLs and a number of timber and forest licences. Besides, it also has some private land. At the corporate level, a separate silviculture division was established in 1980. At the operations level, two divisions have separate silviculture divisions (one being set up in the early 1970s) while the other five still keep silviculture management within timber or woodlands divisions. In total, the *Company* has 54 permanent silviculture employees on staff, and each operation typically has less than 10 silviculture people, with two or three of them having RPF status.

The silvicultural program of F Company Ltd. consists of three components, or priority areas, namely, planting, brushing and weeding, and regeneration surveying. Based on the MOF's terminology, these activities fall in the category of basic silviculture. Although some spacing occurred in the early 1990s, it was not practiced in the strict sense of incremental silviculture.

Planting and brushing and weeding are primarily contracted out although some seasonal workers—mostly summer students—are directly hired by several operations to do planting. The *Company* crew is more heavily involved in surveying. The payment methods that the *Company* uses with seasonal workers include hourly wages, piece rates and salary. While F Company Ltd. uses piece rate and hourly wages in paying for planting, brushing and weeding, salary is the method the *Company* uses for those that carry out surveying. Summer students get paid a monthly salary. Many of the students do supervisory work due largely to their university training and possession of forestry knowledge. It has been learned from interviews that many of the students use summer employment as a sort of internship, and some of them become permanent employees after two or three summers. Seasonal employment ranges from three to six months each year.

For contracting out, the contract period is around two months on average. There are two major types of contracts, "preferred contractor" and "low bid", with the former often being used in *Company*-funded projects and the latter in the MOF-funded projects. Usually, some four to seven contractors are available, with 30 - 70% of them coming from local communities. The selection criteria comprise, in descending order, successful relationship in the past, good reputation, employment for the local community, low bid and the union issue (Table 4.17). Practically, all silviculture contracts are short-term ones. Concerning provisions for contract revision or re-negotiation, some contracts have built-in provisions, others allow settling of disputes anytime upon request from one of the parties to the contract. During the past 10 years, F Company Ltd. and its operations have never resorted to arbitration or litigation although these means are available in case of disputes that fail to be settled by negotiation.

5.1.2 Profile of Silvicultural Activities

As noted above, F Company Ltd. has undertaken mainly three silvicultural activities during the past 10 years—planting, brushing and regeneration surveying.

Planting

As far as the planting program is concerned, the 10-year period has witnessed an increasing trend. On average, 3,467 hectares were planted each year. The increase in planting area is especially pronounced for the period since 1991 (Figure 5.1). On average, some three million seedlings have been planted each year. However, the *Company*'s planting density of 845 trees per hectare is considerably lower than the Provincial average of 1,186 during the same period. Possible explanations for this include the use of larger seedlings, different species, partial natural regeneration, or adoption of company-specific harvesting and silviculture methods (e.g., the use of seed tree methods).

Planting costs have shown a large increase. Specifically, planting costs comprise contract cost, company labor, overhead and other items. Contract costs are by far the largest portion, representing 65.8% of the total. In comparison, company labor and seedling costs represent 10.3% and 23.9% of the entire planting costs, respectively. On average, 18 cents were spent as overhead costs for one tree planted, which is 19.5% of the overall planting costs per tree. On average, 708 person-days were spent managing the planting program each year, that is, 0.2 person-days per hectare planted. Table 5.1 provides a summary of the average levels of itemized planting costs, and Figure 5.2 shows the changes over time.

Table 5.1 F Company Ltd.'s Planting Costs

Average Planting density (trees/ha)	845
Average Planting cost per tree ($/tree)	0.923
- Contract cost ($/tree)	0.607
- Company labor ($/tree)	0.095
- Seedling ($/tree)	0.221

In terms of planting costs, it is more sensible to compare the *Company* against other major Coastal licensees rather than the Provincial average. Given that such data are unavailable, the average figures for the Vancouver Forest Region are used instead. It is found that the *Company*'s unit area planting costs were higher in every year of the period. During the five years from 1988 to 1993, unit area costs were rising moderately for both the *Company* and the Region, as well as elsewhere in the Province. However, from 1993 onwards, there has been a divergence in the trend. While Provincial and Regional average costs were declining, the *Company*'s unit area costs continued to rise (Figure 5.3).

In view of the green-up and adjacency rules resulting from the Forest Practices Code, partial cutting may be a viable method because it avoids invoking the rules, and it is also logical to assume that quick-fix regeneration silviculture emerges as a new solution. Measures include planting more trees per hectare, using larger-sized seedlings and picking quick-growing species (Benskin and Bedford 1994). However, the *Company*'s data set provides no evidence in support of the argument of any increase in planting density; even the MOF sources do not provide enough evidence to prove this argument.

Brushing and Weeding

F Company Ltd.'s brushing and weeding program averaged 927 hectares per year during the past decade. In 1987, it reached 1,004 hectares, but it slid to below 400 hectares two years later. Although the decreasing trend was reversed in the early 1990s, the *Company* did not recover its 1987 level until 1994. Remarkably, the program nearly doubled in 1995 to reach 1,845 hectares (Figure 5.1).

The *Company* reduced the use of chemicals dramatically in the late 1980s, and steadily thereafter. In terms of application methods for brushing and weeding, the corporate strategy has been to reduce aerial application and shift to manual brushing and other methods, such as girdling. In 1993, the *Company* even used sheep on 39 hectares, but some of the new methods were considered experimental and they were discontinued for management as well as economic reasons.

To break down the cost components for brushing and weeding, contract costs on a per-hectare basis are the largest portion, constituting 64% of the entire unit area costs. Chemical costs were relatively small, but *Company* labor was 12% of the total, which is, in relative terms, slightly higher than that of the planting program. *Company* labor, measured by the number of person-days, was 184 for an average year. In terms of unit area costs for brushing and weeding, the *Company* paid more than the Provincial average during the period. Figure 5.4 provides more details about the comparison.

Regeneration Survey

The *Company* covered, on average, 7,607 hectares per year for regeneration surveying during the decade. Regeneration surveying peaked in 1994 (Figure 5.1). The costs of regeneration surveying have two major components, namely, labor and travel plus room and board (R+B). Due to the labor-intensive feature of the activity, it is not surprising that *Company* labor accounts for 85% of the total costs. Labor costs remained high relative to travel plus R&B costs, and the difference between the two seems to have been growing. Figure 5.5 presents regeneration surveying costs on a per-hectare basis.

Using the BC Ministry of Forests data as a baseline (separate accounts for basic silviculture survey and incremental silviculture survey), the graphical presentation in Figure 5.5 shows that the *Company* paid twice as much or more than the Provincial average for regeneration surveys in most years for which data are available.

In summary, the three main silvicultural activities that F Company Ltd. undertook during the period 1987 to 1996 were planting, brushing and weeding, and regeneration surveying. Although costs increased for all three activities, brushing and weeding demonstrated a more cyclical pattern than the other two. Taken together, basic silviculture treatment requires an average cost of $1,500 per hectare. Table 5.2 indicates that the 10-year average for the *Company* is 1.4 to 1.7 times the average for the Vancouver Forest Region and the Province at large. An in-depth personal interview with the silviculture manager at the corporate level has confirmed this point.

Table 5.2 F Company Ltd.'s Costs for Basic Silviculture

	Planting	Brushing & weeding	Surveying	Total
Unit area costs ($/ha)	749.7	725.8	29.5	1505.0
- Contract costs	518.2	468.4	-	986.6
- Company labor costs	52.2	86.6	19.8	158.6
Vancouver Forest Region ($/ha)	433.1	418.2 - 592.1[a]	13.0 - 14.8[b]	864.3 - 1040
BC average ($/ha)	489.0	301.0 - 542.6[a]	11.6 - 12.9[b]	801.6 - 1044.5
Company labor (person-days/ha)	0.204	0.198	0.053	0.455

Source: Forest company data provided by a BC major coastal licensee; Provincial and Vancouver Forest Region data are calculated from BC Ministry of Forests (1996c).

[a] The two figures for brushing & weeding refer to per-hectare costs by chemical and manual means, respectively.

[b] The two figures for surveying refer to basic regeneration and incremental silviculture surveying, respectively.

5.1.3 Regression Analysis: Transaction Costs and F Company Ltd.

In this section, I provide the results of regression analyses. The objective is to identify relationships among determinants and choice variables, and test several hypotheses.

Since the MOF has practiced the low-bid system for decades, whereas forest companies tend to use the 'preferred contractor' approach, the first hypothesis is that the MOF-funded silvicultural projects generally cost less than those funded by the *Company*. One rationale for this hypothesis arises from the recognition that large forest companies operate, proportionally, more area-based forest tenures, and these tenures tend to provide higher incentives for silvicultural investment (Zhang 1994; Luckert and Haley 1993). The second hypothesis is that, due to the introduction of the Forest Practices Code, major licensees are expected to incur higher costs to comply with the Code. Hence, it is hypothesized that a structural change took place in 1995 when the Code was formally adopted by the BC Government.

Testing of the first hypothesis was undertaken by examining project and overhead costs. Under the assumption that the error terms are independently and identically distributed (i.i.d.), with mean zero, the ordinary least squares (OLS) method was used. As the data are pooled data comprising both time series and cross sectional data, tests on heteroscadasticity and autocorrelation were performed. Heteroscadasticity was detected and corrected in subsequent regressions.

Table 5.3 provides evidence that project costs were, indeed, higher on privately funded sites than on the MOF-funded sites for planting (significant at the 1% level) and for surveying only (significant at 10% level). The variable sign for brushing and weeding was insignificant (and incorrect). Table 5.4 provides additional evidence that F Company Ltd. incurred more overhead cost on sites under its own funding source than those funded by the MOF; again, planting and surveying confirm this hypothesis, while the results for brushing and weeding is statistically insignificant.

As shown in Table 5.3, the highly significant and positive coefficient for the 1995-1996 dummy variable indicates that the Forest Practices Code has, indeed, affected silviculture costs. Regression results indicate that the Code has increased the *Company*'s costs for planting, brushing and weeding and regeneration surveying.[26] There is only partial evidence that the Code has also increased the level of

[26] Data on the three activities are not available for the same site. Thus, separate regressions are required.

overhead costs, because results reported in Table 5.4 confirm this only for the planting program. In order to determine the effects of the Forest Practices Code on the *Company*'s silviculture costs, the costs are estimated from the regression for both the pre-Code (dummy variable set to 0) and post-Code (dummy variable set to 1) periods. The difference is assumed attributable to the Code. I conclude that the Code has increased planting, brushing and weeding and surveying costs by $257, $386 and $28 per hectare, respectively. In addition to the shifts in the intercepts, there are also changes in the slopes of several explanatory variables. Table 5.5 provides the details. However, it should be pointed out that the estimates of the impact of the Code could be exaggerated, because the results are based on two years of observations only. Since it is usually a learning process for forest companies to respond to new regulations, opportunities are likely to emerge for firms to adjust their costs under new circumstances.

Regression results also confirm that, as new brushing and weeding methods emerged, the adoption of these new methods had a tendency to increase costs (Table 5.3). But, the adoption of new brushing and weeding methods does not appear to affect overhead expenses (Table 5.4).

In summary, results of the case study indicate the following. First, institutional structures for silvicultural activities have undergone noticeable changes during the past 10 years. Separate silviculture divisions were established either prior to or shortly after 1987 when the major policy changes took place in the Province. Second, with the introduction of new policies, such as the Forest Practices Code, cost structures were altered, with variable silvicultural costs increasing noticeably. And third, F Company Ltd., like many other firms, uses the 'preferred contractor' approach, even if this means that they have to pay more than under the 'low bid' system. Recognizing the possibility of superior outcomes associated with 'preferred contractors' in terms of the quality of silvicultural activities, F Company Ltd. and its field operations defend this approach, although the 'low bid' system remains in place for projects funded by the MOF. In spite of having to pay a higher price for choosing the 'preferred contractor', transaction costs are likely reduced through lowering of project negotiation, implementation and monitoring costs.

Table 5.3 Regression Analysis of F Company Ltd.'s Silvicultural Activities
(Dependent variable is per-ha cost)

Variable	Estimate	t-ratio[a]
Planting		
Planting density per ha	0.58224	6.848***
Funding source (1=MOF; 0=other)	- 136.81	- 5.016***
Time dummy (1=1995, 1996; 0=other)	295.29	6.898***
Constant	295.93	4.074***
N = 423		
R^2 adjusted = 0.3678		
Brushing and weeding		
Area treated	- 9.2637	- 7.092***
Funding source (1=MOF; 0=other)	20.482	0.3395
Time dummy (1=1995, 1996; 0=other)	129.41	1.658*
Treatment method (1=aerial and ground; 0=other)	256.41	3.87***
Constant	854.66	13.65***
N = 181		
R^2 adjusted = 0.2823		
Regeneration Surveying		
Area surveyed	- 0.036971	- 3.942***
Funding source (1=MOF; 0=other)	- 2.9248	- 1.337*
Time dummy (1=1995, 1996; 0=other)	27.723	8.132***
Constant	34.775	13.33***
N = 357		
R^2 adjusted = 0.2526		

[a] *** significant at 1% level; ** significant at 5% level; * significant at 10% level.

Table 5.4 Regression Analysis of F Company Ltd.'s Silviculture Overhead Cost

Variable	Estimate	t-ratio[a]
Planting: dependent variable is overhead cost		
Planting density per ha	-0.0001	-2.081**
Contract cost for planting per ha	0.3506	11.12***
Funding source (1=MOF; 0=other)	-0.0205	-1.463*
Time dummy (1=1995, 1996; 0=other)	0.072	3.851***
Constant	0.006	0.1522
N = 423		
R^2 adjusted = 0.4812		
Brushing and weeding: dependent variable is overhead cost		
Area treated	- 0.2305	-3.335***
Contract cost per ha	-0.0312	-4.569***
Company labor cost per ha	0.1433	7.495***
Funding source (1=MOF; 0=other)	3.3036	0.9182
Time dummy (1=1995, 1996; 0=other)	-3.7033	-1.173
Treatment method (1=aerial and ground; 0=other)	-1.3809	-0.4968
Constant	40.504	8.497***
N = 181		
R^2 adjusted = 0.4306		
Regeneration surveying: dependent variable is company travel, room & board costs		
Area surveyed	-0.0185	-5.107***
Company labor cost per ha	0.2434	2.082**
Funding source (1=MOF; 0=other)	-2.5131	-1.726*
Time dummy (1=1995, 1996; 0=other)	1.5892	0.6398
Constant	9.9816	4.939***
N = 181		
R^2 adjusted = 0.121		

[a] *** significant at 1% level; ** significant at 5% level; * significant at 10% level.

Table 5.5 Effects of Forest Practices Code on F Company Ltd.'s Silviculture Costs
(Dependent variable is per-ha cost)

Variable	Estimate	t-ratio[a]
Planting		
Planting density per ha	0.5650	8.009***
Funding source (1=MOF; 0=other)	-133.64	-4.902***
Time dummy (1=1995, 1996; 0=other)	257.49	1.413*
Interaction between time dummy and planting density	0.0500	0.2189
Interaction between time dummy and funding source	-24.301	-0.2412
Constant	308.84	5.078***
N = 423		
R^2 adjusted = 0.365		
Brushing and Weeding		
Area treated	-9.4002	-5.531***
Funding source (1=MOF; 0=other)	119.92	1.659**
Time dummy (1=1995, 1996; 0=other)	386.37	3.135***
Treatment method (1=aerial and ground; 0=other)	357.47	4.469***
Interaction between time dummy and area treated	-0.0103	-0.0041
Interaction between time dummy and funding source	-335.92	-3.089***
Interaction between time dummy and treatment method	-271.74	-2.062**
Constant	770.25	11.19***
N = 181		
R^2 adjusted = 0.305		
Regeneration Surveying		
Area surveyed	-0.0328	-4.965***
Funding source (1=MOF; 0=other)	-4.1385	-1.784**
Time dummy (1=1995, 1996; 0=other)	28.238	4.268***
Interaction between time dummy and area surveyed	-0.0095	-0.4335
Interaction between time dummy and funding source	4.1750	0.6588
Constant	34.63	15.37***
N = 357		
R^2 adjusted = 0.250		

[a] *** significant at 1% level; ** significant at 5% level; * significant at 10% level.

5.2 An Econometric Study of an In-house versus Outsourcing Model

The main objective of this research is to investigate the institutional restructuring in BC's silviculture sector in the past decade. The chronological overview of historical events provides a context for understanding the changes from the perspective of institutional economics, enabling the formulation of refutable hypotheses to test the validity of transaction cost theories. At the operational level, we observe firms' decisions on the choice of contractual forms—outsourcing and in-house. Empirically testing the effects of TCE attributes and firm characteristics on contractual choices is the subject matter of this section.

5.2.1 Variables of the Model

The model developed in Chapter 3 is employed, with the variables explained in Table 5.6. Several explanatory notes regarding the independent variables are in order. First of all, four TCE attributes are identified. (1) Technical skills refer to the specificity of human skills, such as the amount of training. (2) Frequency refers to the occurrence of an activity and intervals involved. (3) Uncertainty indicates the degree of predictability of results. (4) Specificity of physical assets indicates the types and levels of up-front investment, the re-employability of the equipment and tools involved, and whether the equipment and tools used are idiosyncratic or standard by nature. TCE attributes are measured on a 5-point rating scale, where 1 is low and 5 is high. Physical asset specificity was originally measured on a 9-point scale in the questionnaire in order to solicit more precise judgment from the respondents, but was subsequently converted to a 5-point scale.

Table 5.6 Definitions of Variables used in Probit and Ordered Probit Models

Dependent variable	
Y1	0 for contracting out, 1 for in-house performance or element thereof;
Y2	0 for contracting out, 2 for in-house, 1 for combination of both;
Independent variable	
TCE attributes	
- technical skill	5-point scale from 1 to 5, with 1 being low and 5 being high;
- frequency	5-point scale from 1 to 5, with 1 being low and 5 being high;
- uncertainty	5-point scale from 1 to 5, with 1 being low and 5 being high;
- physical asset specificity	5-point scale from 1 to 5, with 1 being low and 5 being high;
Firm characteristics	
- AAC dummy	0 for ≤ 0.5 million m^3, 1 for above;
- Company size dummy	0 for small company, 1 for large one (with stocks publicly traded);
- Forest tenure type index	ranging from 0 to 1, with 0 for Forest Licence, 1 for TFL/private land;
- Silviculture division dummy	0 for not having one, 1 for yes;
- Region dummy	0 for BC Interior, 1 for BC Coast (Vancouver Forest Region)

According to transaction cost economics literature, the choice of organizational mode depends on both TCE attributes and firm characteristics. AAC is a dummy variable, with 0 for an AAC of half a million m^3 or less and 1 for anything above; although AAC is indicative, to a certain extent, of the size of a company, a company size dummy is also employed, with 0 for small firms and 1 for larger companies whose stocks are publicly traded on the stock market (there are some one dozen such companies in the BC forest industry). It is commonly believed that integrated forest companies tend to carry out more of their silvicultural activities in-house than do smaller firms. Because of the fact that silviculture is directly tied to harvesting divisions rather than pulp and paper divisions, and because of the small number of companies that have pulp and paper operations, the model does not distinguish whether a firm is integrated or not. Given that tenure type is a crucial firm characteristic and it is an essential institutional instrument that the BC government has used in managing timberland operations, its inclusion is fully justified. Because of the diversity and complexity of BC's forest tenure system, a binary dummy variable is inadequate for differentiating the effects of different tenures on the choice variables. The survey was designed to elicit different tenure types, enabling the construction of a tenure type index that ranges from 0 to 1, namely, 0 for a volume-based Forest Licence, 0.25 for tenures under 'other' with or without Forest Licence, 0.5 for Forest Licence combined with TFL or private land, 0.75 for Forest Licence combined with TFL and private or other tenures, and 1 for TFL and or private land only. The tenure index indicates increasing security of property rights on the scale 0 to 1. The *a priori* proposition is that the more secure a company's forest tenure is, the more likely that it wants to rely on internal structure based on the argument concerning the nature of the firm (Coase 1937). A dummy variable for the existence of a separate silviculture division (=1) or not (=0) is also included. This is based on the rationale that there tend to be more opportunities to save on organizational costs if relevant institutional structure is in place within a firm. Lastly, a region dummy is included, with 0 for the Interior and 1 for the Coast.

Hence, the null hypotheses are the following:

H_1: Technical skill does not lead to the choice of in-house performance of silvicultural activities.

H_2: Frequency does not result in the choice of in-house performance of silvicultural activities.

H_3: Uncertainty of management outcome does not result in the choice of in-house performance of silvicultural activities.

H_4: Physical asset specificity does not result in the choice of in-house performance of silvicultural activities.

H_5: AAC does not result in the choice of in-house performance of silvicultural activities.

H_6: Company size does not result in the choice of in-house performance of silvicultural activities.

H_7: Area-based tenure type does not result in the choice of in-house performance of silvicultural activities.

H_8: Existence of a separate silviculture division does not result in the choice of in-house performance of silvicultural activities.

H_9: BC Coast does not differ from the Interior in the choice of in-house performance of silvicultural activities.

The econometric model is specified as follows:

$$(5.1) \qquad y_i^* = b_0 + b_1{*}tech + b_2{*}freq + b_3{*}unce + b_4{*}phys + b_5{*}aac + b_6{*}cos + b_7{*}tti + b_8{*}ssd + b_9{*}red + u_i$$

where y^* is the dependent variable, i.e., the dichotomous choice between outsourcing and in-house, with 0 indicating contracting out to independent contractors, and 1 indicating operations that are performed by directly hired workers as well as company employees. The independent variables are explained in Table 5.6. The error term, u_i, is assumed to be identically and independently distributed with zero mean.

5.2.2 Probit Model

Broadly speaking, the decision variables may be viewed as dichotomous choices. Thus logit or probit methods are useful. However, where the dependent variable involves multiple choices, an ordered probit model may be relevant, as here a probit as opposed to logit model is selected to permit better comparison with results in the next section.

With a probit model, a normal cumulative density function (CDF) is assumed; that is, a variable Z follows the normal distribution with mean, μ_z, and variance, σ^2. By definition, its probability density function (PDF) is :

(5.2) $$f(Z) = \frac{1}{\sqrt{2\pi}\,\sigma} e^{-(Z-\mu_z)^2/2\sigma^2}$$

and its CDF is:

(5.3) $$F(Z) = \int_{-\infty}^{Z_0} \frac{1}{\sqrt{2\pi}\,\sigma} e^{-(Z-\mu_z)^2/2\sigma^2}$$

When one examines the relationship of transaction cost attributes and firm characteristics on the one hand and contractual forms on the other, it is believed that the vector of explanatory variables, **x**, explains the choices. In other words, we are interested in the probability of the event occurring given the identified conditions. That is,

(5.4) $$\text{Prob}(Y = 1) = F(\beta'x)$$

(5.5) $$\text{Prob}(Y = 0) = 1 - F(\beta'x)$$

The set of parameters β reflect the impact of changes in the vector, **x**, on probability. Under a linear probability model,

(5.6) $$F(x, \beta) = (\beta'x).$$

Since $E[y] = F(x, \beta)$, the regression model becomes,

(5.7) $$\begin{aligned} y &= E[y] + (y - E[y]) \\ &= \beta'x + \varepsilon. \end{aligned}$$

However, given the dichotomous nature of the choice variables, in order to constrain the probabilities to the zero-one interval, the probit model is often used:

$$(5.8) \qquad \Pr ob\,(Y=1) \;=\; \int_{-\infty}^{\beta' x} \phi\,(t)\,dt$$

where $\phi\,(t)$ is the normal probability distribution function. By taking the inverse of (5.8), we obtain,

$$(5.9) \qquad \text{Prob}\,(Y = 1) \;=\; \Phi\,(\beta' x)$$

and,

$$(5.10) \qquad \text{Prob}\,(Y = 0) \;=\; 1 \;-\; \Phi\,(\beta' x).$$

Regressions were performed using LIMDEP Version 7.0 (Greene 1995). The advantage of LIMDEP lies in its unique capability of handling multiple choice models like the ordered probit. This feature is further discussed in the next sub-section.

With 103 returns out of 117 questionnaires distributed, and given 10 silvicultural activities involved, some 1,030 observations should be available. However, the number of observations available for use is 697. The reason for the reduction in the number of observations is threefold. First, I asked the respondents to report their silvicultural activities based on occurrences in the most recent time period, but many firms indicated that they had engaged in only some of the 10 activities. Second, some firms did not provide answers about one or more TCE attributes, although the corresponding activity did take place. Thus, the incompleteness rendered the entire observation unusable. Third, seven respondents were corporate-level managers. Since their divisions or operations have also responded, in order to avoid double counting only observations from the level of divisions and operations were used in the regressions.

Four situations were considered. The first uses the complete data set of 697 observations; the second employs observations from all activities except for cone collection and seedling production; the third considers basic silviculture; and the fourth focuses only on incremental silviculture. The rationale for the second case is to examine the 'core' activities commonly understood by silviculture managers and workers. Another reason is to turn it into a basis against which the basic and incremental silviculture results can be compared. For each case, three regressions are considered, i.e., TCE attributes, firm characteristics, and pooled. Since TCE attributes and firm characteristics are not mutually exclusive, one would expect, *a priori*, non-zero coefficients on both groups of variables either in separate runs or in a pooled model, but considering their effects, first in a separate manner and then in a combined way, helps duly differentiate the effects of each independent variable.

The results of the probit model are presented in Tables 5.7, 5.8 and 5.9. In terms of goodness of fit criteria, the likelihood ratios, measured by the χ^2 statistics, are all statistically significant. The four TCE variables are statistically significant in most instances. Specifically, a positive (negative) sign on an explanatory variable's coefficient indicates that higher values of the variable increase (decrease) the likelihood that an activity is performed in-house. The findings lead to the general confirmation of the transaction cost economic theory that those activities requiring a higher level of technical skill, occurring with an increasing frequency, having a higher degree of uncertainty, and demanding more specialized physical assets tend to be performed by the firm itself.

Concerning the five firm characteristics, AAC, company size and tenure type variables are found to be statistically significant. The positive signs on AAC and company size conform to TCE theory, but the negative sign on tenure type is troubling from the TCE perspective. We would normally expect area-based tenures to give rise to more in-house operations since area-based tenures have been found to promote silvicultural investment (Zhang 1994). One possible explanation is that area-based tenures are short term relative to the long period required to profit from the outcome of silvicultural activities; given the competitiveness of BC's silviculture contracting industry, it would be less expensive, in terms of production as well as transaction costs, to contract out most of the silvicultural activities.

Each of the identified transaction cost attributes and firm characteristics has a role to play in determining the choice of contractual forms. Furthermore, they are expected to interact with one another in effecting contractual choices. To investigate these interactive effects, a probit analysis was performed to examine 10 of the interactive terms. Table 5.10 presents the estimated coefficients and t-values. Of the six statistically significant interactive variables, it makes sense that large companies with large volumes of AAC tend to carry out more of silvicultural activities in-house, and area-based tenure holders on the Coast are found to do more silvicultural activities in-house as well. Two anomalies have emerged, namely, the interactive term between technical skill and physical asset specificity for one and the interactive term between frequency and uncertainty. The results indicate that, in the event of joint incidence of high technical skill and high asset specificity, and high frequency and uncertainty, firms choose to employ independent contractors rather than doing the work internally. Masten, Meehan and Snyder (1991, p.16) reported an incidence of non-monotonic effect of complexity on observed organizational arrangements. In BC's case, the empirical results seem to suggest that, for activities characterized by a high level of technical skill, physical specificity, frequency, or uncertainty, in-house is often the preferred choice; however, when an activity requires both technical skill and specialized physical assets, it would pay to contract it out. The same seems to be true of an activity with a high degree of uncertainty even if it occurs at a high frequency.

Possible multicollinearity has been tested by means of constructing correlation tables, but no significant problem was detected. For instance, it is commonly believed that large companies tend to have proportionally more area-based tenures; however, the simple correlation coefficient between the two variables of company type and tenure type is only 0.21. Similarly, the correlation coefficient between region and company type is 0.25. The highest correlation occurs between tenure type and region (=0.42). In other words, more area-based tenures are found on the Coast, while volume-based tenures are associated with the Interior.

In view of the noticeable differences in the means of variables as shown in Table 5.9 for basic silviculture and incremental silviculture, the null hypothesis that the two sampling means are equal against the alternative hypothesis was tested. The testing method described by Pagano (1986) and Newbold (1991) was used. Results provide no evidence to suggest that the differences in the means of the two samples were statistically significant. In other words, in spite of the differences in the sample means, basic silviculture and incremental silviculture are part of a broadly identical silvicultural program, and the differences in the means, measured by the perceived individual TCE attributes and identified firm characteristics, are not sufficient to separate incremental silviculture from the predominant basic silviculture. To put it in another way, BC is primarily at the stage of basic silviculture.

Table 5.7 Probit Model of BC's Silviculture Contractual Form [a]

Dependent variable (0 for contracting out; 1 for in-house)

Variable	Estimate	t-value[b]	Mean of X
Case 1: TCE attributes			
Technical skill	0.1615	3.388***	3.46
Frequency	0.1638	4.034***	3.71
Uncertainty	0.0802	1.610*	2.06
Physical asset specificity	0.0741	1.892*	2.87
Constant	-2.0878	-8.273***	
N = 697			
χ^2 : 51.16 (4); (critical value = 13.28 at 0.01 level)			
Pseudo R^2: 0.410			
Correct prediction: 68.6%			
Case 2: Firm characteristics			
AAC	0.2626	2.505***	0.41
Company size	0.2099	1.862*	0.65
Tenure type	-0.368	-2.541***	0.43
Separate silviculture division	0.0539	0.532	0.52
Region	-0.0124	-0.100	0.30
Constant	-0.6256	-5.691***	
N = 697			
χ^2 : 16.09 (5); (critical value = 15.09 at 0.01 level)			
Pseudo R^2: 0.380			
Correct prediction: 69.3%			
Case 3: TCE attributes plus firm characteristics			
Technical skill	0.1726	3.573***	3.46
Frequency	0.1646	3.961***	3.71
Uncertainty	0.0949	1.858*	2.06
Physical asset specificity	0.0746	1.870*	2.87
AAC	0.2101	1.922*	0.41
Company size	0.2878	2.462***	0.65
Tenure type	-0.4262	-2.849***	0.43
Separate silviculture division	0.0672	0.641	0.52
Region	-0.0428	-0.330	0.30
Constant	-2.2877	-8.296***	
N = 697			
χ^2 : 69.49 (9); (critical value = 21.67 at 0.01 level)			
Pseudo R^2: 0.425			
Correct prediction: 68.7%			

[a] The model covers all 10 silvicultural activities.

[b] *** for significant at the 0.01 level, ** at 0.05 level, * at 0.1 level.

Table 5.8 Probit Model of BC's Silviculture Contractual Form [a]

Dependent variable (0 for contracting out; 1 for in-house)

Variable	Estimate	t-value[b]	Mean of X
Case 1: TCE attributes			
Technical skill	0.2763	4.855***	3.47
Frequency	0.1699	3.714***	3.77
Uncertainty	0.0593	1.064	2.06
Physical asset specificity	0.1495	3.235***	2.73
Constant		-8.354***	
N = 552			
χ^2 : 65.74 (4); (critical value = 13.28 at 0.01 level)			
Pseudo R^2: 0.787			
Correct prediction: 67.6%			
Case 2: Firm characteristics			
AAC	0.2359	2.029**	0.41
Company size	0.1990	1.585	0.65
Tenure type	-0.5136	-3.171***	0.44
Separate silviculture division	0.0946	0.841	0.51
Region	-0.0508	-0.37	0.33
Constant	-0.4690	-3.833***	
N = 552			
χ^2 : 18.07 (5); (critical value = 15.09 at 0.01 level)			
Pseudo R^2: 0.391			
Correct prediction: 68.3%			
Case 3: TCE attributes plus firm characteristics			
Technical skill	0.2986	5.110***	3.47
Frequency	0.1738	3.680***	3.77
Uncertainty	0.0867	1.510	2.06
Physical asset specificity	0.1596	3.353***	2.73
AAC	0.1631	1.316	0.41
Company size	0.3261	2.434**	0.65
Tenure type	-0.6060	-3.353***	0.44
Separate silviculture division	0.0883	0.744	0.51
Region	-0.1077	-0.731	0.33
Constant	-2.8243	-8.253***	
N = 552			
χ^2 : 88.74 (9); (critical value = 21.67 at 0.01 level)			
Pseudo R^2: 0.465			
Correct prediction: 69.9%			

[a] The model covers eight of the 10 silvicultural activities, with cone collection and seedling production being excluded.

[b] *** for significant at the 0.01 level, ** at 0.05 level, * at 0.1 level.

Table 5.9 Probit Model of BC's Basic and Incremental Silviculture

Dependent variable (0 for contracting out; 1 for in-house)

	Basic silviculture[a]			Incremental silviculture[b]		
Variable	Estimate	t-value[c]	Mean of variable	Estimate	t-value[c]	Mean of variable
Case 1: TCE attributes						
Technical skill	0.2771	4.072***	3.65	0.2243	1.982*	3.13
Frequency	0.1137	1.504	4.40	0.0612	0.664	2.60
Uncertainty	-0.0258	-0.389	2.04	0.2697	2.430**	2.10
Physical asset spec.	0.1808	3.337***	2.75	0.0408	0.431	2.69
Constant	-2.1939	-4.922***		-2.4927	-4.477	
N:	359			193		
χ^2 :	36.94 (4)	13.28[d]		12.57 (4)	9.49[e]	
Pseudo R^2:	0.436			0.372		
Correct prediction:	64.1%			80.3%		
Case 2: Firm characteristics						
AAC	0.2689	1.917*	0.41	0.1530	0.666	0.41
Company size	0.3123	2.079**	0.62	0.0504	0.202	0.70
Tenure type	-0.2801	-1.421	0.41	-1.0245	-3.244***	0.50
Silviculture division	0.1786	1.311	0.50	0.0066	0.030	0.55
Region	-0.0663	-0.391	0.31	-0.0525	-0.202	0.36
Constant	-0.4787	-3.317***		-0.530	-2.158	
N:	359			193		
χ^2 :	11.74 (5)	11.07[e]		13.83 (5)	11.07[e]	
Pseudo R^2:	0.401			0.376		
Correct prediction:	61.6%			81.3%		
Case 3: TCE attributes + firm characteristics						
Technical skill	0.2950	4.225***	3.65	0.3114	2.469**	3.13
Frequency	0.0952	1.212	4.40	0.1477	1.428	2.60
Uncertainty	-0.0076	-0.112	2.04	0.4008	3.153***	2.10
Physical asset spec.	0.1762	3.175***	2.75	0.0879	0.816	2.69
AAC	0.2434	1.638*	0.41	0.1913	0.749	0.41
Company size	0.3379	2.130**	0.62	0.0593	0.219	0.70
Tenure type	-0.3345	-1.633*	0.41	-1.324	-3.791***	0.50
Silviculture division	0.0943	0.661	0.50	0.1636	0.693	0.55
Region	-0.0563	-0.314	0.31	-0.2841	-0.989	0.36
Constant	-2.4147	-5.121		-2.9727	-4.396	
N:	359			193		
χ^2 :	47.26 (9)	21.67[d]		35.18 (9)	21.67[d]	
Pseudo R^2:	0.454			0.473		
Correct prediction:	65.5%			83.9%		

[a] Basic silviculture comprises site preparation, planting, brushing and weeding and surveying.

[b] Incremental silviculture comprises spacing, pruning, thinning and fertilizing.

[c] *** for significant at the 0.01 level, ** at 0.05 level, and * at 0.1 level.

[d] Critical χ^2 value at 0.01 level.

[e] Critical χ^2 value at 0.05 level.

Table 5.10 Probit Model of BC's Silviculture Contractual Form [a]

Dependent variable (0 for contracting out; 1 for in-house)

Variable	Estimate	t-value[b]
Technical skill	0.4217	2.327***
Frequency	0.3404	2.242**
Uncertainty	0.2349	1.160
Physical asset specificity	0.3012	1.937**
AAC	0.0735	0.357
Company size	0.2616	1.262
Tenure type	-0.7611	-2.374***
Separate silviculture division	0.0044	0.021
Region	-0.4938	-2.013**
Interaction between technical skill and frequency	0.0002	0.005
Interaction between technical skill and asset specificity	-0.0919	-2.784***
Interaction between frequency and uncertainty	-0.0763	-2.062**
Interaction between uncertainty and asset specificity	0.0499	1.316*
Interaction between AAC and company size	0.3232	1.291*
Interaction between company size and tenure type	-0.2211	-0.725
Interaction between company size and silv. division	0.0531	0.219
Interaction between tenure type and silv. division	0.4262	1.276
Interaction between tenure type and region	1.0546	2.811***
Interaction between silv. division and region	-0.5797	-1.821**
Constant	-3.4513	-4.431***
N = 697		
χ^2 : 94.80 (19); (critical value = 36.19 at 0.01 level)		
Pseudo R^2: 0.454		
Correct prediction: 71.3%		

[a] The model covers all 10 silvicultural activities, but 10 interaction terms are included in the explanatory variables.

[b] *** for significant at the 0.01 level, ** at 0.05 level, and * at 0.1 level.

5.2.3 Ordered Probit Model

In the case of BC's silviculture contracting at the firm level, decisions are rarely binary. Many firms have adopted both contracting out and in-house forms. Hence, the 0-1 model needs to be modified to accommodate multiple choices—in-house, contracting out and a combination of these. From the TCE perspective, the three choices clearly follow the order of outsourcing, combined, and in-house in terms of the incidence of transaction costs and their levels; thus, an ordered probit model is appropriate. The reason that an ordered probit model is chosen in favor of a multinomial logit model is that the three contractual forms are largely categorical and ordinal rather than cardinal. The problem of independence of irrelevant alternatives also rules out the applicability of an ordered logit model (Kennedy 1992).

The ordered-response model was invented by Aitchison and Silvey in 1957. McKelvey and Zavoina (1975) formalized the method and extended its application. Employing the notations used by

Greene (1993) and Maddala (1983), the three-choice ordered probit model for BC's silviculture contractual choices is, mathematically, the following:

(5.10)
$$\text{Prob}\,(Y = 0) = 1 - \Phi(\beta' x)$$
$$\text{Prob}\,(Y = 1) = \Phi(\mu - \beta' x) - \Phi(-\beta' x)$$
$$\text{Prob}\,(Y = 2) = 1 - \Phi(\mu - \beta' x).$$

In any CDF, we implicitly assume the existence of a threshold level up to which the response variables have a certain probability of occurring. This is especially so in the case of an ordered probit model. In (5.10), μ represents such a threshold value. Because only three choices are involved, there is only one μ, which is estimated together with the other coefficients.[27]

The results of the ordered probit model are presented in Tables 5.11 and 5.12. Again, four separate cases were considered using four scenarios to represent (a) the full model, (b) the model without cone collection and seedling production, (c) basic silviculture, and (d) incremental silviculture. Only the results of the pooled case are presented here. Because there are three choices under consideration, the marginal effects of independent variables are differentiated, giving results that are quite different from the probit model. Technical skill is highly significant in all four regressions; frequency is significant in the first two regressions, but insignificant in the basic and incremental silviculture scenarios; uncertainty is only significant in the incremental silviculture scenario; and physical asset specificity is insignificant in the full model as well as in the incremental silviculture scenario.

Concerning the firm characteristics variables, AAC and company size are significant in three of the four cases (not in incremental silviculture) with hypothesized positive signs; the tenure type variable is significant in three cases (not in basic silviculture) with negative signs; the silviculture division dummy and region dummy are insignificant. The threshold value variable is significant in all of the scenarios. According to Greene (1993), marginal effects of changes in the regressors should be interpreted in the following way: the derivative of Prob (Y=0) has the opposite sign from β, and the incremental change in

Prob (Y=2) has the identical sign as β. This means that positive estimates indicate a decline in the probability of the response variable (Y=0) but an increase in the probability of the response variable (Y=2), leaving the change in the choice Y=1 as ambiguous. This ambiguity is not troubling because we are essentially interested in choices between outsourcing and in-house performance of activities.

The χ^2 values indicate that the ordered probit models are highly valid from a statistical point of view. Compared with the probit models, the general TCE hypotheses are confirmed, although fewer regressors are statistically significant. These results are to be discussed in conjunction with other findings in the next chapter.

Table 5.11 Ordered Probit Model of BC's Silviculture Contractual Form

Dependent variable (0 for contracting out, 2 for in-house, and 1 for combined)

	(1)[a]		(2)[b]	
Variable	Estimate	t-value[c]	Estimate	t-value[c]
Technical skill	0.1929	4.349***	0.3054	5.654***
Frequency	0.1228	3.026***	0.1269	2.773***
Uncertainty	0.0708	1.384	0.0546	0.967
Physical asset specificity	0.0597	1.562	0.1304	2.925***
AAC	0.2875	2.746***	0.2651	2.259**
Company size	0.2004	1.801*	0.2299	1.833*
Tenure type	-0.4061	-2.838***	-0.5589	-3.528***
Separate silviculture division	0.0823	0.816	0.1286	1.125
Region	-0.0042	-0.033	-0.0291	-0.208
Constant	-2.1106	-7.626***	-2.5671	-7.523***
MU (1)	0.6229	11.782***	0.6741	11.014***
N:	697		552	
χ^2:	66.34 (9)	21.67[d]	83.98 (9)	21.67[d]
Pseudo R^2:	0.618		0.642	
Correct prediction:	69.2%		66.8%	

[a] The model covers all 10 silvicultural activities.
[b] The model comprises eight of the 10 activities, excluding cone collection and seedling production.
[c] *** for significant at the 0.01 level, ** at 0.05 level, and * at 0.1 level.
[d] Critical χ^2 value at 0.01 level.

[27] If there were four choices, then μ_1 and μ_2 would need to be estimated; with five choices, three threshold values would need to be estimated, and so on.

Table 5.12 Ordered Probit Model of BC's Basic and Incremental Silviculture

Dependent variable (0 for contracting out, 2 for in-house, and 1 for combined)

	Basic	Silviculture[a]	Incremental	Silviculture[b]
Variable	Estimate	t-value[c]	Estimate	t-value[c]
Technical skill	0.2928	4.339***	0.3453	2.832***
Frequency	0.0836	1.112	0.1348	1.107
Uncertainty	-0.0451	-0.663	0.3744	2.396**
Physical asset specificity	0.1368	2.628***	0.1009	0.812
AAC	0.3426	2.498***	0.2704	0.883
Company size	0.2299	1.552	-0.0250	-0.081
Tenure type	-0.2834	-1.546	-1.3162	-3.573***
Silviculture division	0.1438	1.078	0.2241	0.880
Region	0.0340	0.201	-0.2343	-0.779
Constant	-2.2158	-4.46***	-3.0542	-4.382***
MU (1)	0.8127	10.394***	0.3575	3.568***
N:	359		193	
χ^2 :	49.02 (9)	21.67[d]	36.61 (9)	21.67[d]
Pseudo R^2:	0.640		0.659	
Correct prediction:	59.3%		82.9%	

[a] Basic silviculture comprises site preparation, planting, brushing and weeding and surveying.

[b] Incremental silviculture comprises spacing, pruning, thinning and fertilizing.

[c] *** for significant at the 0.01 level, ** at 0.05 level, and * at 0.1 level.

[d] Critical χ^2 value at 0.01 level.

5.3 An Analysis of Main Determinants of Payment Schemes

When a firm hires seasonal workers directly for the purpose of implementing silvicultural projects, the question of payment schemes emerges. A forest company faces two choices, whether to pay a piece wage or a time-based wage. The latter can be further divided into hourly wage, or weekly, bi-weekly, or monthly salary. Contractual forms dictate payment schemes, and payment schemes have distinctive TCE implications (Roumasset and Uy 1980).[28] For instance, since the MOF conventionally used the low bid system with all contractors during the 1970s and early 1980s, under tree planting contracts signed with the MOF, silviculture contractors often practiced on an area planting basis supported by a piece rate scheme. In contrast, the crew directly hired by the Forest Service were found to use line planting coupled with a time rate (Davis-Case 1982). Up until the mid 1980s, emphasis was placed on rapid regeneration of backlog NSR lands. At that time, the low-bid system played its due role because much emphasis was placed on quantity rather than quality. Brodie and Tedder (1982) pointed out that, at the then prevailing prices for forest products, efforts at reducing regeneration delay were probably cost effective. However, the nature of silviculture, especially basic silviculture, is characterized by relatively low technical requirement, with little product differentiation, low bid promotes price competition, and it gives rise to piece wages that tend to encourage shirking in quality. When incremental silviculture becomes more and more important, quality rather than quantity will gain importance and, therefore, the low bid system will have to give way to other payment schemes.

If quality of performances and outcome are both easy to observe and quantify, one would expect the use of the hourly wage method. This is the case where divisibility and separability are high in terms of job composition or job components. Workers, or "agents", are hired to just "do the job". In this instance, workers may shirk on quantity, but the "principal" will not suffer much since the outcome is obvious. Shirking is likely to the workers' disadvantage if the amount of work that the average worker is expected to do has already been established. Such a circumstance leads to integration of activities. When work

[28] Datta, O'Hara and Nugent (1986) have found the following: (a) the greater the labor-intensity, the more seldom wage contracts would be observed; (b) the easier to detect labor shirking, the more frequently wage contracts would be observed; and (c) the greater the tenant's marginal gain of shirking per unit of shirking, the lower is the incidence of wage contracts.

increases sufficiently in amount, with growing complexity and uncertainty, eventually, a salary system will prevail.

If final outcome is observable and quantifiable, with intermediate processes having many types and combinations, one would expect the use of a piece rate system. Here "agents" have an incentive to minimize efforts and shirk on quality for achieving minimum standards. Such a circumstance leads to disintegration of activities. However, if the final outcome is not readily observable and not easily quantifiable, one would expect the use of a salary system, under which workers will not shirk on quality, but, instead, they may shirk on quantity. When quality is a top concern, the salary system works better than other payment schemes. In summary, it is generally the case that contracting out promotes higher level of production in terms of quantity, but in-house operation ensures quality.

In the case of BC, it is assumed that large companies with necessary institutional infrastructures tend to use time rates, especially the salary system. Prior to 1987, the silviculture crew hired by the BC Forest Service used time rates; meanwhile, silviculture contractors often used piece rates (Davis-Case 1982, 1985).

Data were obtained from the questionnaires returned by forest companies or their divisions. The explanatory variables are: AAC dummy ($0 = \leq 0.5$ million m^3, $1 = > 0.5$ million m^3), company type dummy (0 = small, 1 = large), tenure type index (ranging from 0 to 1), number of seasonal workers dummy ($0 = \leq 10$, $1 = > 10$), seasonal work period dummy ($0 = \leq 3$ months, $1 = > 3$ months), and region dummy (0 = BC Interior, 1 = BC Coast). A probit model and an ordered probit model are examined. In the probit model, the dependent variable is dichotomous, 0 for piece rate and 1 for time rate. For the ordered probit model, the time rate is split into hourly wage and salary. Similar to the ordered probit model of contractual choices presented in the previous section, the three payment schemes are ordinal in the sense that piece rate provides least opportunity for shirking in quantity and performance speed, and vice versa for salary; the hourly wage is somewhere in the middle.

The regression results are summarized in Tables 5.13 and 5.14. Judging from the χ^2 statistics, the ordered probit model provides a better explanation than the probit model. In terms of individual regressors, company size is positively related with the choice of salary scheme, but the coefficient sign is negative for the tenure type variable. The number of seasonal workers variable has a significant effect on the choice variable, that is, the more workers that a company hired directly, the more likely that a piece rate system is adopted. As for the seasonal period variable, the longer the period's duration, the higher the probability of adopting a salary system. In terms of regional difference, the salary system is favored on the Coast. These results conform with TCE theories, with the exception of the tenure type variable. Again, multicollinearity has been checked, and the simple correlation coefficients are generally below 0.4, except for a 0.51 between the region and tenure type variables.

Table 5.13 Probit Model of Payment Schemes for Silviculture Seasonal Workers

Dependent variable (0 = piece wage; 1 = time wage)

Variable	Estimate	t-value[a]	Mean of Variable
AAC ($0 = \leq 0.5$ million m^3; $1 = > 0.5$ million m^3)	0.0202	0.061	0.45
Company size (0=small; 1=large)	0.6317	1.789*	0.73
Tenure type index (ranging from 0 to 1)	0.0218	0.05	0.43
Number of seasonal workers ($0 = \leq 10$; $1 = > 10$)	-0.8951	-2.569***	0.37
Seasonal work period ($0 = \leq 3$ months; $1 = > 3$ months)	0.3859	1.138	0.48
Region (0=BC Interior; 1=BC Coast)	0.5346	1.51	0.35
Constant	0.2506	0.766	
N: 103			
χ^2: 19.07 (6); (critical value = 16.81 at 0.01 level)			
Pseudo R^2: 0.459			
Correct prediction: 78.6%			

[a] *** for significant at the 0.01 level, ** at 0.05 level, * at 0.1 level.

Table 5.14 Ordered Probit Model of Payment Schemes for Seasonal Workers

Dependent variable (0 = piece wage, 1 = hourly wage, and 2 = salary)

Variable	Estimate	t-value[a]
AAC ($0 = \leq 0.5$ million m^3; $1 = > 0.5$ million m^3)	0.3841	1.284
Company size (0=small; 1=large)	0.7148	2.355**
Tenure type index (ranging from 0 to 1)	-0.6759	-1.669*
Number of seasonal workers ($0 = \leq 10$; $1 = > 10$)	-1.0043	-3.538***
Seasonal work period ($0 = \leq 3$ months; $1 = > 3$ months)	0.8354	3.014***
Region (0=BC Interior; 1=BC Coast)	0.4767	1.696*
Constant	0.319	1.101
MU (1)	1.4696	7.191
N: 103		
χ^2: 48.92(6); (critical value = 16.81 at 0.01 level)		
Pseudo R^2: 0.795		
Correct prediction: 60.2%		

[a] *** for significant at the 0.01 level, ** at 0.05 level, * at 0.1 level.

5.4 An Analysis of Main Determinants of Silviculture Contracting

In the foregoing two sections, I investigated the relationships between identified variables such as TCE attributes and firm characteristics on the one hand and choice variables of contractual forms on the other. In spite of the conformity of the empirical results to TCE theories, one drawback is the absence of silviculture contractors in those models. As silviculture contracting involves at least two parties, ideally, any investigation should consider both sides of the contractual arrangement. However, for confidentiality reasons, it is understandable that forest companies are reluctant to release information on their contracting partners to protect their own interests and those of their contractors. To remedy this drawback and also to complete the investigation, a survey of BC's silviculture contractors was undertaken (Appendix I).

Out of a total of 139 questionnaires that were communicated to contractors by fax (113) and through personal interviews (26), 52 replies were obtained. The overall response rate was 37% (Table 4.1). Since one respondent was a consulting firm that had virtually no involvement in the physical performance of silvicultural activities, only 51 observations were available for regression analysis.

Given the difficulty in obtaining data about the costs and other particulars of contracts, cause-effect analysis of the underlying factors that account for the way silviculture contracting is undertaken is difficult. However, the following issues have been investigated: (1) the determinants of contract size in terms of trees planted; (2) workers' participation in silvicultural activities, measured by the number of workers hired and the rate of returned workers; (3) management efficiency, with the worker-manager ratio and worker-supervisor ratio used as the dependent variable, respectively; (4) the length of silviculture contracts, with the dependent variable being the length of basic silviculture contracts, (0 = ≤ 50 days, 1 = > 50 days); (5) the determinants of contractors' concentration on regeneration activities such as planting and brushing; (6) the determinants of contractors' involvement in incremental silviculture; and (7) the determinants of the scope of silvicultural activities, with the dependent variable being an index that measures the extent of involvement in silvicultural activities (ranging from 0.1 to 1.0).

Because the dependent variables in (1), (2) (3) and (7) are continuous and not bounded between 0 and 1, OLS is used; logit is used for (4), (5) and (6) due to the binary nature of the dependent variables. During the research, information on contract sizes and the employment of workers was discovered for the two years of 1987 and 1989 from the Pacific Reforestation Workers Association's magazine, *Screef*. This enables some comparison of regression analyses on the determinants of contract size and the hiring of workers for three separate years, and the regression results can be found in Tables 5.15 and 5.16, respectively. The results of other cases are presented in Tables 5.17 and 5.18.

Table 5.15 presents the regression results on the determinants of silvicultural contract sizes for 1987, 1989 and 1997. The number of trees planted was used as the dependent variable.[29] Strictly speaking, the three models are not directly comparable because they differ from one another in terms of regressors and the observations are not panel or longitudinal data. Nevertheless, the results provide a basis for broad comparisons in terms of trends over time. The following conclusions may be drawn. First, the role of the WSCA membership in determining the size of contracts was not detected. Second, contracting experience indicated by the number of years in business was found to have been a statistically significant factor in the late 1980s, but, by the mid 1990s, the role of such experience seems to have declined. Third, no evidence is found about any possible regional difference in regard to contract sizes. Fourth, contract sizes have been positively correlated with the number of workers hired (in 1987 and 1989) and with the worker-manager ratio (in 1997). Finally, those contractors that paid a higher level of wages to planters were able to win larger contracts (in 1987); and if the adoption of a bonus policy was not a determining factor in the 1980s, the evidence has been convincing for the 1990s.

Table 5.16 provides the regression results on the determinants of workers' employment. Clearly, in each of the three years, the number of workers hired was dictated by the availability of silvicultural work. However, over the decade, some other factors seem to have emerged. For instance, payment arrangements that consist of advance payment and settlement of balance pay are found to have played a minimum role in 1987, but, by 1989, a proper balance payment scheme had become a statistically significant factor.[30] Also, the fact that whether a contractor had a bonus policy seems to have no bearing on the recruitment of workers in the 1980s, but it appears to be an important factor in the 1990s. Finally, the size of workforce is

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[29] Of the 51 replies obtained in the 1997 survey, only 26 indicated specific number of trees planted. Therefore, 26 observations are available for the regressions on contract size and workers' recruitment.

[30] This was likely resulted from the adoption of the Employment Standards Act (consolidated on Oct. 20, 1987), which stipulated that all wages earned (gross earnings) must be paid at least semi-monthly. On a piece-rate basis, the legislation means that the employee is owed the total of what he/she has earned (e.g., number of seedlings planted times price per seedling, or number of hectares planted/treated times price per hectare) at the end of a period no longer than 16 days.

positively correlated with the scope of silvicultural activities in 1997, but, from a statistical point of view, such a relationship did not exist several years earlier. It is worth noting that the regression results provide no indication of the influence of other factors such as the WSCA membership, contracting experience and regional differences in the determination of silviculture workers' recruitment.

Table 5.17 provides the regression results for BC's silviculture contracting, using the 1997 survey data. Concerning the participation of workers in silvicultural activities, empirical evidence suggests that the percentage of workers returning to a particular contractor depends on the employment of proper payment schemes and the length of contracts. As expected, the use of a piece rate system is conducive to attracting silviculture workers. It appears that BC's silviculture workers treat income earning and work security as two of the top priorities. The effect of the WSCA membership is found positive but marginally significant from a statistical point of view. The role of contracting experience is statistically insignificant. The negative sign on the region dummy variable indicates that silviculture workers' turnover rate is higher in the Interior than on the Coast, meaning that the silviculture force is relatively more stable in the coastal region.

As far as management efficiency is concerned, two cases were considered (Table 5.17). First, the ratio of workers to managers was used as a proxy. Contracting experience and involvement in regeneration activity such as planting appear to explain the high efficiency of successful contractors, but the evidence of a positive effect of the WSCA membership is not convincing enough. Then, the ratio of workers to supervisors was used as the dependent variable. In this instance, the amount of contracting experience is clearly a significant factor; again, involvement in planting proves to be a determinant. In other words, contractors that have longer experience and are involved in tree planting tend to have a larger crew size. One has to bear in mind that, in the absence of information on contract prices and costs, the ratios of workers to managers and to supervisors merely suggest a technical efficiency rather than economic efficiency.

Also in Table 5.17, the length of silviculture contracts was examined. Given the lack of precision in the 1997 survey data on contract periods, the length of basic silviculture contracts was converted into a binary variable (0 = ≤ 50 days; 1 = > 50 days), and the logit method was used. The results indicate that, except for the constant term, the percentage of returned workers is the only statistically significant explanatory variable, meaning that stability in work crew is helpful with project duration. Contrary to *a* *priori* belief, WSCA membership does not seem to provide any advantage in winning more contract-days, and there is little evidence to argue that contracts are longer on the Coast than in the Interior. The validity of this particular model became questionable due to the low χ^2 value (rejected even at the 0.1 level).

Table 5.18 summarizes the results of regression analyses of regeneration activity, incremental silviculture and the scope of silviculture contracting. It has been found that WSCA members are more likely to be involved in tree planting than non-members and, as expected, the use of piece wage system is positively related with tree planting activity. In contrast, there is insufficient evidence to suggest that the WSCA membership is a factor in determining a contractor's involvement in incremental silviculture. Ordinarily, one would expect that a salary system should be a prevailing payment method in incremental silviculture, but such a hypothesis is rejected based on the model results.

Finally, as far as the scope of silviculture contracting is concerned, Table 5.18 indicates that the extent of silviculture contracting lies in the involvement of both basic and incremental silviculture. It appears that those contractors that have a wider scope of activities invariably use piece wages as a dominant payment method, and time rates that include the salary system is a statistically insignificant factor.

In summary, the regression results reveal that BC's silviculture contracting industry is highly competitive. This is clear from the lack of evidence on the role of WSCA membership and contracting experience. It appears that the scope of silviculture contracting has expanded since the 1980s; however, the Province is still at the stage of basic silviculture, and this is visible in the existing organizational arrangements such as management approaches and payment schemes. Further discussions of these findings are provided in the next chapter.

Table 5.15 Regression Analysis of BC's Silvicultural Contract Size
(Dependent variable = trees contracted for planting)

Variable	Coefficient	T-value[a]
1997		
WSCA membership (1=member; 0=not member)	-1.7739	-0.665
Years in operation	0.2089	1.065
Region (1=BC Coast; 0=BC Interior)	-1.6814	-0.718
Worker-manager ratio	0.0871	2.017*
Piece wage (1=yes; 0=no)	-3.8131	-0.829
Bonus policy (1=in place; 0=no)	8.3478	2.877***
Constant	3.3758	0.854
N = 26; R^2 adjusted = 0.318		
1989		
Years in operation	0.1598	3.668***
Region (1=BC Coast; 0=BC Interior)	-0.0797	-0.183
Number of workers hired	0.0205	10.95***
Advance payment (1=reasonable or explicit; 0=minimun or none)	-0.1993	-0.457
Balance payment (1=within 2 weeks; 0=delayed longer)	-0.5203	-1.216
Bonus policy (1=in place; 0=no)	0.0534	0.124
Constant	0.1143	0.204
N = 42; R^2 adjusted = 0.827		
1987		
WSCA membership (1=member; 0=not member)	-0.0763	-0.109
MOF performance class (1=A; 0=other)	-0.5512	-0.746
Region (1=BC Coast; 0=BC Interior)	-1.4869	-1.785*
Number of workers hired	0.0279	5.106***
Pay for average planter ($/day)	0.0372	2.707***
Advance payment (1=reasonable or explicit; 0=minimun or none)	-0.8419	-1.461
Balance payment (1=within 2 weeks; 0=delayed longer)	-0.0503	-0.081
Fines policy (1=yes, affecting workers; 0=none, or not affecting workers)	0.3718	0.449
Bonus policy (1=in place; 0=no)	-0.2705	-0.428
Constant	-4.3767	-2.337**
N = 40; R^2 adjusted = 0.516		

[a] *** significant at 1% level; ** significant at 5% level; * significant at 10% level.

Table 5.16 Regression Analysis of the Hiring of BC's Silvicultural Workers
(Dependent variable = number of workers hired)

Variable	Coefficient	T-value[a]
1997		
WSCA membership (1=member; 0=not member)	70.003	0.980
Years in operation	-1.8307	-0.450
Region (1=BC Coast; 0=BC Interior)	61.100	1.181
Trees contracted for planting (million)	23.511	4.696***
Number of managers and permanent staff	-10.01	-1.163
Piece wage (1=yes; 0=no)	-59.838	-0.398
Bonus policy (1=in place; 0=no)	190.68	2.332**
Regeneration silv. (1=involved in planting; 0=no planting)	21.861	0.161
Incremental silv. (1=involved; 0=no)	-36.522	-0.635
Activity index (0.1 - 1.0, indicating extent of silv. activity)	390.97	2.463**
Constant	-82.279	-0.977
N = 26; R^2 adjusted = 0.767		
1989		
Region (1=BC Coast; 0=BC Interior)	-16.351	-0.844
Trees contracted for planting (million)	34.161	10.47***
Advance payment (1=reasonable or explicit; 0=minimun or none)	19.147	0.843
Balance payment (1=within 2 weeks; 0=delayed longer)	40.992	2.190**
Bonus policy (1=in place; 0=no)	-3.7092	-0.190
Activity index (0.1 - 1.0, indicating extent of silv. activity)	24.958	0.745
Constant	-39.124	-1.712*
N = 42; R^2 adjusted = 0.781		
1987		
WSCA membership (1=member; 0=not member)	10.722	0.697
Region (1=BC Coast; 0=BC Interior)	-7.333	-0.387
Trees contracted for planting (million)	14.671	4.883***
Advance payment (1=reasonable or explicit; 0=minimun or none)	8.6782	0.649
Balance payment (1=within 2 weeks; 0=delayed longer)	-9.3953	-0.621
Bonus policy (1=in place; 0=no)	11.148	0.771
Constant	14.512	0.790
N = 40; R^2 adjusted = 0.433		

[a] *** significant at 1% level; ** significant at 5% level; * significant at 10% level.

Table 5.17 Regression Analysis of BC's Silviculture Contracts - 1997
(Workers' participation, management efficiency and contract length)

Variable	Estimate	t-value[a]
Case 1: Participation in silviculture; dependent variable is returned worker percentage; OLS		
WSCA membership (1=member; 0=not member)	0.1238	1.388
Years in operation	0.0064	0.780
Region (1=BC Coast; 0=Interior)	-0.1313	-1.307
Piece wage (1=yes; 0=no)	0.2043	1.876*
Length of basic silv. work (1 = > 50 days; 0 = ≤ 50 days)	0.1612	1.882*
Incremental silv. (1=involved; 0=no)	-0.0041	-0.046
Constant	0.2678	2.499**
N = 51; R^2 adjusted: 0.137		
Case 2 (1): Management efficiency; dependent variable is worker-manager ratio; OLS		
WSCA membership (1=member; 0=not member)	6.6078	1.048
Years in operation	0.9696	1.761*
Region (1=BC Coast; 0=Interior)	-4.8557	-0.720
Returned worker percentage	2.0965	0.219
Regeneration silv. (1=involved in planting; 0=no planting)	16.5740	2.351**
Incremental silv. (1=involved; 0=no)	-0.0822	-0.013
Constant	-4.6499	-0.617
N = 51; R^2 adjusted = 0.231		
Case 2 (2): Management efficiency; dependent variable is worker-supervisor ratio; OLS		
WSCA membership (1=member; 0=not member)	1.1575	1.198
Years in operation	0.1744	2.066**
Region (1=BC Coast; 0=Interior)	-0.9052	-0.876
Returned worker percentage	0.4163	0.283
Regeneration silv. (1=involved in planting; 0=no planting)	2.1337	1.976*
Incremental silv. (1=involved; 0=no)	0.7417	0.775
Constant	3.8873	3.363***
N = 51; R^2 adjusted = 0.263		
Case 3: Contract length; dependent variable is length of basic silviculture contracts (0 = ≤ 50 days; 1 = > 50 days); Logit		
WSCA membership (1=member; 0=not member)	-0.7407	-1.105
Years in operation	0.01862	0.330
Region (1=BC Coast; 0=Interior)	0.0090	0.013
Percentage of returned workers	1.6978	1.656*
Regeneration silv. (1=involved in planting; 0=no planting)	0.4022	0.579
Constant	-1.2600	-1.572*
N = 51; χ^2 : 4.539 (5), (critical value = 9.236 at 0.1 level)		
Correct prediction = 64.7%		

[a] *** significant at 1% level; ** significant at 5% level; * significant at 10% level.

Table 5.18 Regression Analysis of BC's Silviculture Contracts - 1997 (Regeneration, incremental silviculture and scope of activities)

Variable	Estimate	T-value[a]
Case 4: Regeneration silviculture; dependent variable is involvement in planting (1=involved in planting; 0=not involved); Logit		
WSCA membership (1=member; 0=not member)	1.3577	1.840**
Years in operation	0.0630	0.900
Region (1=BC Coast; 0=Interior)	0.5593	0.650
Piece wage (1=yes; 0=no)	2.2511	2.361**
Percentage of returned workers	0.6763	0.518
Constant	-3.3634	-2.776***
N = 51; χ^2 : 22.243 (5), (critical value = 15.086 at 0.01 level)		
Correct prediction = 78.4%		
Case 5: Incremental silviculture; dependent variable is involvement in incremental silviculture (1=yes, 0=no); Logit		
WSCA membership (1=member; 0=not member)	0.8237	1.165
Years in operation	-0.0159	-0.283
Region (1=BC Coast; 0=Interior)	-0.2236	-0.305
Salary system (1=yes; 0=no)	0.4806	0.515
Scope of silvicultural activities (ranging from 0.1 to 1.0)	5.1456	2.958***
Constant	-2.5066	-2.611***
N = 51; χ^2 : 13.088 (5), (critical value = 12.833 at 0.025 level)		
Correct prediction = 68.6%		
Case 6: Scope of silvicultural activities; dependent variable is scope of silvicultural activities index (ranging from 0.1 to 1.0); OLS		
WSCA membership (1=member; 0=not member)	-0.0598	-1.135
Years in operation	-0.0016	-0.328
Region (1=BC Coast; 0=Interior)	-0.0149	-0.256
Worker-manager ratio	0.0013	1.011
Involvement in both basic and incremental silv. (1=yes; 0=no)	0.1218	2.127**
Piece wage (1=yes; 0=no)	0.2360	3.560***
Time wage methods (both hourly and other time rates; 1=yes; 0=no)	0.2271	1.247
Constant	0.1745	3.003***
N = 51; R^2 adjusted = 0.389		

[a] *** significant at 1% level; ** significant at 5% level; * significant at 10% level.

Chapter Six

Discussion, Policy Implication and Conclusion

By way of conclusion, I summarize the main contributions of this research and propose an agenda for future research. This research contributes, in an original way, to knowledge in three ways. First, it has documented the main events and policies in BC's silviculture sector by means of a detailed chronology. This is useful in that the trajectory of BC's institutional restructuring in the silviculture sector is more clearly outlined. Second, the research demonstrates the relevance of institutional economics, especially transaction cost economics, to BC's silviculture sector by means of providing an analytical framework. It is a contribution to the area of TCE because it applies TCE theory to the analysis of a natural resource sector—silviculture. The identification of the linkages between TCE and silvicultural institutions enables investigations to be conducted at the level of contractual arrangements. Since this level of analysis is closer to field implementations and operational decision making, the accuracy and reliability of empirical findings are enhanced. Third, up-to-date information has been collected through carefully designed questionnaires that were targeted towards firm/division level silviculture managers. As a result, useful profiles of the full spectrum of the Province's silviculture sector have been constructed, with emphasis on organizational structures and forms. Testing of hypotheses derived from TCE theory has been performed using econometric modeling techniques, augmented by a case study of a major Coastal forest company. The empirical studies provide insights, for policy making purposes, on the linkages between identifiable transaction attributes and firm characteristics and contractual choices.

The philosophical underpinning of this research is grounded at the interface of neoclassical economics and evolutionary-based institutional economics. Fundamentally, the research has been influenced by three lines of thinking, namely, Douglas North's institutions theory, Ronald Coase's theory of the firm (with emphasis on the role of transaction costs as opposed to the conventional production theory) and Oliver Williamson's transaction cost theory (with emphasis on the need to adopt a contracting approach).

In this chapter, I begin by reviewing the empirical results in the context of the institutional framework of BC's silviculture sector. Then, policy implications of the effects of various silviculture contractual arrangements are assessed. Finally, several conclusions about the nature of the institutional reforms in BC's silviculture sector are drawn. The chapter ends with a summary of the contribution of the research to a better understanding of BC's silviculture sector, and some directions for future research in this area.

6.1 Discussion: Institutional Restructuring

The institutional structure of BC's forestry sector has developed in response to the socio-economic needs of the time, evolving along with alterations in political-legislative structures, shifting societal values, advancing technologies, and the dynamics of the resource base. The evolution of silvicultural institutions has proved to be a process of systematization, punctuated by reforms that brought about dramatic changes in, among other things, contractual relationships. The policy change of 1987 that brought major licensees into the vertical contracting structure for silviculture bears witness to an ongoing integration process and new transaction-cost-economizing arrangements.

Since 1987, there have been two opposing forces at play. On the one hand, the complexity of silviculture products and processes has increased; on the other, systematization and institutional restructuring has made the rules governing and evaluating the products and processes clearer, making the actual implementation of silvicultural work easier than before. Transaction costs have been lowered in some aspects (e.g., in contract writing due to diminishing uncertainty in the institutional environment), but transaction costs have increased in other aspects such as monitoring and policing (e.g., increased auditing). The real outcome of the overall net effects on total organization costs is ambiguous, and this depends on the relative strength of the two forces, which is an empirical question. However, the transaction costs of major licensees have definitely increased because they have been required to undertake more management and supervision, which means more overhead costs. Meanwhile, the costs on the part of the MOF have undergone a shift, from the traditional way of heavy involvement in planning and physical implementation towards an increasing regulatory and monitoring role.

BC has witnessed some restructuring of tenurial arrangements; no matter how limited this restructuring has been, the new content being added to the existing forest tenures have transformed contractual relationships that, in turn, result in a partial internalization of transactions. One effect of this change is the saving of bargaining costs and reduction in opportunism. Since 1987, the integration process has been accompanied by a process of specialization. Silviculture is now vertically integrated and many of the transactions that had previously been organized and implemented by the Forest Service are now directly negotiated by the parties concerned at the operational level. The requirement for Pre-Harvesting Silviculture Prescriptions serves the purpose of infusing greater credibility into silvicultural practices that are otherwise fraught with high transaction costs.

The essence of the institutional reform in BC's silviculture sector is decentralization. Not only have obligations been decentralized, decision making has also been decentralized. In comparison, power and control were considerably concentrated at the level of the Forest Service prior to 1987.

The main findings of this research into changes in contractual relationships are the following. First, transaction cost economizing behavior is clearly observable from the choice of contractual forms by firms, be it a seed orchard, a nursery or a forest company. For the purpose of synchronizing the characteristics of various silvicultural activities with the transaction-cost attributes of alternative organizational arrangements, firms evidently choose to contract out straightforward and labor-intensive activities, while performing in-house those operations that require a high level of technical skill and the use of specialized equipment. While results of the survey on nursery management indicate that growing and maintenance tend to be done in-house by permanent employees, personal interview with Pelton Reforestation Ltd.'s manager confirms the finding. For instance, that nursery each year hires college students as seasonal workers to do harvesting, but it retains three experienced workers to be responsible for the seeding operations (one of the workers having been with the nursery for 16 years). Since this is a highly mechanical process, no seasonal workers are used in the process (Pelton 1996).

Second, transaction cost minimizing behavior is more evident with profit maximizing private enterprises than with government-run entities. This is clear from the differences in the ratios of technical staff to seasonal workers between public and private entities for the same activity (Tables 4.10 and 4.13).

Third, in addition to transaction cost attributes and firm characteristics, the choice of contractual forms depends on the competitiveness of the silviculture industry. New contractors without much experience can easily compete with established contractors for silviculture work because very little venture capital is required to begin silviculture contracting. The fact that less than 20% of contractors choose to join WSCA and the lack of evidence on the benefits associated with WSCA membership is an indication of its lack of influence on the industry. The overall competitiveness of the silviculture contracting industry is also due to the presence of multiple arrangements in funding allocation and contract awarding procedures. The almost unanimous preference by silviculture contractors for work with the forest companies as opposed to the government (Table 4.4) should send a signal to the MOF about the need to transform some of its management approaches.

Finally, an obvious asymmetry exists between major licensees and silviculture contractors. Most contractors are small firms or individuals. In contrast, major licensees are likely to be large companies with considerable bargaining power. Also, the high competitiveness of the contracting industry compromises even further the bargaining position of individual contractors.

The results of the empirical work provide strong support for the proposition that firms choose appropriate contractual forms that align the attributes of the activities in question with the characteristics of the firms. In spite of the evidence, which is generally consistent with the theory of transaction cost economics, several anomalies did emerge. First, regarding incremental silviculture, one would expect that forest companies do it in-house based on uncertainty arguments because the likelihood of integration should increase with the difficulty of monitoring performance (Anderson and Schmittlein 1984, p.388). However, most of the companies that undertake any incremental silviculture have chosen to use the services of contractors. One possible explanation is that concerns about uncertainty in quality of performance are outweighed by profitability concerns, outcome uncertainty and lack of incentives in the existing forest tenures. Another explanation is that, given insecure tenures, monitoring falls with the MOF and it may be lax in enforcement.

Second, the coefficient on tenure types turned out to be unexpected. Possibly, the presence of a competitive silviculture contracting force, uncertainty about tenure security, lack of incentives for performing activities internally, and lack of scale economies all play a role. It is simply cheaper to contract out rather than preserving a year-round silviculture crew under most circumstances (Barker 1997). Because of the high competitiveness of BC's contracting industry and because of the nonspecific nature of the silvicultural activities and their seasonality, outsourcing makes more economic sense, not only on the grounds of saving production costs but also on the grounds of reducing transaction costs. The above anomalies do not disprove the general validity of the transaction cost theory, though. But, as Kuhn (1970) suggested, researchers should be alerted to the emergence of any anomaly out of a scientific investigation.

6.2 Policy Implications

The BC forestry sector is characterized by a unique dual relationship, namely, the predominance of public ownership of forestlands and growing reliance on private initiatives in forestry related activities. This relationship is important because forest tenures, organizations and contractual arrangements are essential elements in the overall forestry planning and management processes in the Province. The results of this research may be useful to policy makers from several perspectives.

6.2.1 Role of the BC Ministry of Forests

Prior to the 1980s, the BC Forest Service acted as a testing ground for new developments in silviculture. The introduction of containerized seedling production techniques in the early 1970s was an example. As the scale of operations grew, a need for specialization arose. When the management capacity of the Forest Service was exceeded, it became more economical for the Forest Service to promote division of labor by involving the private sector to undertake some of the operations. Thus, new institutional arrangements emerged to facilitate a transfer of obligations from the public to the private sector. For instance, the MOF contracts may have served as a training ground for contractors subsequently working with forest companies. Contractors who work with the major licensees are mostly those that have "graduated" from the MOF contracts and already "known the ropes", and they are largely the "creme de la creme" of contractors (Davis-Case 1982). The institutional changes since 1987 have altered the role of the MOF, from that of an implementing body to that of a regulatory agency.

The free-to-grow requirement in BC represents a minimum quality standard for regeneration. Currently, the best that the major licensees would choose, or accept, is basic silviculture. Anything more than that will mean a commitment to a location-specific performance over a relatively long time span. Given the forest tenure structure and overall institutional setup, it is logical for each licensee to commit to the minimum length of time but to aim for the maximum of space. In other words, a rational licensee would choose to minimize her effort in regeneration along the temporal dimension in order to be able to cover a larger area and thus meet the minimum regulatory requirement.

Given the increase in the scope and scale of silvicultural activities, the government lacks the ability and desire to continue implementing silvicultural projects, and the evidence for the period before private companies were made responsible for silviculture bears this out. Neither can the government monitor the quality of silvicultural performances in a discriminating fashion, without incurring formidable costs—the MOF is too far removed, institutionally, from the forest (see Figure 4.1). The major licensees face a similar difficulty but to a lesser extent because they are not as far removed. As expectations and standards rise, complexity will also increase, resulting in a shift towards more in-house operations. The Small Business Forest Enterprise Program is no exception. The BC Ministry of Forests should completely relinquish its control over the SBFEP program as far as specific silviculture contracting is concerned.

6.2.2 Contract Type and Duration

The contractual relationships in BC's silviculture sector are highly interdependent, and institutional reforms have heightened this inter-dependency among the agents. Prior to 1987, silviculture was characterized by single activities, such as reforestation, so dependency was weak. But since 1987, silvicultural activities of all kinds have increased and the volume of transactions has also increased dramatically. Since major licensees have been required to undertake basic silviculture that encompasses a range of activities, inter-dependency is intensified and the degree of sequential collaboration has also increased.

Before a contract is signed, contractors depend on major licensees in an attempt to win contracts over rival fellow contractors. However, after a contract is signed, the dependency is reversed, because, if contractors do not perform up to standard, the licensees are in trouble. This reasoning is only valid for one contracting period. Since BC's silvicultural activities have moved away from the "one-shot" game into multiple periods, the dependency has become mutual and sequential, correlating positively with the duration and extent of operations.

When the final product of silviculture (e.g., free-to-grow forests) is based on a string of performances involving a host of agents, individual contracting is costly in terms of the time incurred by both parties. New circumstances call for multi-activity and multi-period contracts. From a transaction cost economics perspective, long-term contracts help promote economic efficiency because such contracts diminish opportunism by reducing uncertainty. Therefore, we expect to see more long-term silviculture contracts in the future. Of course, for long-term contracts, problems of enforceability hamper the ability to spell out all possible contingencies in advance. So, it has become important to build into long-term contracts escape clauses that provide for re-negotiation and modifications when the need arises.

According to Williamson (1996, 1979), the problem of economic organization is to devise contract and governance structures that have the purpose and effect of economizing on bounded rationality while simultaneously safeguarding transactions against the hazard of opportunism. When it comes to contracting procedures and payment schemes, the results of this research indicate a need for changes. For instance, the insistence of the MOF on awarding contracts on the basis of lowest bid is likely to be advantageous to new contractors. Since BC is moving in the direction of more and more enhanced silviculture, the chances of winning contracts and maintaining contractual relationships will depend, increasingly, on the quality of performance in addition to the ability to make competitive bids. Therefore, one would expect an increase in the use of 'preferred contractors' and a shift towards time wages (especially salary schemes) instead of the popular piece rate system. After all, contract type, duration and payment schemes are reflections of dynamic contractual relationships.

In BC, there are two major trends in the forestry sector and they have significant policy implications for silviculture practices. First, at the end product level, differentiation of wood products is increasing, calling for greater attention to product quality, while providing opportunities for niche markets. Second, at the forest resource level, single use has given way to multiple uses and stand management is being replaced by landscape management. As a result, while mass production that achieves an economy of scale remains a central concern in planning and program delivery, regional features are becoming increasingly important. In consequence, interconnections become an issue. Repeated contracts enhance identity recognition and proximity gains importance. With the leveling off of regeneration programs, in terms of the number of seedlings being planted each year, smaller scale contracts are more trendy, and silvicultural contracts are moving into other activities such as incremental silviculture.

6.2.3 Forest Renewal BC and Jobs & Timber Accord

On June 19, 1997, BC Premier Glen Clark announced the Jobs and Timber Accord (JATA) (BC Ministry of Forests 1997a). JATA promises to create 22,400 direct jobs and 17,400 indirect jobs over the next four years through expansion of small businesses and secondary industry, intensification of forest renewals, company efforts and innovative work arrangements.

Of the above four vehicles, creating value-added jobs from the Small Business Forest Enterprise Program requires adjusting the present procedures of channeling timber to the secondary industry for re-manufacturing; increasing jobs by forest companies calls for altering corporate strategy and product orientation that have implications for industry profits and cost structures; and designing new arrangements to foster employment entails protracted negotiations among industry, union, local communities and the government. Hence, forest renewal appears to be the only instrument for creating jobs immediately.

Generating the JATA-outlined 5,000 direct jobs from forest renewals requires basic and incremental silviculture. As basic silviculture has become a mandatory obligation that forest companies have to meet in order to harvest public timber, no additional jobs should be expected from this category. It is incremental silviculture that holds the prospect of job creation.

Based on the findings of this research, three essential features regarding incremental silviculture may be pointed out. First, incremental silviculture is a program-based sub-sector that has been turned on and off in the past two decades depending on the availability of funding and political will. This feature has much to do with the lack of incentives associated with the public ownership of BC's forestlands. The relatively short duration of forest tenures and uncertainty arising from tenure renewal and replacement procedures discourage companies from investing in silviculture beyond the free-to-grow stage. Second, seasonality is a hard reality. While basic silviculture averages some 70 days annually, the average length of incremental silviculture contracts is not much higher, a mere 80 days (Table 4.4). Given the seasonality of most silviculture work, forest companies may find it difficult to utilize employees fully for significant periods during a year. To occupy workers fully, a company may have to integrate a variety of activities that use related skills and that can be produced during slack periods (Masten, Meehan and Snyder 1991). Third, contracting out has been a primary organizational form. Although employing seasonal workers is common, each year those that directly hire more than 10 people—usually summer students—account for only one third of the major licensees. It is simply cheaper, from an economic standpoint, to contract out much of the straightforward silviculture work to independent contractors.

The findings of this research reveal that the institutional structure of BC's forestry sector dictates the program-based nature of incremental silviculture activities. Therefore, the earmarking of Forest Renewal BC funding is absolutely essential to successfully implementing incremental silviculture projects. Furthermore, launching incremental silvicultural programs is a far cry from creating permanent silviculture jobs. Having workers space plantations, prune trees and fertilize stands for up to nine months a year is difficult to arrange, both physically and biologically. In the event that this difficulty is overcome, a sufficient number of economically viable and environmentally sound projects will have to be identified across the Province. Finally, concrete arrangements in personnel recruiting, performance supervision and quality assessment needs compatible organizational structures. Since nearly half of BC's major licensees have a separate silviculture division either at the corporate or operations level, management of enhanced silviculture is more effective and efficient if forest companies are permitted some latitude in their choice of contractual forms, including the freedom to work with their preferred contractors.

6.3 Conclusion: Relevance of TCE Approach

This research has adopted the transaction cost approach—a micro-analytic approach—to the study of economic organizations. The focus of the research is on the institutional restructuring in BC's silviculture sector since the mid 1980s. Documentation of the major institutional changes provides a context that facilitates the building of an analytical framework for subsequent investigations of firms' choice of contractual forms. Surveys have been conducted and useful data have been obtained regarding management of silvicultural activities at the level of seed orchards, forest nurseries and companies. Based on survey results and structured interviews with MOF officials and industry representatives, a comprehensive profile of BC's silviculture industry has been pieced together insofar as organizational forms are concerned.

Transaction costs are difficult to quantify. According to Williamson (1985), empirical research on transaction costs almost never attempts to measure such costs directly. Transaction costs are always assessed in a comparative, institutional way, by comparing one mode of contracting with another. Instead of seeking to measure the absolute magnitude of transaction costs, this research has investigated whether organizational forms (such as contractual choices and payment schemes) agree with the transaction attributes and firm characteristics predicted by transaction cost reasoning. Qualitative probit methods have been used for testing the hypothesis that one governance mode rather than another is chosen given a certain set of firm-specific characteristics, such as AAC and company size, and transaction attributes that include asset specificity, technical level, frequency of occurance and uncertainty of outcome. In view of the fact that the choice variables follow an obvious order in terms of transaction cost features, the ordered probit method has also been employed. In the research, determinants of forest companies' payment schemes and silviculture contractors' performances have also been investigated through regression techniques. A case study of a Coastal major licensee has been carried out that provides useful information about the impact of BC's institutional changes on the cost structure at the firm level. For example, the research suggests that the Forest Practices Code has increased this firm's planting, brushing and surveying costs by $257, $386 and $28 per hectare, respectively (Table 5.5).

The TCE approach is, by and large, an extension of the neoclassical economic approach. Instead of replacing conventional cost-benefit analysis, it simply draws attention to organizational modes with emphasis on contractual relations. The empirical results confirm that governance structures tend to align with transaction attributes and firm characteristics so that some costs of transacting can be saved. The research findings suggest that, ultimately, neither pure market-based institutions nor vertically integrated forms should prevail. The choice of governance mode should, thus, be dictated by the nature of the transactions involved; and transaction attributes as well as firm characteristics are subject to change under the influence of institutional circumstances that are in a state of flux.

6.4 Limitations and further Research

The research reported here has several limitations. First, since organizational costs are invariably incurred by each party to a transaction (Masten, Meehan and Snyder 1991), it is necessary to collect information from both sources. Ideally, parties that have contractual relationships with each other should be examined simultaneously in order to reveal the interactions and decision processes so that behavioral patterns can be uncovered. Unfortunately, information on a firm's contractual partner is often treated as confidential information by the manager. In spite of considerable efforts, detailed bilateral data were not obtained. As a result, the data on silviculture contractors and on major licensees do not inform about the one-to-one relationship in a contract, since each party is independently surveyed. To overcome this deficiency, future research needs to dwell upon the grass-root level, for instance, selecting a representative company or its division and tracking down the contractors that the company/division deals with.

In addition to interdependencies between licensees and contractors, and due to the dynamic and often transient nature of contracts, it is worthwhile to carry out studies on the negotiation and re-negotiation processes. Preferably, contract-specific information may be gathered, explicitly linking silviculture contractual arrangements with forest tenure relations. However, notwithstanding the advantages of revealing operational decision making processes, micro-level case studies may suffer from a lack of generality. In the case of BC where site conditions and contractual relationships are quite heterogeneous, the trade-off between Province-wide studies and geographically focused research has to be properly weighed. Future research may also expand to encompass both production costs and transaction costs, and the relationship between the two; its joint impact on the choice of governance modes will be of interest both from an academic point of view and from a management perspective. Finally, there are two other fruitful avenues of inquiry. One route is the principal-agent approach and the other is the trust-and-team-work approach. The former focuses on ex ante mechanism design and understanding of the role of incentives and asymmetric information, whereas the latter emphasizes the opportunities for economic agents to gain from their collaborative relations. Both these approaches offer an alternative to that presented in this dissertation. Clearly, much research on institutions and contractual arrangements remains to be done.

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Figure 1.1

Silvicultural Activities in BC, Scope and Scale

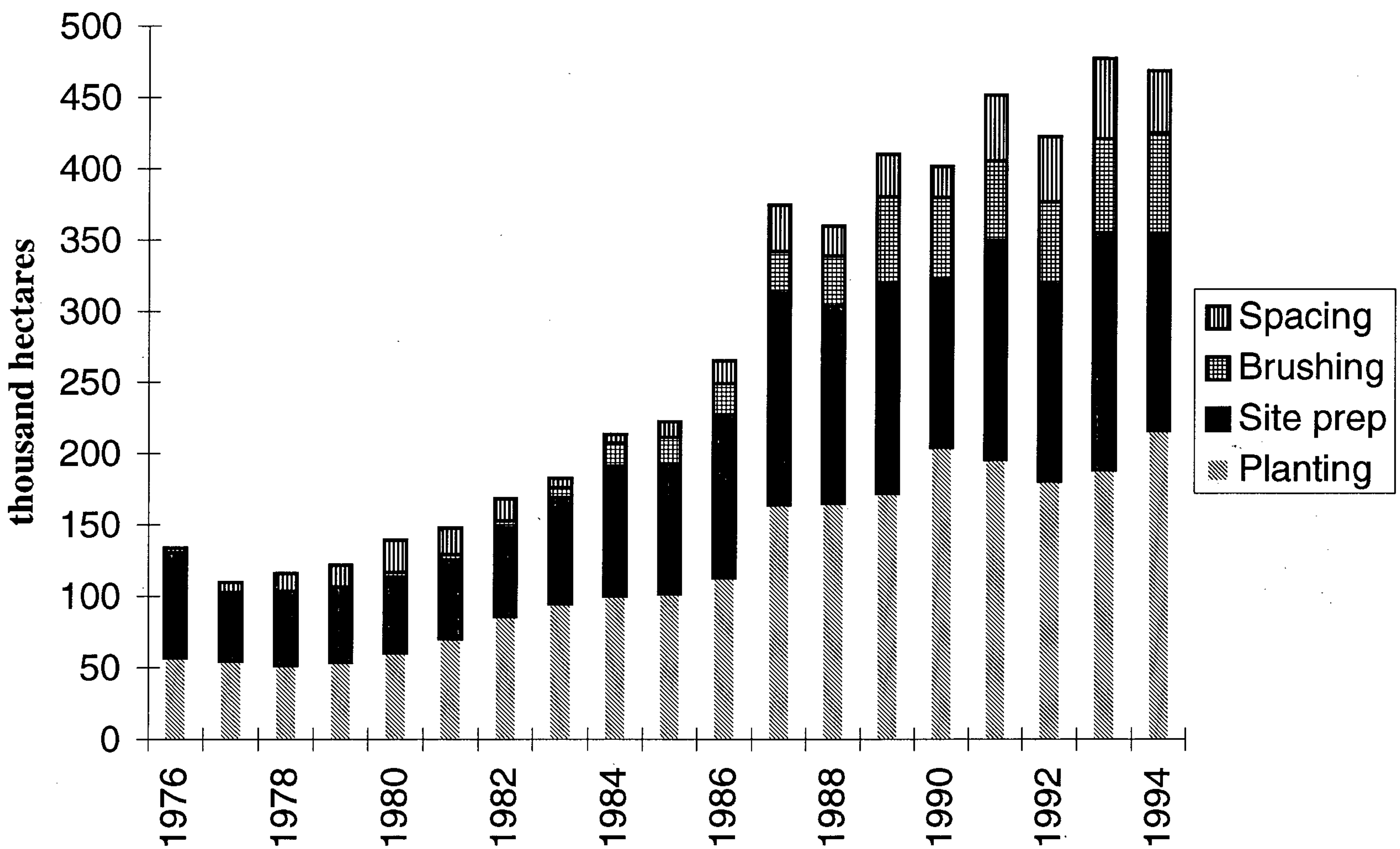


Figure 1.2

Seedlings Planted on BC's Public Forest Land

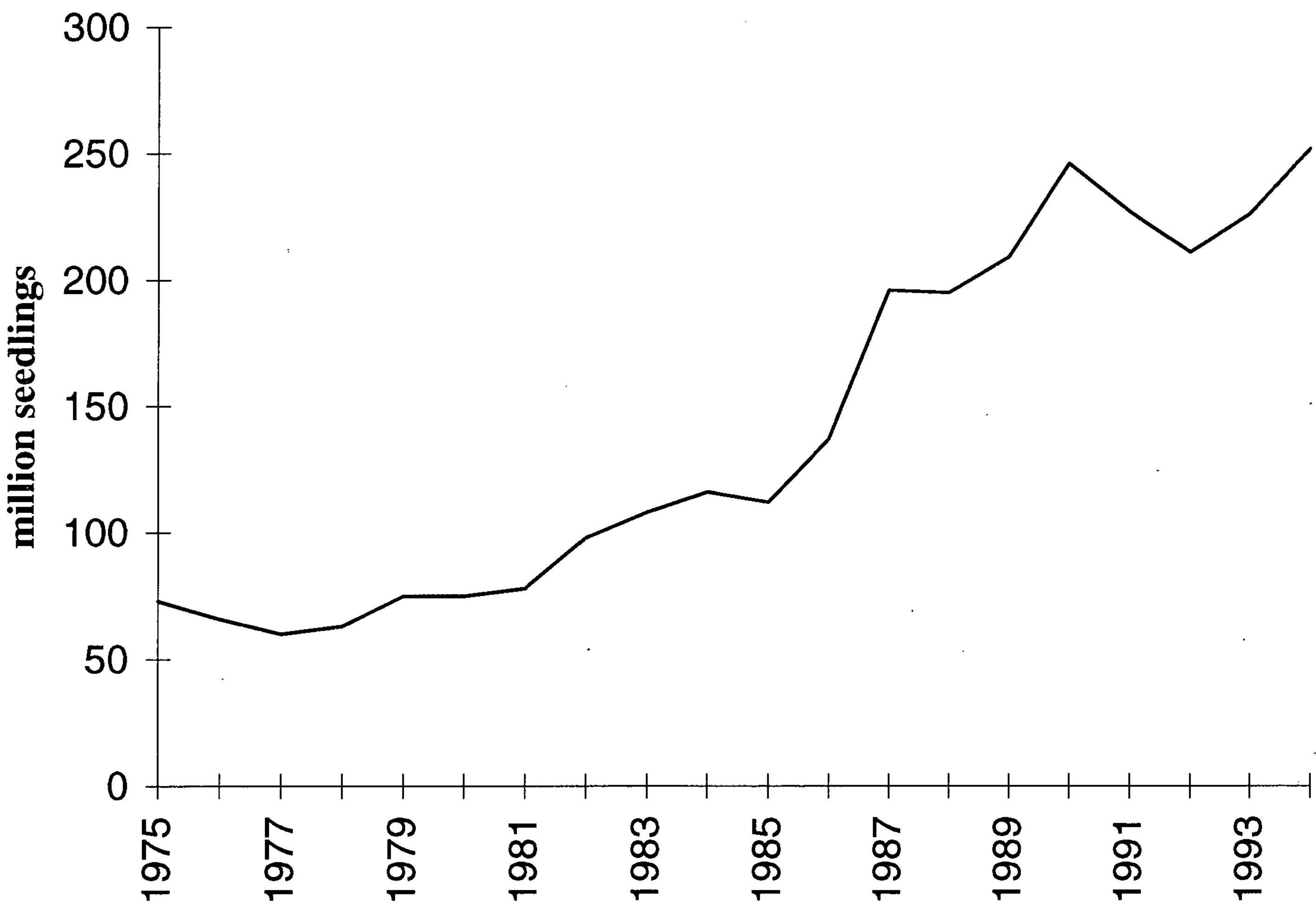
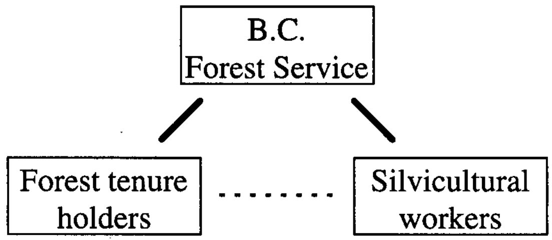
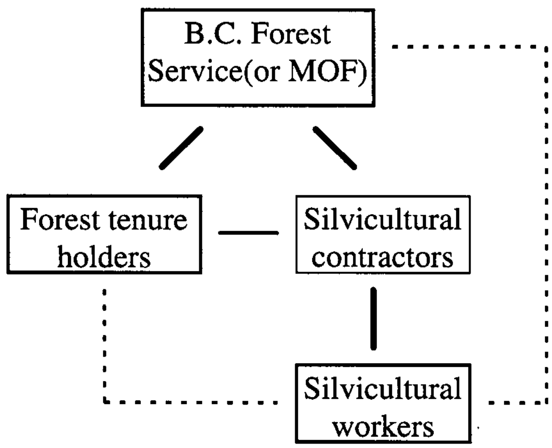


Figure 1.3 Evolution in Contractual Relationship of BC's Silviculture Sector

Pre-1967



1967 - 1987



Since 1987

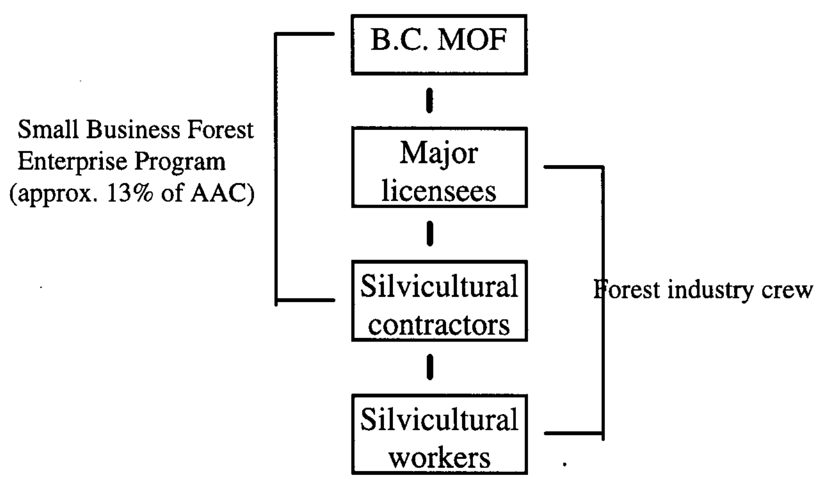
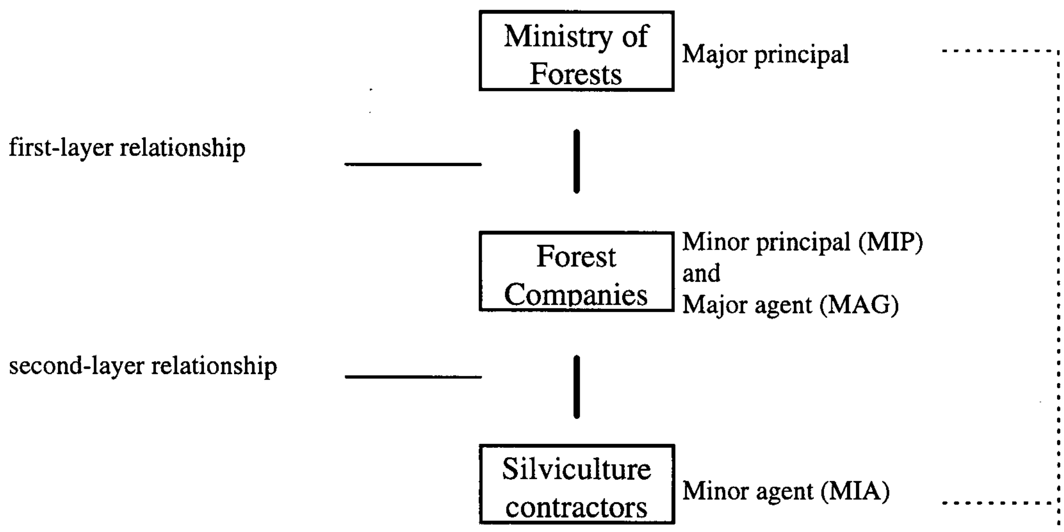


Figure 4.1 Stratified Contractual Relationship in BC's Silviculture Sector



Solid lines indicate main relationship and dashed lines show subsidiary relationship.

Figure 4.2

Silviculture Contractors in BC, by Age Group

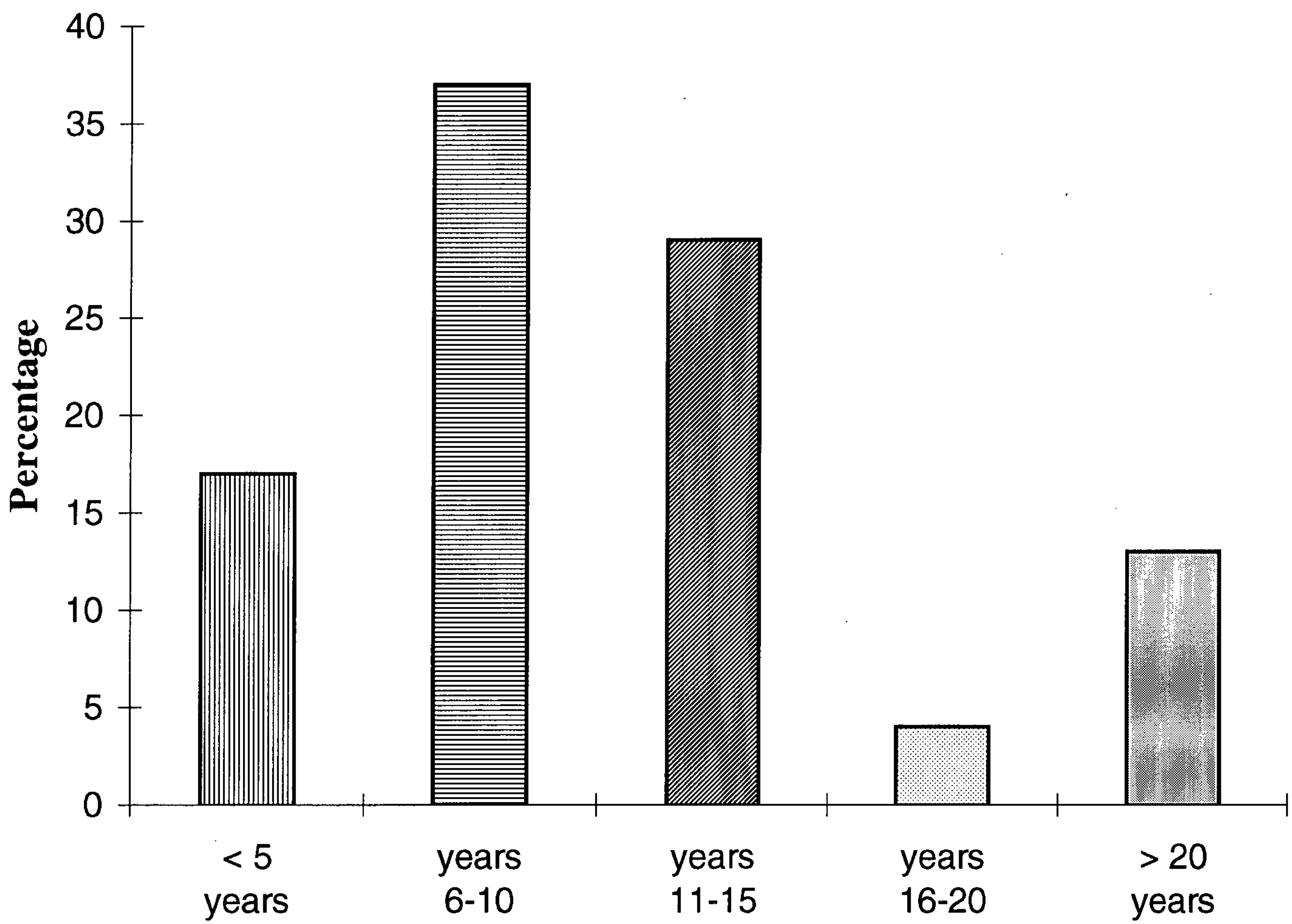


Figure 4.3

Silviculture Divisions, by Time of Establishment

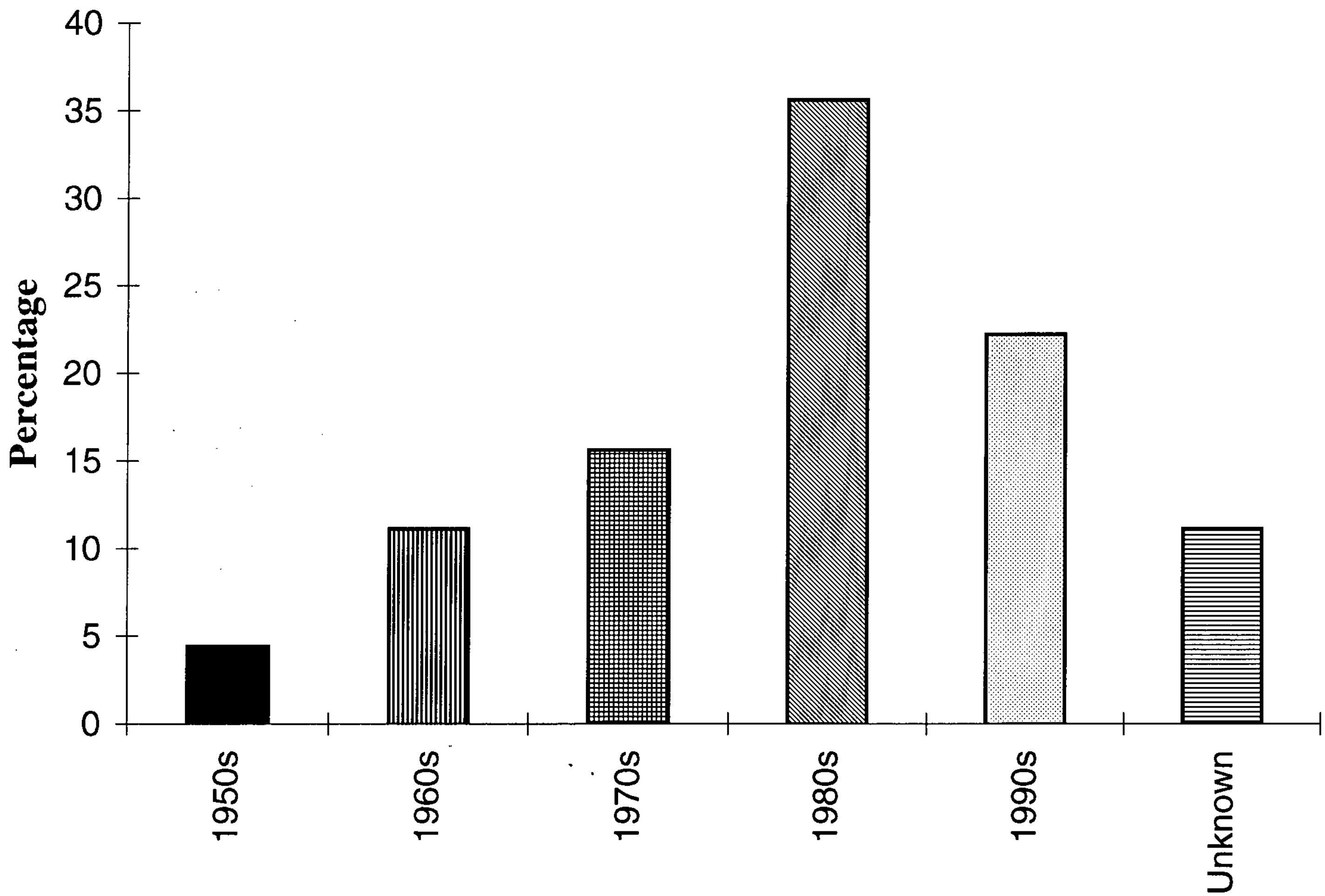


Figure 5.1

F Company Ltd.'s Silviculture Program

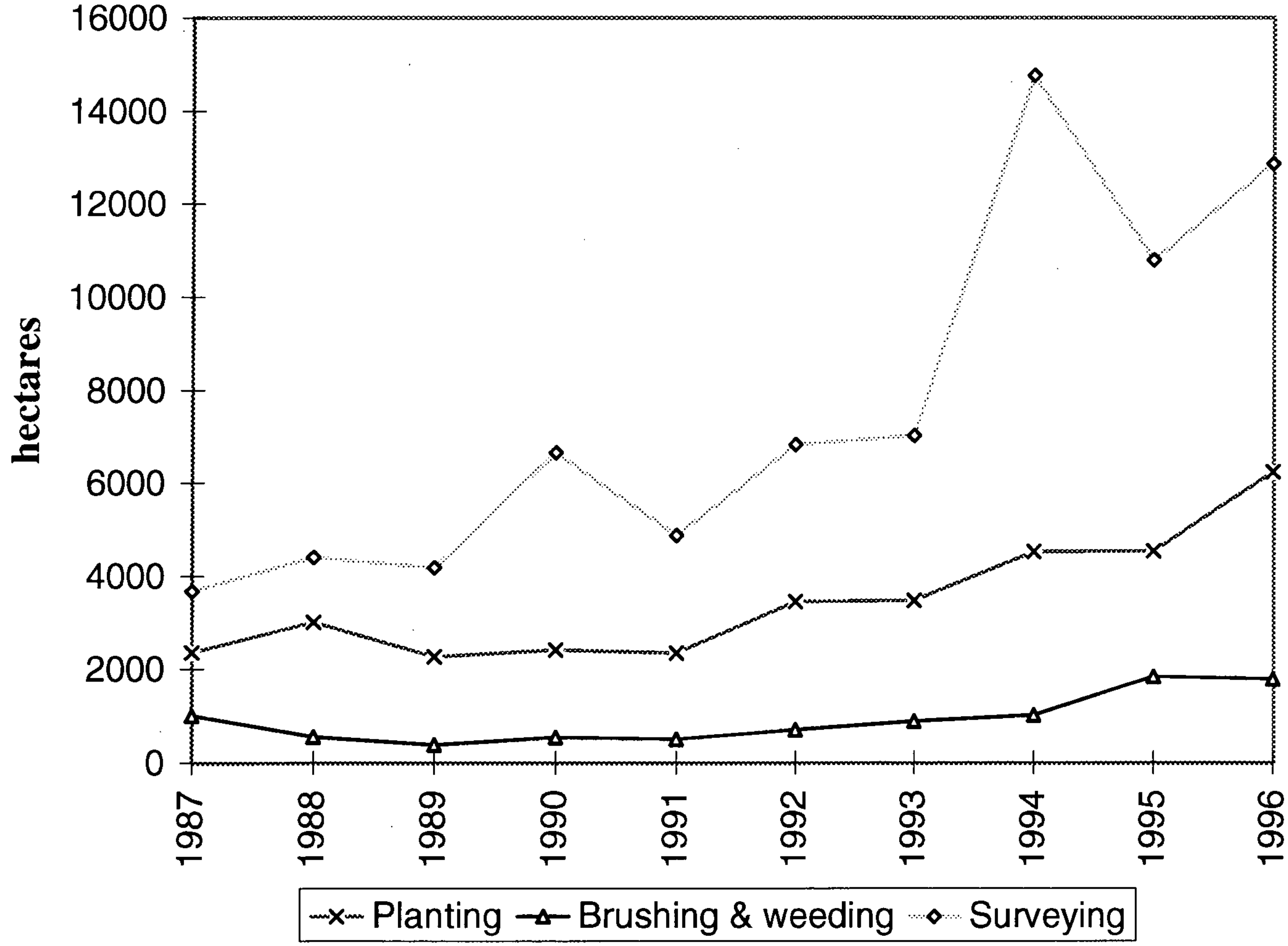


Figure 5.2

F Company Ltd.'s Planting Costs, by Item

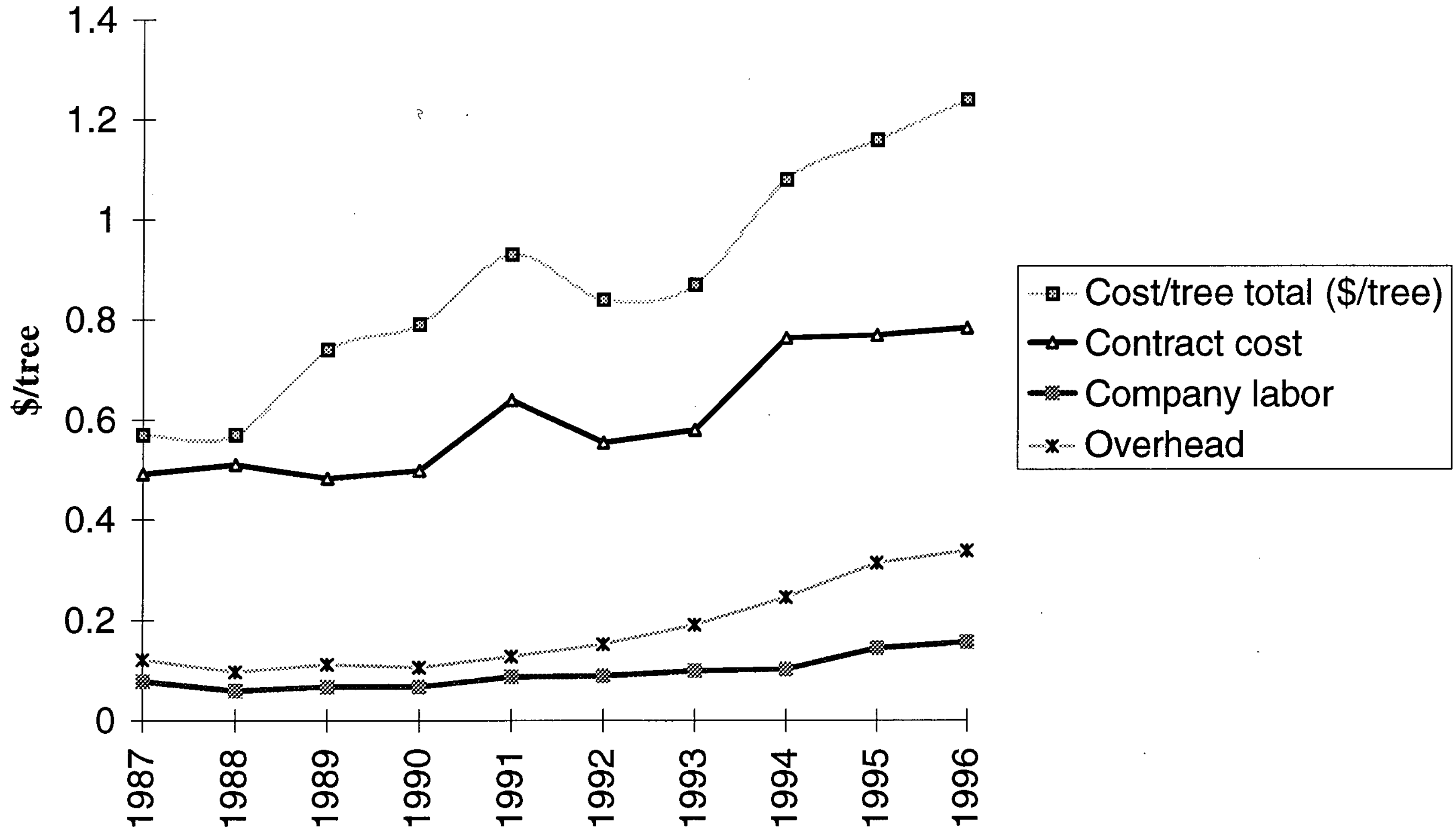


Figure 5.3

F Company Ltd.'s Planting Costs and Comparison

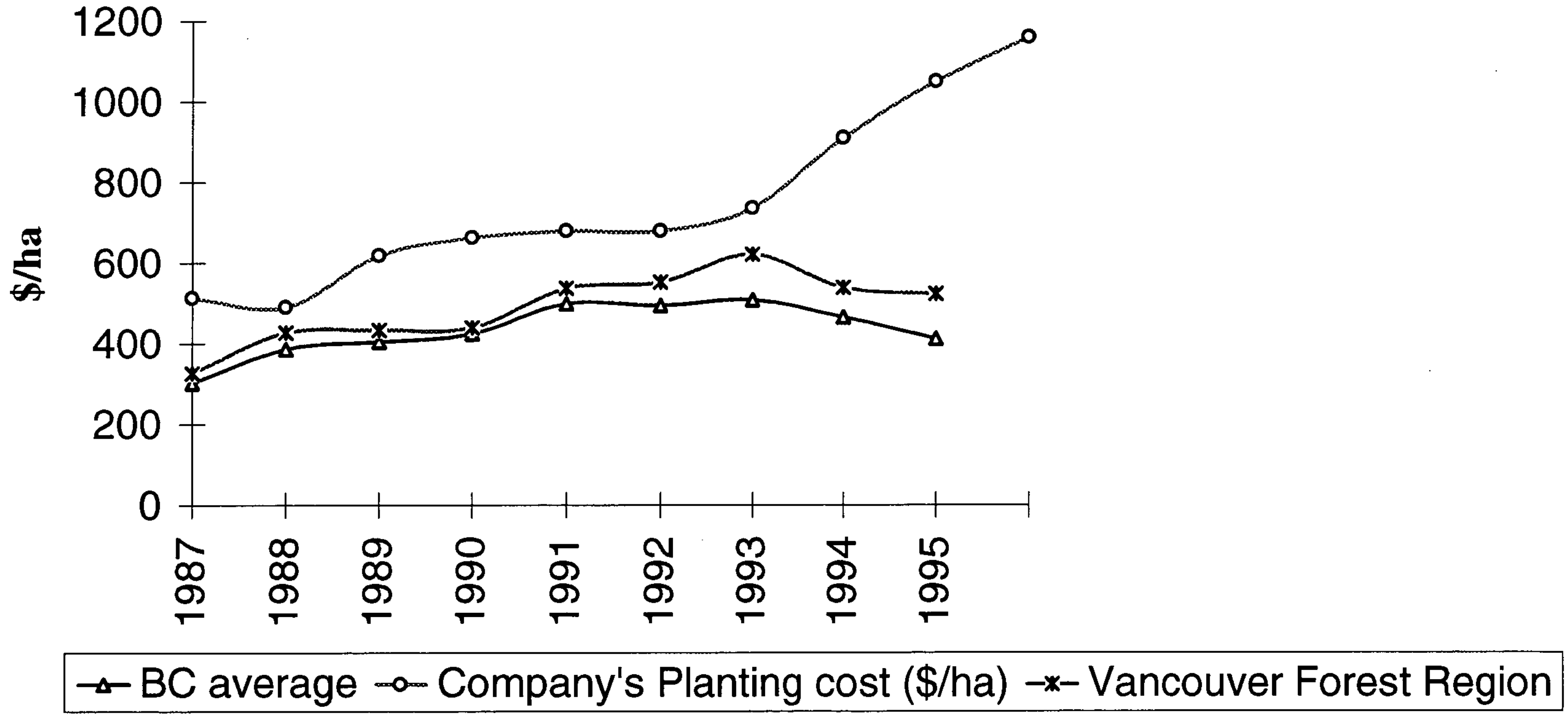


Figure 5.4

F Company Ltd.'s Brushing and Weeding Costs and Comparison

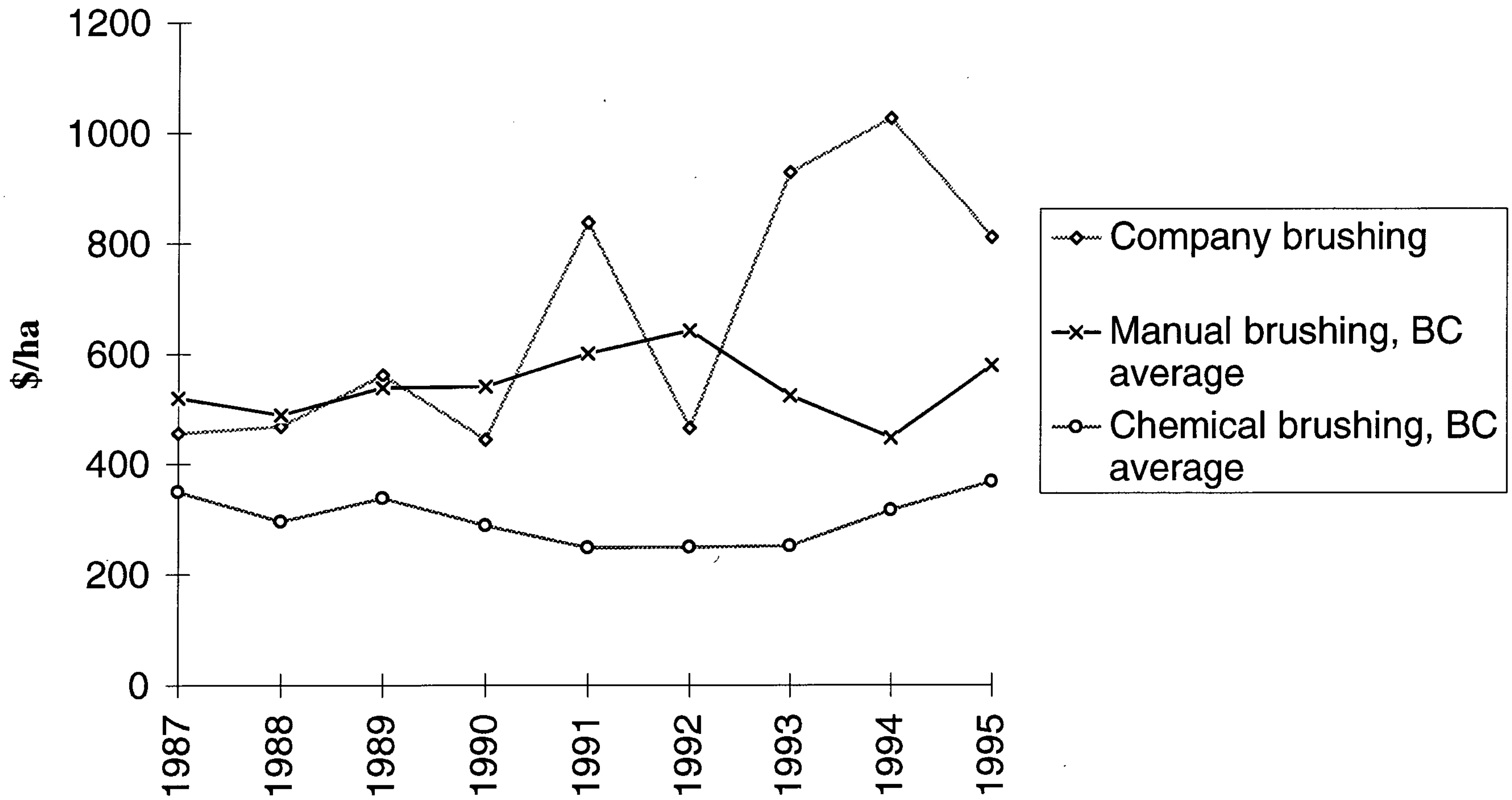
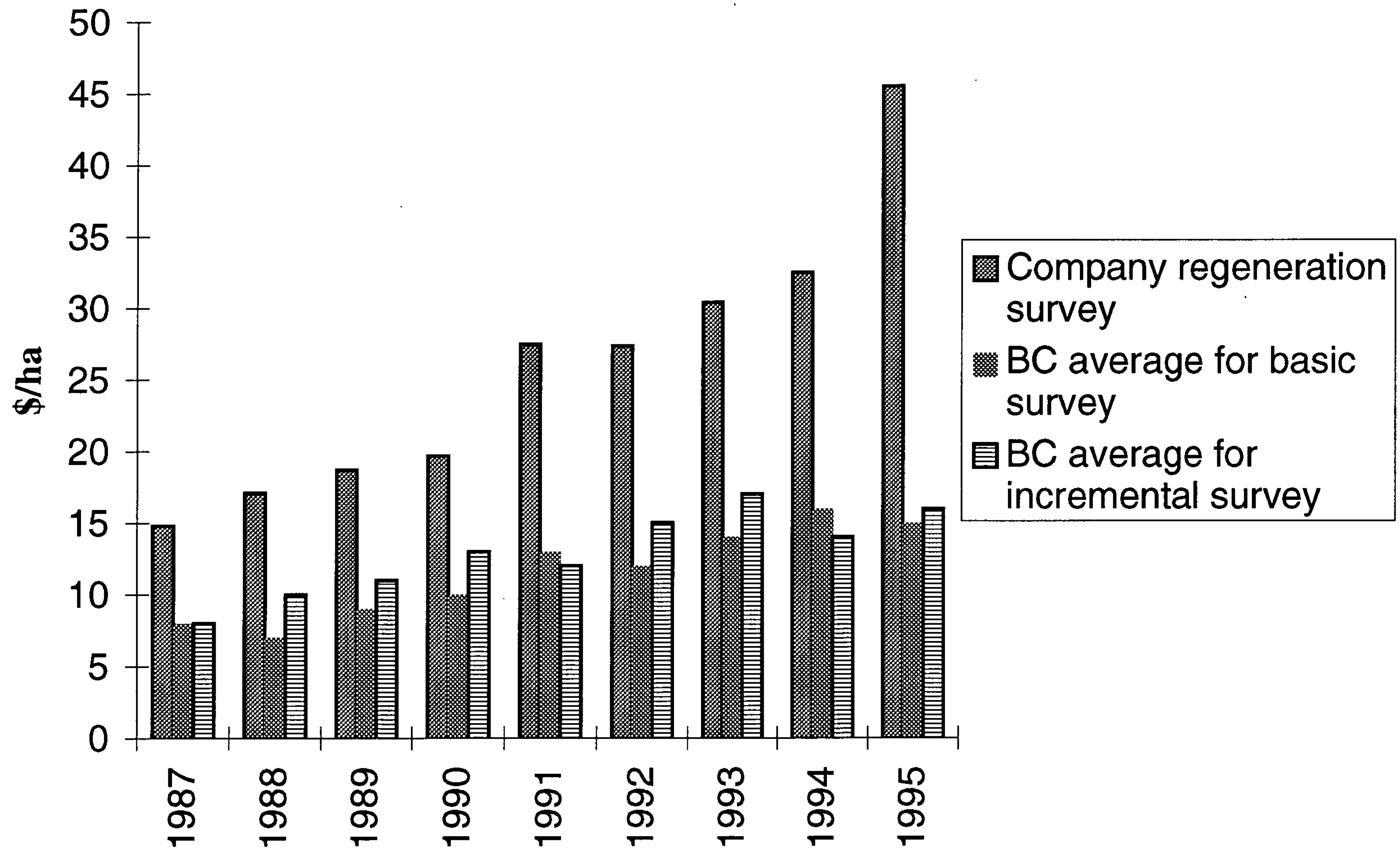


Figure 5.5

F Company Ltd.'s Surveying Costs and Comparison



Appendix I Surveys

(A)

SURVEY ON SEED ORCHARD MANAGEMENT IN B.C.

1) What year was your seed orchard established? 19_____

2) How many hectares does your seed orchard cover? _______ ha

3) How long has your seed orchard been producing cones? _______ years

4) How many cones are collected per year on average? _______ hectolitres

5) On a 5 point scale, indicate the **FREQUENCY** of cone production in your orchard?

"rare" "frequent"

1 2 3 4 5

6) How many permanent employees work in the seed orchard? _______

of whom the number of professional and administrative staff is: _______

7) How many seasonal employees are hired each year on average?

none 1 - 3 4 - 6 7 - 10 > 10

8) If you hire seasonal employees, what is their typical period of employment?

< 5 weeks 5 - 8 wks 9 - 12 wks > 12 wks

9) On average for a crop year, what % of the cones is collected by the seasonal workers?

< 10% 10 - 25% 26 - 50% 51 - 75% 76 - 100%

10) Check (√) the most commonly used payment scheme for seasonal workers?

_____ time rate by the number of hours worked
_____ piece rate according to job done
_____ lump sum
_____ other (please explain)

11) Who is doing the supervision work? Please check (√) the appropriate answer.

_______ technical people on permanent staff
_______ hired people

12) How many workers is a supervisor usually responsible for?

< 4 4 - 6 7 - 10 > 10

13) Using the 5 point scale, indicate the degree of **MANAGEMENT COMPLEXITY** required to ensure that cone collection is performed up to technical standards.

"fairly simple"				"highly complex"
1	2	3	4	5

14) Does your seed orchard provide any training to people before they start collecting cones?

Yes No

If 'yes", how long is the training?

< 0.5 day 0.5 - 1 day 1 - 2 days > 2 days

15) Using the 9 point scale below, indicate the **USE SPECIFICITY** of the equipment and tools used in cone collection.

"relatively standard "				"somewhat specific"				"very specific"
1	2	3	4	5	6	7	8	9

"Relatively standard" means that equipment and tools can be easily adapted for use by other industries.
"Somewhat specific" means that equipment and tools can be adapted for use by other seed orchards.
"Very specific" means that equipment and tools **cannot** be easily adapted for use in other industries or by other seed orchards.

16) Using the 5 point scale, indicate the **LEVEL OF TECHNICAL SKILL** required for cone collection.

"unskilled"				"highly skilled"
1	2	3	4	5

(B)

SURVEY ON FOREST NURSERY MANAGEMENT IN B.C.

1) What year was your nursery established? 19_____

2) How many hectares does your nursery cover? _______ ha

3) What is the annual production capacity? _______ seedlings

4) How many permanent employees work at the nursery? _______

   of whom the number of technical and administrative staff is: _______

5) How many seasonal employees are hired each year on average?

   < 10 11 - 15 16 - 20 21 - 25 26 - 30 > 30

   - what % are from local communities? _______ %
   - what % are unionized? _______ %

6) Do you contract out some of the nursery work?

   Yes No

7) What kinds of work are generally assinged to seasonal employees? Check (√) relevant ones.

   _______ sowing _______ stock growing _______ thinning
   _______ weeding _______ lifting and packing _______ other

8) What kinds of work are usually contracted out? Please check (√) relevant ones.

   _______ sowing _______ stock growing _______ thinning
   _______ weeding _______ lifting and packing _______ other

9) On a 5 point scale, indicate the FREQUENCY of seasonal hiring and contracting out at your nursery?

"rare"				"frequent"
1	2	3	4	5

10) What is the average period of employment for seasonal employees and contractors ?

   < 3 months 3 - 6 mos 6 - 9 mos > 9 mos

11) What is the commonly used payment scheme for seasonal workers? Check (√) the appropriate answer.

   _____ time rate by number of hours worked _____ piece rate according to job done
   _____ lump sum _____ other (please explain)

12) Who is doing the supervision work? Please check (√) the appropriate answer.

   _______ technical people on permanent staff _______ hired people

13) How many workers is a supervisor usually responsible for?

1 - 5   6 - 10   11 - 15   16 - 20   > 20

14) Using the 5 point scale, indicate the degree of MANAGEMENT COMPLEXITY equired to ensure that seasonal workers and contractors perform up to technical standards.

"fairly simple"				"highly complex"
1	2	3	4	5

15) Does your nursery provide training to workers before they start working each season?

Yes   No

If 'yes", how long is the training?

< 0.5 day   0.5 - 1 day   1 - 2 days   > 2 days

16) Using the 9 point scale below, indicate the USE SPECIFICITY of the equipment and tools used by nursery workers.

"relatively standard"				"somewhat specific"				"very specific"
1	2	3	4	5	6	7	8	9

"Relatively standard" means that equipment and tools can be easily adapted for use by other industries.
"Somewhat specific" means that equipment and tools can be adapted for use by other nurseries.
"Very specific" means that equipment and tools cannot be easily adapted for use in other industries or by other nurseries.

17) Using the 5 point scale, indicate the TECHNICAL SKILL required by nursery workers.

"unskilled"				"highly skilled"
1	2	3	4	5

(C)

SURVEY ON MANAGEMENT OF SILVICULTURAL ACTIVITIES IN B.C.

I. Organization

1) Do you have a separate silviculture division? Yes No

If 'yes', what year was it established? 19_____

If 'no', is silviculture part of the timber division? Yes No

2) What is the approximate AAC of your company (or division)?

0 - 0.5 million m^3 0.6 - 1.0 mil. m^3 1.1 - 1.5 mil. m^3 1.6 - 2.0 mil. m^3

2.1 - 2.5 mil. m^3 2.6 - 3.0 mil. m^3 3.1 - 3.5 mil. m^3 > 3.5 mil. m^3

3) Check (√) the forest tenure types relevant to your company. (Can √ more than one)

_______ private land _______ TFL _______ Forest Licence _______ other licences

4) How many permanent employees are engaged in silviculture?

< 10 11 - 20 21 - 30 31 - 40 41 - 50 > 50

How many of them are professionals (with RPF) and administrative staff?

1 2 3 4 5 > 5

5) Each year, typically, how many seasonal employees does your company directly hire for silviculture work?

< 10 11 - 20 21 - 30 31 - 40 41 - 50 > 50

6) What is the typical or average period of employment for seasonal workers?

< 1 month 1 - 3 mos 4 - 6 mos 7 - 9 mos > 9 mos

7) Check (√) the relevant types of work that seasonal workers are hired for. (√ more than one)

_______ cone collection
_______ seedling production
_______ site preparation
_______ planting
_______ brushing and weeding
_______ spacing
_______ pruning
_______ thinning
_______ fertilizing
_______ surveying

How are such silviculture workers paid? (please √ appropriate answer)

_______ hourly wages _______ piece rate _______ salary _______ other (explain)

8) Does your company **CONTRACT OUT** any silvicultural work to independent contractors (or nursery growers and helicopter company, etc.)?

Yes No

Use √ to indicate those activities performed by company employees and directly hired seasonal workers.
Use *x* to indicate those activities performed by independent contractors.

_______ cone collection
_______ seedling production
_______ site preparation
_______ planting
_______ brushing and weeding
_______ spacing
_______ pruning
_______ thinning
_______ fertilizing
_______ surveying

9) What is the usual length of contracts?

-- basic silviculture activities _______ months
-- incremental silviculture _______ months

Which selection system do you use most often in contracting out? (Please √)

_______ low bidding

-- how many contractors are usually available for selection?

< 3 4 - 7 > 7

-- what % of bidders are from local communities?

< 30% 30 - 70% > 70%

_______ preferred contractor

-- Check (√) the important selection factors (Can √ more than one)

_______ low bid
_______ good reputation
_______ successful relationship in the past
_______ union issue
_______ employment opportunity for local community

On a 5 point scale, indicate the **DEGREE OF COMPLEXITY** of contract negotiation.

"very simple"				"highly complex"
1	2	3	4	5

What are the provisions for contract revision/renegotiation? (Please √)

_______ built into contract every (√)
_______ 1 year _______ 2 - 4 years _______ 5 + years _______ other

_______ by request from one of parties to the contract

10) How are disputes handled? (Please √)

_______ negotiation _______ arbitration _______ litigation

II. Silvicultural Activities

1) Using a 5 point scale, indicate for EACH silvicultural task the **LEVEL OF SKILL** required. (Place the appropriate number next to the activity)

1	unskilled	_______ cone collection
		_______ seedling production
2		_______ site preparation
		_______ planting
3		_______ brushing and weeding
		_______ spacing
4		_______ pruning
		_______ thinning
5	highly skilled	_______ fertilizing
		_______ surveying

2) Using a 5 point scale, indicate for EACH silvicultural task the **FREQUENCY** of occurrance. (Place the appropriate number next to the activity)

1	rare	_______ cone collection
		_______ seedling production
2		_______ site preparation
		_______ planting
3		_______ brushing and weeding
		_______ spacing
4		_______ pruning
		_______ thinning
5	frequent	_______ fertilizing
		_______ surveying

3) Using a 5 point scale, indicate for EACH silvicultural task the **DEGREE OF UNCERTAINTY** in controling the quality of performance. (Place the appropriate number next to the activity)

1	fairly assured	_______ cone collection
		_______ seedling production
2		_______ site preparation
		_______ planting
3		_______ brushing and weeding
		_______ spacing
4		_______ pruning
		_______ thinning
5	highly uncertain	_______ fertilizing
		_______ surveying

4) Using the 9 point scale below, indicate for EACH silvicultural task the **USE SPECIFICITY** of the equipment and tools involved. (Place the appropriate number next to the activity)

"Relatively standard" means that equipment and tools can be easily adapted for use by other industries.
"Somewhat specific" means that equipment and tools can be adapted for use in other silvicultural activities.
"Very specific" means that equipment and tools **cannot** be easily adapted for use in other industries or by other silvicultural activities.

1	relatively standard	_______ cone collection
2		_______ seedling production
3		_______ site preparation
4		_______ planting
5	somewhat specific	_______ brushing and weeding
6		_______ spacing
7		_______ pruning
8		_______ thinning
9	very specific	_______ fertilizing
		_______ surveying

(D)

SURVEY ON MANAGEMENT OF SILVICULTURAL CONTRACTS IN B.C.

1. Which year did you start silviculture contracting? 19_____

2. How many managers and permanent staff are in your company?

3. How many silviculture workers did you hire last year?

4. How many of them (or %) were returning workers?

5. How are silviculture workers paid? (please √ appropriate answer)

_______ hourly wages
_______ piece wages (_______ by hectare, _______ by number of trees)
_______ base wage plus bonus
_______ other (please explain)

6. Check (√) the relevant types of work that your company is usually engaged in (√ more than one)

_______ cone collection _______ spacing
_______ site preparation _______ pruning
_______ planting _______ thinning
_______ brushing and weeding _______ fertilizing
_______ pest and disease control _______ surveying

7. How many hectares of trees (or number of trees) did your company plant last year?

8. What is the usual length of a contract?

-- basic silviculture activities _______ months
-- incremental silviculture _______ months

9. How many workers is a supervisor usually responsible for? Please circle.

1 - 5 6 - 10 11 - 15 16 - 20 > 20

10 If you have a choice, are you more comfortable carrying out contract work from the Forest Service or forest companies?

Forest Service Forest Companies

Appendix II List of People Interviewed

Name	Affiliation	Position	Date
Abebe, Gashaw	Scott Paper Ltd.	Manager, Hybrid Poplar Nursery at Harisson Mills	Jan.29, 1997
Barker, John	Western Forest Products Limited	Manager, Technical Forestry Services	Feb.17,1997
Brinkman, Dirk	Brinkman & Associates Ltd.	President	Feb.7, 1997
Caldicott, Norman	International Forest Products Ltd. (Interfor)	Project Forester and Superintendent of Silviculture Operations	Feb.19, 24, 1997
Crover, Jim	FRBC	Program Manager	Feb.5, 1997
Juvik, Ken	Greater Vancouver Regional District	Watershed Forester, Watershed Management Division	Jan.27, 1997
Kiss, Les	Coast Forest & Lumber Association	General Manager, Forestry	Nov.27, 1996
Kolotelo, Dave	Surrey Tree Seed Center, MOF	Seed Improvement Specialist	Jan.15, 1997
Larsen-Saxby, Melanie	Forest Worker Transition Program	Manager, Workforce	Feb.7, 1997
McCloy, B.W. (Brian)	COFI	Vice President, Environment and Energy	Feb.17,1997
Merrel, Bob	Green Timbers Forest Nursery, MOF	Superintendent	Jan.17, 1997
O'Neal, Bob J.	District of Mission	Forestry Manager	Jan.29, 1997
Patterson, Dave	Weldwood of Canada Limited	Forest Practices Forester	Mar.3, 1997
Thomson, Ross	MOF	Planning Forester, SBFEP	Feb.5, 1997
Willingdon, Tony	Surrey Nursery, MOF	Superintendent	Jan.15, 1997
Winter, Ralph	MOF	Stand Management Officer, Forest Practices Branch	Feb.5, 1997

Appendix III Scientific Names of Commonly Planted Tree Species in BC

Scientific name	Common name
Thuja plicata Donn *ex* D. Don in Lamb.	Western redcedar
Chamaecyparis nootkatensis (D. Don) Spach	Yellow-cedar
Pseudotsuga menziesii (Mirb.) Franco	Douglas-fir
Tsuga mertensiana (Bong.) Carr.	Mountain hemlock
Tsuga heterophylla (Raf.) Sarg.	Western hemlock
Larix occidentalis Nutt.	Western larch
Picea sitchensis (Bong.) Carr.	Sitka spruce
Picea engelmannii Parry *ex* Engelm.	Engelmann spruce
Picea glauca (Moench) Voss	White spruce
Pinus contorta Dougl. *ex* Loud.	Lodgepole pine
Pinus monticola Dougl. *ex* D. Don in Lamb.	Western white pine
Pinus ponderosa Dougl. *ex* P.&C. Lawson	Ponderosa pine
Abies lasiocarpa (Hook.) Nutt.	Subalpine fir
Abies amabilis (Dougl. *ex* Loud.) Forbes	Amabilis fir (balsam)
Abies grandis (Dougl. *ex* D. Don) Lind.	Grand fir

Appendix IV Acronyms

AAC	Allowable annual cut
BC	British Columbia
COFI	Council of Forest Industries of British Columbia
FRBC	Forest Renewal BC
FRDA	Canada-British Columbia Forest Resource Development Agreement
JATA	Jobs & Timber Accord
MOF	British Columbia Ministry of Forests
NIE	New institutional economics
PHSP	Pre-harvesting silviculture prescription
SBFEP	Small Business Forest Enterprise Program
SP	Silviculture prescription
TCE	Transaction cost economics
TFL	Tree Farm Licence
WSCA	Western Silviculture Contractors' Association