RESOURCES AND THE REGIONAL ECONOMY:
AN HISTORICAL ASSESSMENT OF THE FOREST INDUSTRY
IN BRITISH COLUMBIA

by

CHERIE MAUREEN METCALF

B.A. (Honours), Queen's University, 1990
M.A., University of British Columbia, 1991

A THESIS SUBMITTED IN PARTIAL FULFILMENT OF
THE REQUIREMENTS FOR THE DEGREE OF
DOCTOR OF PHILOSOPHY
in
THE FACULTY OF GRADUATE STUDIES
Department of Economics

We accept this thesis as conforming
to the required standard

THE UNIVERSITY OF BRITISH COLUMBIA
November 1998

©Cherie Maureen Metcalf, 1998
In presenting this thesis in partial fulfilment of the requirements for an advanced degree at the University of British Columbia, I agree that the Library shall make it freely available for reference and study. I further agree that permission for extensive copying of this thesis for scholarly purposes may be granted by the head of my department or by his or her representatives. It is understood that copying or publication of this thesis for financial gain shall not be allowed without my written permission.

Department of \textit{Economics}

The University of British Columbia
Vancouver, Canada

Date \textit{Dec. 20, 1998}
Abstract

This thesis provides empirical evidence to assess the long term contribution of the B.C. forest industry to the provincial economy.

Estimates of resource rent are constructed to measure the direct contribution of the resource to provincial income and growth. Measures of rent are constructed for a firm level sample (1906-76) and at an industry level (1918-92). The figures for rent are used to generate estimates of the share of provincial income measures directly attributable to the industrial exploitation of the province's forests. While there were periods during which the direct contribution to provincial income and its growth was nontrivial, in general the growth of forest industry rent did not drive overall economic growth but rather lagged behind.

Rent was low on average and volatile during the years before W.W.II, rose rapidly from roughly 1940-51, then declined unevenly. To investigate the forces which underlie both the broad trends and the variability in rent, a stylized model of the forest industry is applied in an empirical analysis. Broad changes in aggregate rent were the result of changes in rent per unit of B.C. timber. The rapid increase in rent coincided with a marked rise in the price of forest products. The secular decline resulted from the combination of a falling output price and rising costs. An investigation of real harvesting costs indicates that depletion played a role in this increase. The variability of rent is also explored and found to be most strongly influenced by factors reflecting market risk which the B.C. industry could not diversify away from.

The rent measures may not capture the full impact of the forest industry, so the industry's potential role as a leading export sector is also examined. The possibility of a stable long term link between forest exports and provincial income is investigated using cointegration tests. B.C. forest exports and G.D.P. are not cointegrated; their levels are not linked in a deterministic way in the long run. A bivariate VAR is used to examine the short run interaction between the growth of forest exports and provincial G.D.P. The results do not strongly support the view that the forest industry acts as a leading export sector in the provincial economy.
## Contents

Abstract .......................................................... ii
Contents ............................................................ iii
List of Tables ......................................................... v
List of Figures ......................................................... vi
Acknowledgement ...................................................... viii
Chapter 1 Introduction .............................................. 1
Chapter 2 Resource Rent in B.C.'s Forest Industry ............... 8
  2.1 Introduction .................................................. 8
  2.2 Related Literature ........................................... 13
      2.2.1 Resource Rent in the Canadian Context ................ 13
      2.2.2 Returns to the Forest Industry in B.C. ................. 16
  2.3 Forest Resource Rent: Theoretical Framework ................. 21
  2.4 Measuring Forestry Rent at the Firm Level ................. 26
      2.4.1 Defining Rent at the Firm Level ....................... 26
      2.4.2 Firm Level Sample ....................................... 28
          Firm Level Data ........................................... 28
          Sample Firms .............................................. 31
      2.4.3 Rent Captured by Firms ................................ 39
      2.4.4 Rent Captured by Labour ................................ 44
          Union History in B.C. ..................................... 46
          Union Rent Capture ...................................... 51
          Implications for the Study of Firm Level Rent .......... 57
      2.4.5 Rent Collected by Government ......................... 60
          Forest Policy in B.C. .................................... 60
          Government Collection of Rent from Sample Firms ....... 67
      2.4.6 Total Firm Level Rent .................................. 71
  2.5 Measuring Rent at the Industry Level ......................... 76
      2.5.1 Defining Rent at an Industry Level .................... 77
      2.5.2 Industry Level Results ................................ 80
  2.6 Conclusion .................................................. 92
Chapter 3 Resource Rent in the B.C. Forest Industry: Driving Forces 112
  3.1 Introduction ................................................ 112
List of Tables

2.1 Summary Information for Sample Firms ................... 33
2.2 Percentage Difference Between Annual Earnings in Forest Industries vs Other Manufacturing Industries for B.C. ............ 52
2.3 A Simple Test of Union Influence .......................... 54
2.4 Forestry Resource Rent as a Share of Provincial Income: Firm Level Estimates, Decadal and Selected Averages .................. 73
2.5 Forest Resource Rent as a Share of Provincial Income: Industry Level Estimates, Decadal Averages .................. 83
2.6 Forest Resource Rent Retained in B.C. as a Share of Provincial Income: Industry Level Estimates, Decadal Averages ............. 85
2.7 Actual vs. Counterfactual G.D.P Growth and Share of Growth due to Rent: Decadal and Selected Averages .................. 87
2.8 Actual vs. Counterfactual Growth of Personal Income and Share of Growth due to Rent: Decadal and Selected Averages ............. 88
2.9 Comparison of Firm Based and Industry Level Estimates of the Share of Forest Industry Rent in G.D.P. ................... 90
3.1 Regression Results: Harvesting Costs ....................... 145
3.2 Models of Forestry Rent Evolution: Fit and Regression Significance ............................................ 154
3.3 Regression Results, Multi-factor Model of Forestry Rent Evolution 155
4.1 Decadal Average Growth Rates of the Forest Exports and G.D.P. of British Columbia ............................................. 178
4.2 Dickey-Fuller Unit Root Tests; Real B.C. G.D.P. and Forest Exports ......................................................... 180
4.3 Engle-Granger Cointegration Tests: B.C. G.D.P. and Forest Exports ......................................................... 183
4.4 Johansen-Juselius Cointegration Tests; B.C. G.D.P. and Forest Exports ......................................................... 186
4.5 Forecast Error Variance of Growth in B.C.'s G.D.P. Attributable to Forest Export Growth Shocks ................... 195
# List of Figures

2.1 Forest Resource Rent as a Share of Provincial Income: Industry Average derived from Firm Level Estimates, 1919-76 ............. 74
2.2 Forest Resource Rent as a Share of Provincial Income: Industry Level Estimates, 1919-92 .................. 83
2.3 Forest Resource Rent Retained in B.C. as a Share of Provincial Income: Industry Level Estimates, 1919-92 ......... 86
2.4 Victoria Lumber Company: Resource Rent and Distribution, 1906-35 .................................................. 96
2.5 Columbia River Lumber Company: Resource Rent and Distribution, 1913-26 .................................. 97
2.6 Canadian Western Lumber Company: Resource Rent and Distribution, 1913-53 ................ 98
2.7 Bloedel Stewart and Welch: Resource Rent and Distribution, 1918-51 ........................................ 99
2.8 B.C. Pulp and Paper Company: Resource Rent and Distribution, 1926-49 ................................. 100
2.9 Powell River Company: Resource Rent and Distribution, 1943-58 101
2.10 MacMillan Bloedel: Resource Rent and Distribution, 1945-76 102
2.11 Crown Zellerbach Canada: Resource Rent and Distribution, 1954-76 103
2.12 Excess Rates of Return to Capital: B.C. Sample Forest Industry Firms, 1906-76 .......................... 104
2.13 Excess Returns: B.C. Sample Forestry Firms’ Average vs Stelco, 1906-76 ........................................ 105
2.14 Forest Resource Rent as a Share of G.D.P.: Firm Level Estimates, 1919-76 ............................. 106
2.15 Forest Resource Rent as a Share of Personal Income: Firm Level Estimates, 1926-76 ..................... 107
2.16 Rent in All Forest Industries, 1919-92 ........................................ 108
2.17 Rent in Logging Industry, 1919-92 ................................. 109
2.18 Rent in Wood Industry, 1919-92 ........................................ 110
2.19 Rent in Paper and Allied Industry, 1919-92 ......................... 111
3.1 Average Shadow Value of B.C. Timber, 1926-92 .................. 161
3.2 Difference between Growth of B.C. G.D.P. and Forest Industry Output ................................................. 162
3.3 Prices and Costs in B.C.'s Forest Industry, 1926-92 ............. 163
3.4 Share of B.C. Log Exports Classified as Grade 1 and Grade 2 Timber, 1926-82 .......................................... 164
3.5 Share of Provincial Timber Harvest Originating from Coast Forest District, 1926-92 ......................................... 165
3.6 Rate of Change in Average Shadow Value of B.C. Timber, 1926-92 .................................................................. 166
3.7 Real Value of New Residential Construction, 1906-92 .......... 167
3.8 Index of Real Stock Prices (TSE), 1919-92 ............................ 168
4.1 Forest Exports and G.D.P. of British Columbia, 1919-92 ....... 199
4.2 Ratio of Forest Exports to G.D.P. for British Columbia, 1919-92 ................................................................. 200
4.3 Level of Forest Exports and G.D.P. of British Columbia, 1919-92 ................................................................. 201
4.4 Responses of B.C. G.D.P. Growth to Forest Export Growth Shocks ................................................................. 202
Acknowledgement

I would like to thank the members of my thesis committee; Robert C. Allen, Angela Redish, Ronald Shearer, and Brian Copeland, for their comments, suggestions, and support. Further assistance from those attending the Economic History Workshops at U.B.C. is gratefully acknowledged. Financial support from the Social Science and Humanities Research Council of Canada made this research possible. I would also like to thank my fellow graduate students. My family, friends, and especially my husband have patiently borne all the worst moments of this project with love and seemingly boundless faith; I could not have done this without you. Thank-you!
Chapter 1
Introduction

The role played by natural resource endowments in economic development is a perennial subject of Canadian economic history. The origins of this tradition can be traced to the work of Innis [93] who framed early Canadian economic development as a series of (more and less successful) transitions from one staple resource export to another.\(^1\)

The relevance of the staples view has been questioned at a national level, largely as a result of the search for empirical verification of the framework's general predictions. The first serious empirical challenge was leveled by Chambers and Gordon [40] who measured prairie land rent during the wheat boom they concluded that this staple export boom had contributed little to per capita income growth in Canada.\(^2\) McCalla [118] and McInnis [119] have recently produced evidence which calls into question the established view that a wheat staple was key to Upper Canadian economic development. McCalla [118] also contests the view that the earlier development of the timber industry was a significant stimulant to this same regional economy. Green and Green [78] examine micro data for immigrants during the wheat boom period and find that the prairie resource boom was not the motivating force for most migrants, as suggested by the traditional staples view. Henriques and Sadorsky [89] implicitly challenge the export led growth assumption of the staples framework with their finding

\(^1\) Although Innis is the best know proponent of this view of Canadian history, other contemporaries such as Mackintosh [121] shared a similar view.

\(^2\) The publication of this article ignited a vigorous debate. The resulting literature generated estimates of the importance of the wheat boom which varied from insignificant (Chambers and Gordon [40], [41]) to very large (Lewis [111].)
that Canadian economic growth causes the growth of Canadian exports rather than the alternative.

The confrontation between the staple 'model' and the data has led to considerable refinement of the view of Canadian economic development. What was once accepted as a unifying theme of Canadian economic history has largely been discarded as too limiting a view of the complexities of historical economic development.\(^3\)

In spite of this 'national debate' the staples framework figures prominently in both historical and contemporary analysis of the B.C. economy. The empirical accuracy of this view is largely unquestioned.\(^4\) Perhaps the abundance of natural resources reinforces the compelling descriptive appeal of a staples view of the B.C. economy, so that measuring the secular importance of the resource industries would seem to be stating the obvious, in a tedious, time consuming and uninteresting way. In fact, as the following chapters of this thesis will demonstrate, this is far from the case.

This thesis examines the relationship between natural resource endowments and the regional economy through a historical study of the forest industry in British Columbia. I focus on the forest industry (broadly defined) in B.C. By any measure, the forest industry must be considered the province's leading resource industry over the twentieth century. It is a natural focal point in attempting to assess the historical role of B.C.'s resource industries empirically. This thesis provides empirical evidence to assess both direct and indirect influences of the forest industry through its effect on measures of provincial income and growth.

\(^3\)This is clearly the message in critiques of the staples view, such as McInnis [119] and McCalla [118]. Even amongst those who are more favourably disposed to the potential importance of staples, such as Inwood [94] and Gerriets [74], there is a recognition that this is only one part of the development story.

\(^4\)Historical work which considers the importance of agriculture and the role of immigration in shaping B.C. society indirectly undermines the staples view by broadening the perspective on important aspects of provincial development (Harris and Demeritt [87], Barman [6], Harris [86]). Allen [1] directly questions the primacy of B.C.'s resource industries in determining (intensive) provincial growth and welfare.
The direct value of the resource to the province is captured by a measure of resource rent. The generation of a time series for aggregate forest industry rent and estimates of the share of provincial income and growth which it accounts for are the focus of the first substantive chapter. Measures of rent are first generated for a sample of B.C. forest industry firms. This unbalanced panel spans the period 1906-76. The sample firms provide disaggregate estimates of resource rent, including its distribution between firms, labour and government. The results for the sample firms are used to generate industry level estimates of the relative share of rent in provincial income measures. The firm level sample also provides some necessary data to construct aggregate forest industry capital stock estimates for the period from 1918-54. This facilitates the estimation of forest industry rent and its distribution at an aggregate level for the period 1918-92.

The disaggregate and aggregate estimates produce consistent results. Resource rent was volatile and low on average during the period before W.W. II. From 1940-51 forest industry rent displayed a strong upward trend, peaking in relative terms in 1951 at 11.1% of provincial G.D.P. and 12.9% of personal income according to aggregate estimates. Corresponding figures for the firm based estimates are 13.4% and 15.7% respectively. The volatility of forest rent diminished during this period of growth. Uneven decline in forest rent characterized the period from 1951-92. During the 1960s rent became increasingly volatile. By the sample endpoint in 1992 forest industry rent did not appear to contribute significantly to provincial income measures. During the period of low rent before W.W. II government collected a substantial share of rent. Firms were the main beneficiaries of the rapid increase in rent during the period from 1940-51. Neither government nor labour captured a substantial share of rent during this period. From the early 1950s government and labour began to retain a larger share of rent. By the sample endpoint they captured the majority of the resource
rent which the forest industry generated.

Over the period 1919-92 forest resource rent accounted for a relatively small share of provincial income measures. In addition, it made a negligible contribution to both aggregate and per capita provincial income growth. These results for the period as a whole are partially driven by the decline in resource rent from roughly mid-century. If the period during which rent was relatively largest and increasing most rapidly is isolated (1940-51) forestry rent retained in B.C. accounted directly for 5.7% of G.D.P. growth and 11.8% of per capita G.D.P. growth. The corresponding figures for personal income and personal income per capita were 6.5% and 13.4% respectively. Forest industry rent contributed significantly to provincial income during this period, however, this is not generally true over the full sample period. Rather than driving provincial income, the growth of forest industry rent lagged behind that of other components of provincial income over the latter half of the 20th century. The results of this chapter indicate that the forest industry made a relatively modest direct contribution, as measured by resource rent, to aggregate income and its growth in British Columbia over most of the twentieth century.

What factors were responsible for the pattern of rent observed in these results? This is the question which the second substantive chapter addresses. The behaviour of aggregate forest industry rent in B.C. reflected a combination of forces. The broad trends in rent were the result of similar movement in value of rent per unit of B.C. timber. The examination of the average rent per unit of B.C. timber, broken down into its price and average cost components, is revealing. The rapid rise in rent during the period from 1940-51 appears to have resulted from a rapid increase in the price of forest products. The secular decline from mid-century was produced by the combination of a declining output price and rising harvesting costs. Price movements generally reflected the influence of forces exogenous to the B.C. industry, but may also have been influenced
by the quality of timber harvested in B.C. The real cost of harvesting per unit of timber rose at an average of 4.83% annually over the period from 1926-92. Real harvesting costs are estimated as a function of current output, technology and depletion to investigate this increase. The results indicate that technological change lowered costs slightly, by an average of 0.566% annually. Depletion, as measured by the cumulative harvest, accounted for an estimated increase of 3.792% annually. This provides some evidence that depletion of the resource influenced the secular decline in the average rent per unit of B.C. timber.

Forest industry rent appears to have a stronger influence on provincial growth at shorter time horizons. This is the result of the extreme variation in forest rent from year to year. What explains this volatility in forest rent? I use a model of a depletable natural resource industry which incorporates uncertainty to identify variables which should determine the dynamic behaviour of the shadow value of B.C. timber. I regress the percentage change in the average rent per unit of B.C. timber on these variables to investigate the forces driving the observed variation in rent. I find that the variables which reflect market risk are most significant. This indicates that forest resource rent in B.C. included a substantial premium for risk in order for the expected return on the resource to compare favourably with other assets. It also implies that B.C. forest rent was highly sensitive to market conditions which were beyond the influence of the industry.

The view that B.C.'s forests were responsible for provincial growth is pervasive. Measurement of the direct contribution (resource rent) does not fully support this view, however, it may be that the forest industry's influence was more general equilibrium in nature. The industry is credited with attracting factors of production, including labour and capital, to the regional economy. The generation of regional income and stimulation of local demand may have generated regional externalities in the form of agglomeration economies or other spillovers. In the third substantive chapter the forest industry's role as a leading
export sector is examined. The view that B.C.'s forest exports drive the provincial economy is prevalent in both historical and contemporary analysis. This is an obvious channel through which the province's forest endowment may have been responsible for provincial growth and economic development. The focus of the third substantive chapter is the nature of the empirical link between B.C.'s forest exports and its G.D.P.

I investigate the relationship between B.C.'s forest exports and G.D.P. taking the time series properties of the data into account. I find that the series are difference stationary, so I look for a stable long term relationship between forest exports and provincial growth by testing to see whether the series are cointegrated. I employ both single equation and systems approaches to testing for cointegration. In spite of an apparent relationship between the levels of these two variables they are not cointegrated. This means that the level of forest exports and provincial income are not deterministically related in the long run. In addition to testing for a long term relationship between B.C.'s forest exports and G.D.P. I also examine the short term relationship between the variables. I estimate a bivariate vector auto regression (VAR) to examine the dynamic interaction between forest export and G.D.P growth. This allows the empirical relationship between the variables to be more completely revealed. Growth of forest exports could have positive, or negative consequences for B.C.'s G.D.P. growth. Theory suggests that either outcome is possible.

Vector auto regressive methods are used to reveal the nature of the empirical connection. The results indicate that over the full sample period greater than average growth in forest exports led to an increase in G.D.P. growth. This response is larger in the following year than initially, but by the third year the effect is to slow growth slightly. The effect is essentially negligible after

\footnote{See for example Marchak [123], [122] who casts the forest industry as a leading export sector in a staples framework of development.}
two years. Decomposition of the forecast error variance indicates that shocks to forest exports account for approximately 22% of forecast error variance of G.D.P. growth. While this is not a trivial share, other factors must also contribute to the volatility of provincial growth. VARs are also estimated for two subsample periods, 1920-45 and 1946-92. The changes in the response of G.D.P. to forest export shocks between the periods are interesting. During the initial period the response of G.D.P. to forest export shocks was relatively larger and more persistent. In the later period the response was smaller and dampened rapidly. The forecast error variance decompositions reveal a similar pattern. During the early period export shocks accounted for 34% of G.D.P. growth forecast error variance, relative to 18% during the second subsample period.

The VARs provide some evidence that the effect of the forest industry had a stronger connection to provincial economic growth during the pre-W.W. II period. The effect of forest export growth was more evidently reflected in provincial growth during this period. Forest export volatility likely accounted for a greater share of overall economic volatility during this early period.

While there is some possibility that the forest industry may have played a role as a leading export sector during the province’s early history, the evidence does not generally support such a view of the industry. The failure to find a cointegrating relationship between forest exports and provincial income indicates that the two variables are not deterministically linked in the long run. A view which assigns the forest industry a continuous role as the foundation of the provincial economy, responsible for determining the level of provincial income, is inconsistent with the evidence.
Chapter 2
Resource Rent in British Columbia's Forest Industry

2.1 Introduction

The profits from a permanent Crown timber business should make British Columbia that phenomenon of state craft and good fortune - a country of 'semi-independent means.'
F. J. Fulton, 1910¹

What is a forest?...it is the broad base upon the continuance of which depends the prosperity and high standard of living of this Province.
G. M. Sloan, 1945²

The preceding quotes eloquently illustrate the belief that the forest resources of B.C. are of critical importance for the generation and growth of provincial income. In fact, it is difficult to find an assessment of the forest industry which suggests otherwise. In spite, or perhaps because of, this widely held view there has been little systematic empirical investigation of the historical role of the forest industry in the provincial economy. The objective of this chapter is to begin such an investigation.

The focus of this chapter is the measurement of resource rent generated by the forest industry in B.C. This is a measure of the flow of income which is implicitly derived from the value of the province's forests as an asset. It captures the direct contribution of the resource itself to provincial income. Rent is a

¹Fulton [71], pp. 20.
²Sloan [157], pp. 8-9.
particularly important source of income in an open economy which is too small to influence prices in output markets and which is integrated with larger markets for mobile factors of production. Rent is a source of income which can raise per capita income in the region. In this sense rent can raise the welfare of residents. Point estimates have shown that natural resource rent, almost all of which is generated in the forest industry, accounts for as much as 38% of the discrepancy between average per capita income in B.C. and the national average.\(^3\) This suggests that the direct contribution of the resource to provincial income and growth is significant. Even if the conclusions drawn from existing point estimates generalize accurately, there are interesting questions which remain unanswered. How has this direct measure of the economic contribution of the province’s forests changed over time? How is forest industry rent distributed and is it retained in the province? More comprehensive measurement of rent is necessary to answer these questions.

While there are some existing estimates of forest resource rent for B.C., these are either for short time intervals (Copithorne [49], [50]; Percy [140]), based only on relatively recent data (Grafton and Nelson [77]), or both (Schwindt and Heaps [152]).\(^4\) In order to study the historical contribution and evolution of rent a more complete series must be generated. A difficulty which perhaps explains the absence of longer time series in the literature is a lack of complete, consistent aggregate data. This chapter begins with a study of rent at the firm level as a means of circumventing the limitations of the aggregate data. The firm level data provide an independent check on the reliability of the results generated with the aggregate data, as well as information to construct aggregate capital stocks. This supplies the missing industry level data, which I combine with

\(^3\)Copithorne [50], pp. 87.

\(^4\)Although Schwindt and Heaps [152] explicitly consider the question of resource rent capture, they provide direct estimates of ‘wealth’ generated in the forest industry rather than resource rent.
existing aggregate data to calculate consistent time series of provincial forest industry rent. The combination of firm level results and aggregate estimates provides a broad range of evidence on the level and evolution of resource rent in B.C.’s forest industry.

At both the industry and firm level determining the distribution of forest rent is a fundamental aspect of measurement. The distribution of rent is of critical importance for its contribution to provincial income and growth. One reason for this is the presence of significant foreign investment in the industry. When rent is captured by firms in the industry it is likely that a substantial portion of this rent does not go to residents of British Columbia, but to foreign owners of capital. This reduces the effect of resource rent on the regional economy. An argument has also been put forward by Copithorne [50] that resource rent capture by unionized labour in B.C.’s forest industries has inflated the general provincial wage level. The implied consequences are unemployment and reduced competitiveness of the provincial manufacturing sector, both of which have negative effects on provincial income and growth. It is essential to know the distribution of forest rents between firms, labour and government in order to address these issues.

The distribution of resource rents is of interest for other reasons. There has been significant debate over whether provincial timber charges are adequate to capture rents in B.C.’s forest industry. An ongoing claim by U.S. producers that B.C.’s charges are too low and constitute an unfair subsidy is at the root of the modern literature. There is also a view that historically the government has collected less than the true value of returns to the province’s timber. The

---

5 See Pearse [138], pp. 47-48, or Paterson [135] for more general discussion of foreign investment in B.C.
6 Copithorne [50], pp. 163-164.
7 Grafton and Nelson [77], for example, measure resource rent annually from 1970 and compare their estimates with government timber charges to assess the validity of the U.S. claim.
8 See, for example, Barman [6], pp. 182-183; Fulton [71], pp. 45-46.
results in this chapter on the distribution of rent and its evolution over time provide direct evidence to assess these views.

The results on the general level and distribution of forest rent are consistent across the firm level and aggregate samples. During the industry’s early history rent was relatively small and on average government collected a significant share. From roughly 1940 the situation changed and resource rent rose rapidly through the early 1950s. During this phase government’s share fell significantly. While organized labour achieved some of its first victories soon after forestry rent began to rise, it did not succeed in capturing a large share of industry rent during this period. Most of the resource rent during this phase of the industry’s history was retained by firms. During the 1960s a different pattern emerged. Forest industry rent became increasingly volatile and any apparent trend was negative. Government captured a more significant share of rent and its timber revenue became much more cyclical. Rent captured by labour fluctuated some and by the end of the sample it became substantial. In relative terms rent declined over the second half of the century.

In terms of the issues raised in the literature it seems that government was relatively successful at rent capture, with the important exception of the period during which rent was relatively largest. Firms captured most of this rent. Firms do not appear to retain large rents by the sample endpoint, making an implicit subsidy through this channel currently unlikely. 9 Over the period as a whole labour does not appear to capture a significant share of resource rent generated in the forest industry. Examination of wage differentials between forest sector occupations and other manufacturing in B.C. provides some support for the view that these are not due to rent capture. Wage differentials existed before unions became firmly established in the forest industries. It seems unlikely that resource rent capture by unions is significant enough to have major effects on

9This result is supported by the findings in Grafton and Nelson [77].
the provincial economy.\textsuperscript{10}

In terms of the direct contribution of rent to provincial income and growth the results are somewhat surprising. Over the period 1919-92 forestry resource rent was a small component of provincial income measures. In addition, it made a negligible contribution to both aggregate and per capita provincial income growth. These results for the period as a whole are partially driven by the decline in forest resource rent from roughly mid-century. Even if the period during which rent was relatively largest and increasing most rapidly is isolated, rent peaked at a maximum of 11.1\% of provincial G.D.P. and 12.9\% of personal income. Forestry rent accounted directly for 5.7\% of G.D.P. growth and 11.8\% of per capita G.D.P. growth during this same period from 1940- 51.\textsuperscript{11} The conclusion which must follow is that the forest industry has made a relatively small direct contribution, as measured by resource rent generated in the industry, to aggregate income and its growth in British Columbia over most of the twentieth century.

The remainder of this chapter is organized as follows. Section 2 begins with a survey of related literature. The use of rent as a measure of the contribution of staple industries to income and growth for Canada is reviewed. Literature which estimates forest rent for B.C. is then presented in some detail. Section 3 considers the formal definition of rent. In Section 4 I estimate rent and its distribution for a firm level sample. In this section the firm level implementation of the definition of rent is discussed, followed by an introduction to the data and the sample of firms. Rent at the firm level is then calculated as the sum of three components; rent captured by firms, government and labour. The derivation of the estimates for each of these components is considered in turn before the final

\textsuperscript{10}The Copithorne [50] hypothesis has also been discounted on the grounds of higher measured productivity in B.C.'s forest industries. See Percy [140], pp.37, Denny et al [56], pp. 402- 403.

\textsuperscript{11}The corresponding figures for personal income and personal income per capita are 6.5\% and 13.4\% respectively.
firm level estimates are discussed. In Section 5 I generate estimates of rent at an industry level. The direct contribution of the forest industry to provincial income and growth is assessed using both the firm-based and industry level estimates. A concluding section summarizes the results of the chapter.

2.2 Related Literature

2.2.1 Resource Rent in the Canadian Context

One of the best known debates of Canadian economic history centers on the measurement of land rent during the wheat boom, a period of strong economic growth from roughly 1898-1913. Chambers and Gordon [40] constructed a simple general equilibrium model which showed that the induced change in agricultural land rent captured the economic contribution of this primary export boom. They proceeded to measure this change in rent and found that, contrary to the established 'staples' view, the wheat boom had little effect in increasing per capita income. One critique of Chambers and Gordon, noted in Bertram [9] and Dales, McManus and Watkins [54] was that their measure of rent was incomplete and inaccurate.\footnote{Dales et al [54] have a number of other criticisms of Chambers and Gordons' approach.} Chambers and Gordon addressed some of these claims themselves in a rejoinder (Chambers and Gordon [41]) and others (arguably) did not appear to substantively alter their claim (Bertram [9].)

Of more interest with respect to this study of forest rents in B.C. and greater consequence to the significance of their result, was criticism of Chambers and Gordons' [40] interpretation of their rent measure. Chambers and Gordon argued that the change in agricultural land rent captured the full general equilibrium effect of the wheat boom. A claim which was based on their own general equilibrium model. Critics such as Bertram [9] and Lewis [111] undermined this comprehensive aspect of Chambers and Gordons' measure by attacking the the-
oretical foundations on which it was based. The 'weak link' which bore the brunt of criticism was the inability of the agricultural sector to influence the level of wages in the economy. This was critical to the interpretation of land rent as a general equilibrium measure. In Chambers and Gordons' model, a perfectly elastic demand for labour in manufacturing, the result of perfectly elastic output demand and constant returns to scale production in labour alone, was what determined the economy-wide wage. Once the assumption of perfectly elastic labour demand was relaxed, there were additional general equilibrium consequences of the wheat boom via the wage level. Lewis [111] estimated that the wheat boom accounted for as much as 42% of per capita income growth during the period 1901-11.

It is not difficult to imagine plausible reasons why the demand for labour in an industry might not be perfectly elastic. What may not be quite so easily done is to explain why in the long run a small open economy would have rates of return to mobile factors different from those prevailing in larger markets of which it is a part. The movement in factor prices which drives the Lewis result for the wheat boom is the consequence of assumptions which restrict the movement of the factor itself. The appropriateness of using a general equilibrium model which restricts factor movements to assess the contribution of a primary export boom to regional growth in the long run is a question which requires careful consideration. If labour and capital are regionally and sectorally mobile in the long but not the short run, then the measurement of the general equilibrium effect will differ for the two time horizons. Changes in resource rent alone will

---

13 Bertram [9] attacked the whole notion of the applicability of competitive equilibrium models for empirical work. In part his objection was motivated by the contemporary inability to incorporate increasing returns as a feature of a competitive general equilibrium model. This was a theoretical weakness addressed in the 'new growth' literature (Lucas [114], Romer [148]), although unfortunately not in ways which are particularly amenable to empirical applications.

14 Lewis [111] assumed that the Canadian labour force would have remained the same size as it was in 1911 in the absence of the wheat boom, relaxed the assumption of perfectly elastic labour demand in manufacturing and generated induced general equilibrium wage effects of the wheat boom which were up to 1.7 times the size of the change in agricultural land rent.
not capture the full short run effect on per capita incomes. In the long run other factor price effects will be eroded by induced factor mobility, leaving the returns to the immobile factor as the only possible means to increase regional per capita income. The degree to which factor markets are integrated is critical to the interpretation of the general equilibrium significance of resource rent.\textsuperscript{15}

The oil boom of the 1970s renewed interest in the question of how important resource rent could be for Canadian regional development. Norrie and Percy \textsuperscript{[131], [132]} investigate the effect of rent generation and distribution for the economic development of the resource owning West and the consequences for other regions in Canada. The analysis is carried out using simulation methods intended to produce qualitative rather than quantitative results. Their results indicate that the generation of resource rent can significantly raise per capita income in a region. The distribution of this rent is important because of the consequences for regional adjustment. For example, if rent is captured by government and used to provide lower priced government services or a fiscal dividend for residents, it stimulates labour migration. This leads to extensive growth in the resource owning region. This results in lower per capita real income growth as the resource rent is spread over a larger population.\textsuperscript{16}

Another interesting result of Norrie and Percys' model is that the presence of resource rent leads to increased regional specialization in the resource industry. In their model the generation of resource rent does not lead to the development of a more diversified provincial economy unless the government captures the rent and specifically directs it to such a policy. This, however, reduces the real per capita income gains from the resource boom.

\textsuperscript{15}Another possible complication which has not been addressed in the wheat boom debate is the possibility of agglomeration or thick market externalities. If these are present, then extensive growth leads to per capita income growth. In this case, measuring the long run general equilibrium effect would become more complex.

\textsuperscript{16}This result is a function of the assumptions in Norrie and Percys' model. For example, if significant agglomeration economies are allowed, these could generate increases in per capita income sufficient to offset the dilution of rents by extensive growth.
This brief literature survey highlights some relevant points for this study of rent in the British Columbia forest industry. First, the interpretation of rent as a measure of the forest industry's contribution to provincial income and growth requires care. If we are interested in the long run contribution, assume that the B.C. regional economy is a small player in well integrated markets for mobile factors of production and do not think that spillovers or agglomeration economies are significant, then forestry rent represents the general equilibrium contribution of this resource industry to per capita income growth. Under any other circumstances the significance of the rent measure is more limited. Resource rent measures the direct contribution of the resource itself to provincial income. While this interpretation limits the conclusions which can be drawn on the basis of the rent measure alone, it still provides information about how the resource contributes to the provincial economy. Norrie and Percys' work illustrates that resource rent may play a role in explaining specialization in the regional economy. Measuring rent and its distribution in B.C.'s forest industry may help explain the evolution of the provincial economy, as well as establishing the direct contribution of the forest resource itself.

2.2.2 Returns to the Forest Industry in B.C.

Quantitative analysis of forestry rent for B.C. is relatively recent. The work of Copithorne [49], [50] is the earliest to measure the contribution of resource rent to provincial income. The primary focus of Copithorne's studies was more general, examining the role that natural resource rent plays in regional disparity in Canada. 'Windfalls' in natural resource industries were calculated by subtracting costs of labour and capital used in primary industries, valued at their opportunity costs in the manufacturing sector, from primary value added. The 'windfall' in B.C.'s forest industries, calculated as a per capita average for

17This is the implicit view of rent in Norrie and Percy [131], [132] and Percy [140].
the period 1970-73, was found to be substantially larger than for other natural resource industries. The forest industry contributed an average of $192.06 to B.C. per capita income during 1970-73. The logging industry generated $118.21 of this, while the wood and paper and allied industries combined accounted for $73.85. The rent which other B.C. resource industries, such as fishing and mining, generated did not exceed $20 per capita in any case. Forest industry rent alone accounted for 24% of the differential between average income per capita in B.C. and the Canadian average for the period from 1970-73. Copithorne's results suggest that forest industry rent makes an important contribution to provincial income.

Copithorne [50] also considered some potential consequences of rent distribution. The main point relevant to this study is the claim that unionized labour captured a significant share of forest industry rent in B.C. The supporting evidence for this view was a comparison of the average annual and weekly earnings of workers in the logging and wood industries in B.C., Alberta and Ontario. The wages paid to B.C. workers were substantially above those received by their counterparts in the other regions. This wage differential was interpreted as evidence that B.C. workers captured resource rent, given the context of the contemporary system for setting B.C. stumpage fees. The calculation of stumpage rates allowed labour costs, evaluated at the average industry wage, to be deducted from stumpage payments. In theory this permitted firms in the industry to pay higher wages on average by implicitly financing them out of stumpage payments. The overall effect of such rent capture by labour, according to Copithorne, was

---

18 These figures are net of a share of the 'windfall' which foreign capital owners were assumed to capture.
19 Copithorne [50], Table 5-2, pp. 86-87. ‘Windfalls’ from secondary manufacturing for the B.C. forest industry were included. This accounts for rent transfer within vertically integrated firms in the industry.
20 It should be noted that Copithorne emphasized that resource windfalls alone did not explain regional income disparity according to his results.
21 Copithorne [50], pp. 61-74.
ithorne [50], was inflation of the general wage level in the province. This led to high unemployment (migration was induced by the higher wages, but union control restricted employment opportunities) and contributed to making alternative manufacturing industries uncompetitive in B.C. relative to other regions. Whether or not labour captured a significant share of rent in the industry is crucial to the relevance of this view.

Percy [140] also measured forest rent generated in B.C.'s forest sector and investigated who captured it. This was part of a more comprehensive study which applied computable general equilibrium modeling to examine the role of the industry in the provincial economy. The study updated Copithorne's work, providing estimates of rents in B.C.'s logging and total forest industries for 1979. The results indicated that there was substantial rent in both industries. Government captured approximately 60% of the rent in logging, but only 40% of rent in the industry overall. Possible explanations for the lower share of rent captured when the industry was considered more broadly were: the use of transfer pricing in integrated forest product firms; collusive behaviour in the setting of log prices in the Vancouver log market; and leakage of rent into wages due to the stumpage system in place. Percy noted that rent measures the sole long run contribution of the resource to intensive (or per capita) income growth for a small open economy.

Schwindt and Heaps [152] have taken up the measurement of the role of the forest industry more recently. In this study the authors examined the 'wealth' which the sector generates and its distribution. They calculated net returns to the Crown, labour earnings and returns to capital for the period 1982-1994.

---

22 The general nature of the effect was attributed to the role of the forest industry in setting the pattern for other unions in the province. See Copithorne [50], pp. 61-74.
23 Percy [140], Table 4-6, p.39
24 Percy [140], pp. 45.
25 Results are presented in Schwindt and Heaps [152] Table 2.8, pp.46; Figures 3.9-3.11, pp. 58-59; and Figure 4.7, pp.84 respectively.
The study also considered some of the possible rent leakages suggested in the earlier literature. To examine the 'rent in wages' theory average weekly earnings in the forestry, wood products and pulp and paper industries were compared with average weekly earnings in all 'goods producing' industries for Canada. The results showed that labour in the wood industries did not earn substantially higher wages, while forestry workers earned roughly a 10% premium and those in pulp and paper a 20 – 30% premium. The authors did not view this as significant evidence of 'rent in wages' on the basis of suggested skill differentials. The possibility that firms captured some rent was also considered and rejected on the basis of a comparison of rates of return between B.C. forestry firms, Eastern Canadian and U.S. forestry firms and government bonds. The authors did not rule out the possibility that some firms may have been capturing rents. Their calculations indicate that the Crown failed to capture any rent before 1987. If the net rent collected by the Crown is indeed a measure of the direct contribution of the industry to the provincial economy during the period, then the contribution was very small.

The studies above represent the efforts to assess the contribution of forest resource rent to the provincial economy quantitatively. Another vein of research measures forest rent in B.C. with the objective of determining the adequacy of government stumpage charges. This focus is largely the result of trade disputes between B.C. and U.S. Pacific Northwest producers who claim that the B.C. industry is effectively subsidized through stumpage rates which are set too low. Haley [81] examined this issue by looking at stumpage rates for comparable timber in B.C. and the Pacific Northwest. While he found that values were lower for B.C., there are a number of differences between the two stumpage systems which confound a direct interpretation of the results in terms of rents collected.

26 See Schwindt and Heaps [152], Figure 4.10, pp.87.
27 See Schwindt and Heaps [152], pp.48. In making this assessment, the authors net out forestry related government expenditure from total rent collected.
In general, this approach must focus on the specific characteristics of timber on which the stumpage is appraised and include consideration of heterogeneous costs in terms of road building, transportation, etc. For the purposes of investigating the pattern of rents in the industry over an extended period of history this approach is not feasible.

Grafton and Nelson [77] measure aggregate rent for the wood industry and compare it with the revenue collected by the government in a recent investigation of this issue, rather than directly comparing stumpage rates like Haley [81]. A series of rent was generated for the period 1970-94. The conclusion of the authors is that the government was quite successful at capturing measured rent; in fact too successful. Particularly during later years of their sample the authors found that the rent the government collected actually exceeded the total rent which the industry generated. On the basis of these findings they suggested that the current stumpage system was not sufficiently flexible. There was nothing in their evidence to indicate that the industry was being subsidized by low stumpage. They do not address broader questions about the significance of the measure of rents which they calculate. The starting point for their work was an assumption that the forest industry plays a crucial role in the provincial economy.

As this brief review indicates, nothing is known quantitatively about rent generated by B.C.’s forests before 1970. More recent results drawn from the literature which focuses on measuring the impact of the industry on the provincial economy are for short time periods (Copithorne [49], [50], [140]) or use only relatively modern data (Schwindt and Heaps [152]). In addition, the results which are discussed above point to different conclusions. While Copithorne [49], [50] finds that forest industry rent makes a substantial contribution to provincial income per capita, Schwindt and Heaps’ [152] results imply the opposite. These conflicting results pertain to different time periods, so there is nothing inherently wrong with this discrepancy. Consequently, however, it is not possible to
draw a general conclusion about the importance of forest industry rent for the provincial economy from the existing work. As noted in the introduction, incomplete and inconsistent aggregate data frustrate the easy generation of longer time series for forest industry rent. In order to gain a complete and accurate historical perspective on the broad questions raised in this chapter, such long term evidence is required.

2.3 Forest Resource Rent: Theoretical Framework

Resource rent is conventionally defined as the return earned by natural resources which are necessary factors of production for resource goods. This is the definition of forest resource rent adopted in this paper and it is the standard definition applied in the literature discussed in Section 2.2. It is, however, somewhat limited in its focus on the production uses of forests. A true measure of the social value of the resource would consider additional factors, such as aesthetic or environmental values. The measure of rent I use refers to the value of B.C.’s forests only as commercial timber. It captures the direct contribution of forests to provincial income and growth through the industrial exploitation of the resource. A more comprehensive historical measure of the value of the province’s forests is beyond the scope of the current work. Given that many of the alternative uses of forests are in direct conflict with the industrial exploitation of the forest, the current measure likely overstates the welfare contribution of the forest industry in British Columbia.

The rent on a unit of timber, also known as its shadow value, is determined by the value of the output which it produces and the costs of harvesting it. A factor which makes natural resources unlike many other inputs is the dynamic connection between the choice of how many units to use today and the availability of the resource for future production. When deciding how many hours of labour input to hire, a producer does not need to worry that employing
labour today will affect the number of hours employees have available to work tomorrow.\textsuperscript{28} A forestry firm does face such an explicit dynamic tradeoff. By cutting timber today it reduces the potential supply in the immediate future. Forest industry firms should take this into account when making production and harvest decisions. A simple stylized model of the forest industry illustrates how this dynamic effect influences the value of rent and how the definition of rent is arrived at.\textsuperscript{29}

Suppose that firms in B.C.’s forest industry do not have price setting power in the world market in which they sell most of their output, so that they take prices as given exogenously. Firms then choose a harvest level in each year which maximizes the present discounted value of their profits over an indefinite horizon. When making this output choice, firms recognize the dynamic connection between current and future harvest decisions through the evolution of the resource stock.\textsuperscript{30} Mathematically we can represent this problem as follows:

\[
\max_q \int_0^\infty e^{-rt}[P(t)q(t) - C(q(t), S(t))]dt
\]

subject to

\[
\dot{S} = f(S(t)) - q(t)
\]

where \(P(t)\) is the price of output at time \(t\), assumed exogenous; \(q(t)\) is the resource harvest at time \(t\) chosen by the firm; \(C(q(t), S(t))\) is the total cost of harvest to the firm, modeled as a function of the current harvest, \(q(t)\) and the level of the stock, \(S(t)\); and \(S(t)\) is the resource stock, which grows naturally

\textsuperscript{28}This analogy assumes a competitive labour market.

\textsuperscript{29}The typical problem in forest economics is deciding when to cut a tree or a stand of even aged growing timber. The consideration of this problem and other issues related to the age-class structure of the stock are abstracted from by using a general growth function in the stylized model. This permits a more transparent examination of the determination of resource rent. Forestry firms in B.C. have generally harvested indigenous forests (rather than managed forests) by the method of clear cutting. Historically it may be more accurate to model these firms as making the decision of how much of their growing stock to harvest in each period, rather than at what age to harvest individual trees, stands, or ‘crops’ of timber.

\textsuperscript{30}An underlying assumption is that firms have well defined property rights to the stock of timber.
Harvesting costs are an increasing function of current output, \( C_q > 0 \) and a decreasing function of the stock size, \( C_S < 0 \). The first condition simply states that costs rise with output. The second condition represents a depletion effect. As the stock of timber is reduced, the costs of harvesting are increased. In British Columbia the forest industry has progressed from harvesting mature 'old growth' stands in river valley bottoms to drawing on less heavily timbered, more remote stocks at higher elevations. The depletion effect in the model captures the increase in harvesting costs which accompanies such a transition.

The problem above is reformulated as a current value Hamiltonian:

\[
\max_q H = Pq - C(q, S) + \lambda[f(S) - q] 
\]

(2.3)

where \( \lambda \) is the shadow value of a unit of the resource stock. Solving the maximization problem leads to the following system of necessary conditions:

\[
H_q = 0 \Rightarrow P - C_q(q, S) - \lambda = 0 
\]

(2.4)

\[
\dot{\lambda} = r\lambda - H_S \Rightarrow \dot{\lambda} = r\lambda + C_S(q, S) - \lambda f'(S) 
\]

(2.5)

\[
H_{\lambda} = \dot{S} \Rightarrow \dot{S} = f(S) - q 
\]

(2.6)

From Equation 2.4 we can see that the shadow value of the resource, \( \lambda \), is determined by the value of the output it is used to produce and the cost of harvesting it.\(^{33}\) Resource rent as it is defined in this model is a marginal concept. The shadow value of the \( q \)th unit of the resource is the difference between the marginal revenue generated and the marginal cost of harvesting that unit.\(^{34}\)

\(^{31}\)The growth function \( f(S(t)) \) is assumed to have the 'standard' properties. Growth is an increasing function of the stock size up to a certain point and decreasing thereafter. There is a finite level of the stock which could be sustained in the absence of human intervention in the ecosystem.

\(^{32}\)The variables continue to be functions of time as indicated in the original specification, however the explicit time dependence is suppressed from this point for expositional clarity.

\(^{33}\)Equation 2.5 implies that an optimally managed firm chooses its output such that the shadow value appreciates at a rate which is comparable to that on other assets.

\(^{34}\)The assumption that B.C. forest firms are price takers in the output market implies that marginal revenue is equal to average revenue, or the exogenously given output price.
This rent is a function of the level of the resource stock through its effect on marginal costs. The firm chooses the sequence of harvests so that the rent on the marginal unit appreciates at a rate of return (net of natural growth and the depletion effect) which is equivalent to the return on other assets. The shadow value of the marginal unit is equivalent to the value of a standing tree in the forest. The dynamic condition implies that the value of the standing forest as an asset should appreciate in a way which provides a rate of return equivalent to other assets.

The model above clarifies the definition of rent as a marginal concept and shows how the dynamic interaction between the current harvest and the evolution of the stock enters the firm's decision problem. Unfortunately this marginal measure alone cannot help to answer the empirical questions this chapter raises. One problem is that there is no empirical equivalent to this measure of rent. There are no perfectly competitive markets in which the forest resources of B.C. are traded, which would generate a 'market price' for timber equivalent to the theoretical marginal rent measure.\(^{35}\) A more significant shortcoming is that the shadow value of the marginal standing (or harvested) unit of timber need not tell us anything about the magnitude of total rent generated by the annual harvest of timber. This aggregate measure of the income implicitly generated by the resource itself is the value which can be used to assess the direct contribution of the resource to provincial income measures. Fortunately the definition of rent in the model above leads to a theoretically consistent measure of this aggregate resource rent.

Consider the case of a single firm. The model above implies that the rent generated on each unit of timber which the firm harvests is equal to the difference between the price of the output it generates and the marginal cost of harvesting

\(^{35}\)While access to timber has been awarded through competitive bidding at some points in B.C.'s history, timber is not generally allocated in this way.
that unit. The marginal cost need not be the same for each unit the firm harvests, so in principle the rent generated on each unit of timber harvested may be different.\textsuperscript{36} Suppose we want to know the total rent generated by a firm’s harvest during a specific period, a year of operation. If the firm’s annual output is given by $\bar{q}$, the rent on the $q$th unit is given by $P - C_q(q, S)$ and the firm begins the year with no output produced, then the annual rent generated will be given by the following:

$$r = \int_0^{\bar{q}} P - C_q(q, S) dq$$  \hspace{1cm} (2.7)

This is simply the following:

$$r = P\bar{q} - C(\bar{q}, S)$$  \hspace{1cm} (2.8)

where $r$ is the firm’s annual aggregate resource rent and other variables take their previous definitions. In other words, the total resource rent the firm realizes on the $\bar{q}$ units which it harvests during the year is given by the difference between the firm’s total revenues and total costs.

It is not difficult to see how the annual aggregate resource rent generated by the industry (the sum of the rents generated by all the firms in the industry) is similarly defined as the difference between total revenues and total costs at the industry level.

$$R = P\bar{Q} - C(\bar{Q}, S)$$  \hspace{1cm} (2.9)

where $R$ is the annual forest industry rent aggregate, $\bar{Q}$ is the annual output of the B.C. forest industry and the other variables are as previously defined. This is the definition which Copithorne [49], [50], Percy [140] and Grafton and Nelson [77] apply in their measurement of industry level forestry rents for British Columbia. It is the definition which I also use to measure resource rent realized

\textsuperscript{36}In fact the condition which would insure that the rent on each unit is the same (marginal cost equal to average cost) would make it impossible for the firm to choose its output level to satisfy Equation 2.5, the second first order condition.
through the operation of the industry. In practice there are still some details to
attend to in implementing this definition empirically, but these are dealt with
in the following sections.

2.4 Measuring Forestry Rent at the Firm Level

As mentioned previously, it is impossible to generate a time series for forest
rent with only existing industry level data. In this section I use a sample of
firms to investigate the evolution of the level and distribution of forestry rent. I
also generate estimates of the resource’s direct contribution to provincial income
with the firm level measures of rent.

2.4.1 Defining Rent at the Firm Level

A general definition for total forest rent generated by a firm in the B.C. forest
industry is derived in Section 2.3. In practice, a number of practical difficulties
prevent this definition from being implemented empirically exactly as it is given.
Some of these complications are applicable at both the firm and industry level,
while others are peculiar to the firm level estimates of this section. The general
complications which must be addressed in order to calculate rents at the firm
level are discussed below.

The first problem is in the nature of the data which are available at the
firm level. Generally, these data are found in companies’ annual balance sheets
and income statements. It is uncommon for a detailed breakdown of costs to
be part of these data sources. One reason this is an issue is because a firm
itself regards government timber charges as a cost of operation, but from the
point of view of determining the resource rent which the firm generates they
are not a relevant cost. Another reason why the absence of a cost breakdown
is problematic is that payments to labour may include a share of the rent the
firm generates. If unions successfully negotiate high wages which firms finance
out of stumpage payments, then the cost for labour which a firm includes as an undisclosed part of its income statement costs is not appropriate from the point of view of measuring rent. Essentially, the data from the firm level sources provide an estimate of the rent which a firm itself retains. In order to estimate the total rent which a firm generates, the rent which government and labour capture (which is netted out of the firm's data) must be estimated and added to the rent the firm retains. More formally, the total rent any B.C. forest industry firm, $j$, generates is given by the following:

$$r_j = f_j^f + r_j^l + r_j^g$$

(2.10)

where $f_j^f$ is the rent retained by firm $j$, $r_j^l$ is the rent firm $j$ generates which is captured by its labour force (presumably through high union wages), and $r_j^g$ is the rent firm $j$ generates which the government collects through various timber charges. I separately estimate each component of the rent which a firm generates. Each component is considered in more detail in the following sections.

Another complication in applying the definition of rents empirically is the degree of vertical integration of firms in the B.C. forest industry. In theory, resource rent is generated at the primary stage of converting the resource from its natural state to a resource good. In the case of the B.C. forest industry, this means that resource rent should only be generated by the logging industry. Both Copithorne [49], [50] and Percy [140] raise the point that the degree of integration in the B.C. forest industry may make this too narrow a basis for measuring resource rent. One complication is that the cost of stumpage charges for the coast industry depended on the price at which logs traded on the Vancouver log market until 1987. This market was dominated by a relatively small number of integrated forest companies. By colluding, depressing the apparent price of logs and transferring profits to other divisions of their operations, firms could reduce
the share of rent which they paid to the government as stumpage.\textsuperscript{37} Transfer pricing in integrated firms also allows firms to avoid a provincial logging profits tax of approximately 4\% (net) applicable since 1953.

Archival records for the Victoria Lumber Company indicate that transfer pricing may predate these concerns. The records from the Victoria Lumber Company show that logs which the company harvested itself were charged to the sawmill, shingle and lath accounts of the company at the cost of production recorded in the log accounts. This practice is apparent from 1913, well before the logging profits tax was a factor. The cost of logs purchased from independent contractors was often significantly higher than the cost of the logs which the company harvested itself even though all logs were being harvested from roughly the same area. To accommodate the possibility of transfer pricing, rent is assessed for integrated firms and the sample reflects not only logging, but all aspects of the forest industry in British Columbia.\textsuperscript{38}

2.4.2 Firm Level Sample

Before calculating forestry rents at a firm level, it is useful to briefly consider the nature and sources of the firm level data and introduce the sample firms in some detail.

Firm Level Data

The firm level data set consists of information obtained from annual reports, income statements, balance sheets, tax records and other archival material for eight B.C. forest companies. Most of the data are taken from firms’ corporate

\textsuperscript{37} For a discussion of this issue, see Pearse [137], pp. 32-64.

\textsuperscript{38} All of the rent which is captured by the sample firms is attributed to the resource. If there are firms in the sample which captured rent by exercising market power, or through some other means, then this rent will mistakenly be considered resource rent. In this sense, the estimate of rent for each firm is an upper bound on the true resource rent generated by the firm.
balance sheets and income statements. The largely financial data are supplemented with data on production capacity, number and distribution of employees from the *ABC Lumber Trade Directory* [85]. The data, like the financial data are self-reported by the firms. Unlike the data from firms' annual reports (once the companies are publicly traded) figures published in the directory are not subject to an independent audit. I use data from the *ABC Lumber Trade Directory* [85] only when the corresponding data are not available as part of a firm's own records.

The individual sources include a relatively standard set of variables. *Operating profits* are reported as part of the income statement and generally defined as total revenue from sales, less total costs of production. Timber charges are often included in these production costs. *Net income*, which also appears on the income statement, is a little less standard across companies. In general, net income adds other income (such as interest or exchange) to operating profit and subtracts other nonproduction costs. These costs routinely include interest paid on corporate debt, depreciation (of plant and equipment), depletion (of the firm's forest assets) and taxes. Occasionally timber charges are reported separately as 'other costs' rather than incorporated in operating costs. While other variables may appear in a firm's income statement, the variables above are most relevant to this study and the most frequently encountered. I use firms' balance sheets to obtain data on fixed assets. The *Value of Fixed Assets* is a balance sheet category which either includes only plant and equipment, or reports on fixed assets more broadly. Land and timber reserves are the most common additional assets. The value of plant and equipment is generally reported both

---

39 I obtain some of these data from records reproduced in *Moody's Manual of Industrials* [127] and *Poor's Manual of Industrials* [142].

40 Costs associated with timber harvesting, such as timber license fees, stumpage, etc. are much more commonly netted out of operating profits and are rarely reported separately in the income statement. Even when the charges are reported separately, these are not broken down into fixed (i.e. license fees) and variable (i.e. stumpage or royalty) components.
as a gross (at cost) and net (less depreciation) figure. This allows a depreciation rate for the firm’s fixed assets to be calculated.

This discussion of the firm level data sources indicates that there is some variation in the reported data. Constructing standardized measures for the variables of interest requires a myriad of small adjustments. For example, since the opportunity cost of capital is constructed in a standardized way based on the value of each firm’s fixed assets, using a firm’s net income figure which nets out interest payments would result in double counting part of the capital cost in the calculation of resource rent. Similarly, income from the company store, which net income figures often include during the early years of the sample, is probably not relevant to the measurement of resource rent. The data adjustments are usually straightforward and immediately obvious with limited observation of the sources for each firm. The only adjustments which are specifically noted are those which the reader would not find readily apparent from the data sources given the general discussion in this chapter.

The firm level estimates of forest rent do not require any data from the firms’ balance sheets related to the value or depletion of timber as a fixed asset of the firm, however, it seems that these data should still provide information of interest. In fact, these data are of questionable quality and significance. The principle reason for this is that the balance sheet value for timber assets is not calculated in a standard way by firms. Sometimes the figures are reported specifically as at cost and less depletion. Even in this case, the measure is not clearly defined as there is no obviously standard method for evaluating timber depletion charges. If a firm’s timber assets are not reported explicitly as at cost, it is unclear how the value is determined. Archival material for MacMillan Bloedel suggests that

---

41 A case might be made for including this income if firms use the monopoly supply power represented by a company store as a way to reclaim resource rent which labour captures via union bargaining power. While this might be interesting to investigate, it is well beyond the scope of the current work and would not alter the results of this study in any substantive way.
they valued their timber holdings by multiplying the estimated volume in their stands by the current assessed stumpage rate.\textsuperscript{42}

The Victoria Lumber Company provides a revealing example of the unreliability of firms' timber asset data. Between 1914 and 1921 the firm reported negative values for its timber asset, even though they possessed timber land of relatively homogenous and high quality and had exhausted only a fraction of the total volume they estimated their stands contained.\textsuperscript{43} This was a result of the practice of subtracting timber charges and expenses and a large depletion cost (based on an arbitrary, high 'stumpage' rate applied to the annual cut) each year from the original purchase price of timber holdings. In 1922, the company reinstated its timber as an asset, valuing it at $5.472 million dollars, compared with $−1.327 million in 1921.\textsuperscript{44} The company continued to calculate depletion in the same way, subtracting it from the value of the timber asset and from operating profits. Part of the reason the company went into voluntary receivership in 1944 was to avoid paying back taxes on a substantial portion of this 'depletion' cost, which tax authorities deemed to be undisclosed profit.\textsuperscript{45}

Sample Firms

Data availability constrains the sample size, nevertheless the sample is a relatively good representation of the provincial industry.\textsuperscript{46} The main components of the forest industry are all represented; the Logging, Wood and Paper and Allied Industries. The sample firms represent a significant share of the industry.

\textsuperscript{42}This is based on estimates for 1950 which are part of a document related to the merger of Bloedel, Stewart and Welch and the H.R. MacMillan Co; Bloedel, Stewart and Welch files, H.R. MacMillan fonds, U.B.C. Archives.

\textsuperscript{43}The company records contain precise annual estimates of the timber stand, adjusted for any purchases or sales and the cut in each year.

\textsuperscript{44}Victoria Lumber Company, Timber Accounts, Humbird Family fonds, U.B.C. Archives.

\textsuperscript{45}Auditor's Report, Humbird Family fonds, U.B.C. Archives.

\textsuperscript{46}Resource constraints limited the number of firms for which records were obtained. Provincial Archives appear to contain records which would allow a few more firms to be added to the sample. Unfortunately these are geographically too far flung to be added at present.
The location of the firms matches the main source of production for most of the sample. Firms are integrated, which is typical. The data set is not a truly representative sample of the firms operating in the province's forest industry over the period because it does not include the records of very small enterprises, or interior operations for the latter part of the sample. The lack of representation for the interior is not critical until after the 1960s as up to this point the industry was dominated by coast production. While the lack of records for small operators is unfortunate, these are extremely difficult to locate. The shortcomings of the data in terms of their representativeness probably lead to an upward bias in terms of the projected industry level figures. It seems unlikely that small operators competing for timber, or firms operating in marginal regions would earn higher rent than established firms which secured rights early to accessible, high quality timber.

The firm level sample is an unbalanced panel. Data are not available for all companies in each year. The full panel spans the period 1906-1976. The starting point is the earliest year for which data were obtained. The end point requires a bit more explanation. The primary objective of this chapter is to assess the direct contribution of the forest industry to the provincial economy. Firm level data are used largely to fill in gaps due to inadequate aggregate industry data. Provincial industry level data are readily available from 1970. Examining the records of firms to the present might be interesting, but it is not necessary. In addition, firms operating in B.C. have become increasingly multinational. It is much more difficult to obtain data from firms which represent only their operations in British Columbia. As the firm level estimates are used to derive implications for the industry, a period of overlap with industry level estimates is useful. The end point of the firm sample data coincides with the Pearse Royal Commission of Inquiry into B.C.'s forest industry.

The main details of the firm level data set are summarized in Table 2.1. All
of the firms are located in the Coast region of the province, with the exception of the Columbia River Company which is in the Interior. I will briefly introduce each of the firms in more detail including the sources for the data.

The Victoria Lumber and Manufacturing Company of Chemainus, Vancouver Island is distinguished by having records which date back to 1906, the earliest year of the sample. The company was established in 1889 and acquired a large stand of mature Douglas fir (Pseudotsuga menziesii) from the Esquimalt and Nanaimo Railway lands, which was estimated to contain over two billion f.b.m. of timber. The company operated both a saw and shingle mill and had an extensive logging railway system. The company was one of the larger operations in the province during its sample years. It produced output for local, Canadian, U.S. and overseas markets. The enterprise represented 2% of the province’s sawmilling capacity, approximately 6 times the average capacity.\footnote{\textsuperscript{47}Capacity data are obtained from the \emph{ABC Lumber Trade Directory} \cite{85} and the Ministry of Forests \emph{Annual Report} \cite{13}.}
An incomplete set of the company's annual reports supplied the data, which were available from 1906 to 1935. Some additional data were obtained from the Humbird Family fonds. This American family controlled the enterprise for the duration of the sample. The company continued to operate independently until 1944 when it went into voluntary receivership. The company was purchased by the H.R. MacMillan Company in 1946 so its operations are reflected in the data for MacMillan Bloedel after this point. The company records consist of standard financial data, as well as much more detailed records on production and costs for various phases of operations.

The Canadian Western Lumber Company's records date back to 1913, three years after it was incorporated. During the years for which its data are available it was one of the largest operations in the province both in terms of its productive capacity and the number of employees. In 1920 it accounted for 5% of provincial sawmilling capacity. It was one of only five establishments in the province employing close to one thousand employees. The company had access to substantial timber reserves, over half of which were Crown granted lands. All the company's timber holdings were accessible to salt water and well timbered, making them high quality stands. The company also had a large sawmill on the Fraser River, at Fraser Mills, with extensive waterfront available for ocean going vessels. The company produced a range of goods, including lumber, shingles, lath, mouldings and doors. The data for this firm were obtained from Moody's Manual of Industrials [127] and Poor's Manual of Industrials [142] for various years. The data begin in 1913 and continue up until 1953, at which point the company was purchased by Crown Zellerbach. It is included in the operations of the Canadian subsidiary, Crown Zellerbach Canada, from 1955 on. Data are missing for the years 1923-1924 and 1939-1940. Again the data include stan-

---

48 Data are from The ABC Lumber Trade Directory [85]. The Canadian Western Lumber Co. had 900 employees in 1920. While there were larger companies, the vast majority of operations in the province at that time were an order of magnitude smaller.
standard financial variables from the company’s income statement and balance sheet. Data are also available on lumber production (1913-1935) and sales (1913-1945).

The Columbia River Lumber Company is one of the few interior operations for which data are available. It was associated with the Canadian Western Lumber Co. and after 1926 data are not available for the Columbia River Co. as a separate operation. The company was incorporated in 1911, however data are available only from 1913. The company operated out of Golden, B.C. and served the Canadian market. The company had access to approximately 62,000 acres of timber. 40% of this land was Crown granted land, the remainder was held under license from the Province. The operation was moderately large. The company accounted for approximately 2% of provincial sawmilling capacity. The firm had 350 employees in 1920, a number which was fairly large relative to other firms in the province, particularly those in the interior region. The data for the company are reproduced in various volumes of Moody’s Manual of Industrials [127] and Poor’s Manual of Industrials [142]. They include standard financial data from the company’s annual Income Statements and Balance Sheets. The data for 1923-1924 are unavailable. This lack of data is likely because a strike disrupted the firm’s operations during these calendar years.

The firm of Bloedel, Stewart and Welch was one of the oldest logging operations in B.C. During the early years of operation, the company was exclusively involved in logging, however it soon established a number of milling operations. The company operated a lumber mill at Great Central Lake and Port Alberni, as well as its Red Band Shingle Mill. In addition, the company had major logging operations on Vancouver Island. Over the period for which I have data the company continued to grow, expanding the size of its logging operations, as well as opening another shingle mill and a pulp mill. The company merged with the H.R. MacMillan company in 1951, so its operations are represented in the data

---

49 Data on employees are from The ABC Lumber Trade Directory [85].
for MacMillan Bloedel after that point. The data for Bloedel Stewart and Welch come from archival records which include an incomplete series of annual reports covering all the operations of the company, tax records for selected years, summary tables of financial data and annual reports for the initial logging division of the company. From 1940 on the data are extremely detailed, outlining the cost components of each of the company's operations separately, as well as the revenue generated. Detailed records of this type extend back to 1925 for the Bloedel logging division. The standard financial data series are complete from 1918 to 1951.

The B.C. Pulp and Paper Company was incorporated in 1925, when it took over the assets of the Whalen Pulp and Paper Company. Data, which are obtained from various issues of Moody's Manual of Industrials [127] and Poor's Manual of Industrials [142], are available from 1926 to 1949. At this point the company was acquired by Alaska Pine and Cellulose. Over the sample years, the firm was one of the largest pulp producers in the B.C. forest industry. It operated plants at Woodfibre, Port Alice and Swanson Bay. The company also had a relatively large lumber and shingle production capacity, approximately 2% of the provincial total in 1920. The company was one of the largest employers in the province, with a work force of over 1300 in 1920, including 300 employed in the company's substantial logging operations.\footnote{Firm data for capacity and employees are obtained from The ABC Lumber Trade Directory [85].} The B.C. Pulp and Paper Company had access to approximately 155,000 acres of timber, most of which was held under lease from the province. The data available again include standard financial variables from the company's annual Income Statements and Balance Sheets.

The Powell River Company was incorporated in 1911 and it became one of the largest pulp and paper operations in the province. The data for this company
are obtained from an incomplete series of annual reports. The sample covers
the years 1943 to 1958, at which point the company merged with MacMillan
Bloedel. Access to the Annual Reports yields data on not only the financial
variables in the Income Statement and Balance Sheet, but also on production,
number of employees and wage costs. The company data include the operations
of subsidiary logging and lumber manufacturing operations, but the bulk of the
company’s business is in the production of newsprint and pulp. The Powell
River Company, at 900 tons per day in 1950, had twice the capacity of its only
significant provincial rival in newsprint production, Pacific Mills. It also had a
respectable pulp production capacity, although it was dominated in this respect
by the B.C. Pulp and Paper Co.\footnote{Again, capacity comparisons are made
on the basis of data reported in \textit{The ABC Lumber Trade Directory} [85].} The company was a large employer, and
had close to 2000 employees in 1950. The company had access to substantial
timber reserves, estimated to contain over 4 billion f.b.m. of merchantable saw
timber.\footnote{This information is obtained from descriptive material in \textit{Moody’s Manual of Industrials}
[127] for 1937. It is not clear what is meant precisely by ‘merchantable saw timber’ or how this
estimate relates to the company’s total timber holdings. Data are available on the estimated
value of the company’s timber from the annual reports, but not the quality (i.e. saw timber vs
pulpwood) or volume.}

The name MacMillan Bloedel is familiar to even casual observers of the
forest industry in B.C. This firm which became an industry ‘giant’ originated
in 1919 as the H.R. MacMillan Export Company. In the company’s infancy,
it was largely in the business of selling other people’s lumber and produced
little of its own. This situation soon changed as it rapidly began to acquire
other operations, eventually of a very large nature. By 1935, the company
possessed a number of sawmills and an 18,000 acre stand of Douglas fir on
Vancouver Island.\footnote{Drushka [60], pp. 176-177.} Eventually the company became truly integrated, with
major operations in logging, sawmilling, pulp and paper production, plywood
production and a range of other specialty products. The data for the various incarnations of MacMillan Bloedel are obtained from annual reports. Standard financial variables are obtained from the Income Statements and Balance Sheets, and additional data on output, sales, employees, labour costs etc. are also available. The data are available continuously from 1945.

Crown Zellerbach is another familiar name in the modern forest industry of B.C. The Canadian subsidiary, Crown Zellerbach Canada is one of the firms included in this sample. This firm's origins can be traced to the Ocean Falls Pulp and Paper Company, which was incorporated only in 1914 after being taken over as Pacific Mills. The name Crown Zellerbach Canada was adopted in 1954. At this point, the company absorbed the Canadian Western Lumber Co. and the Elk Falls Company and data for its operations after 1954 reflect this change. Crown Zellerbach Canada, like MacMillan Bloedel was an extremely integrated operation. It owned access to substantial timber reserves, over 5 billion f.b.m. were owned, or held under timber licenses or pulp leases in 1954. The company produced a wide range of products, from lumber to newsprint, pulp and paper products such as tissues and fibre containers adapted for use in B.C.'s packing industries. The company was a large employer, with a work force of over 5000 in 1956. Data for the firm are obtained almost entirely from Annual Reports, although data for 1954-1955 are from Moody's Industrial Manual [127]. The data are available continuously from 1954 to the sample endpoint. Variables include both standard financial data from the Income Statements and Balance Sheets, as well as output, number of employees and wage costs. This concludes the review of the firms in the sample and the data involved.

54 Company Annual Report, 1958
2.4.3 Rent Captured by Firms

In this section, I calculate the resource rent retained by the sample firms. This is the first of the three potential components, identified in Section 2.4.1, of the total resource rent a firm generates.

The resource rent which a firm itself retains is defined as the difference between the revenue the firm generates through the sale of the resource good and the costs of production. These production costs are those the firm itself faces and can include payments to the government for timber, or rents transferred to labour through high wages. More formally, the rent retained by a firm, \( j \), is defined as follows:

\[
r_{j}^f = PQQ_j - w_l_j - ik_j - P_M m_j - P_V v_j - T_j
\]

where \( PQQ_j \) is the firm's total revenue from the sale of the resource good, \( w_l_j \) is the firm's labour cost (including wages and benefits paid by the firm), \( ik_j \) is the cost of capital to the firm (including opportunity cost and depreciation), \( P_M m_j \) is the cost of materials purchased by the firm, \( P_V v_j \) is the cost of services purchased by the firm (including implicitly purchased services, such as transportation supplied by the firm) and \( T_j \) is the timber related payment to the government, including both fixed (i.e. license) and variable (i.e. stumpage or royalty) payments. The consistent operating cost figures I construct for all the firms represent the difference between the firms' resource production revenues and all the above elements of costs except for the capital cost component.\(^{55}\)

The opportunity cost of capital is measured by the rental cost of the capital, which I calculate using the ten year corporate bond rate adjusted for expected inflation with the wholesale price index.\(^{56}\) A depreciation charge of 5% annually

---

\(^{55}\)The only adjustment which requires noting here is the addition of the 'stumpage' figures for the Victoria Lumber Co. to its operating profit. These are not government timber charges, but the company's own depletion charges as previously discussed.

\(^{56}\)One potential difficulty is determining how to measure expected inflation. One simple
is added to the rental rate to yield the cost of capital to the firm.\textsuperscript{57} Subtracting
the capital cost from operating profit generates the aggregate resource rent a
firm retains. This can be conceptualized as a return to the firm over and above
the opportunity cost of its capital. In this sense, the firm earns an 'excess'
return.\textsuperscript{58} This facilitates comparison between firms. The rent the firms retain
is also expressed in real levels.\textsuperscript{59}

While the rent the firm retains is only one piece of the puzzle, there are
still some interesting results to note. First consider the real level of rent the
sample firms generate in each year, shown as the series 'firm rent' in Figure 2.4-
Figure 2.11. Even the most casual glance at the data indicates that the rent
which firms retained was extremely volatile. There are significant fluctuations
in the series for all companies and during all periods. Comparison between the
firms suggests a temporal pattern. Rent was low on average and did not display
any obvious trend before W.W. II, after this point it rose. This relative growth
in real rent is particularly apparent for firms with data spanning both periods
such as Bloedel Stewart and Welch (Figure 2.7) and the Canadian Western
Lumber Co. (Figure 2.6). The data show both the shift in the apparent trend
in rent and also illustrate the marked increase in the level. From 1940 rent was
always positive, with the exception of 1972 and 1975 for MacMillan Bloedel. In

\textsuperscript{57}Depreciation charges from the firms' income statements and changes in the depreciation
reserves in the balance sheets are used to calculate estimates of the depreciation rates observed
in the data. These range from a low of roughly 3% to a high of 6%, but average close to 5%
anually across the sample. This standard rate is applied to all firms.

\textsuperscript{58}It is assumed that capital is the factor of production the firm owns. The annual excess
rate of return is calculated for each firm as the rent it retains in current dollars as a proportion
of the current value of its capital stock in each year.

\textsuperscript{59}The nominal annual series are deflated using the Canadian G.N.E. deflator. There are no
suitable provincial deflators which would span the full sample period.
the earlier period, negative rent was observed for all firms at some point. This indicates that rent capture by firms was a much more important aspect of the industry after W.W. II. Before 1940 it was a very uncertain business.

As mentioned, rent retained by the firms was highly variable from year to year. Much of this volatility is correlated across firms. For example firms share common periods during which they earned negative real rents, in 1914, 1921, the Great Depression and 1938. Fluctuations in rents also show a high degree of correlation in the postwar era. The timing of the movements coincide with business cycle fluctuations. Major macro-level events, such as the onset of the world wars, the deflations of 1921 and the 1930s and the first OPEC oil shock are apparent in the data. This suggests that common factors may be driving the fluctuations in firms' rent. I will investigate this possibility in greater detail in Chapter 3. The fact that lumber, a major output of the forest industry, is essentially an investment good may help to explain why business cycle fluctuations are so prominent.

The series generated for excess rates of return to capital employed in B.C. forestry firms are shown in Figure 2.12. An immediately striking feature of these series is the presence of relatively large positive values. It appears that at least in some periods, firms were able to capture resource rent through their operations. Excess rates of return were frequently greater than 10% and in some instances exceeded 50%. The volatility of the industry may be such that the implicit risk premium in the corporate bond rate is too low. In this case, part of what appears to be rent capture may be compensation for risk. The relationship between risk factors and resource rent will also be explored in more detail in Chapter 3. Even allowing that some part of the return represents compensation for higher than average corporate risk, there were periods during which firms were likely retaining resource rent. For example, while the 8% average excess return from 1906-39 might be largely explained away as compensation for risk,
a similar argument is unlikely to eliminate all of the 33% average excess return earned from 1940-59. Interestingly, the average excess return from 1970 dropped to 11%. While firms appear to have retained significant resource rents during the relatively brief period from 1940-59, the evidence for rent capture by firms outside this period is not particularly strong.

The evidence on rent retained by firms displays a remarkable correlation across the sample firms, however, there are some periods of divergence. This is to be expected, to a certain extent, as the idiosyncratic experience of the individual firms should lead to some variation across the sample. For example, some firms’ operations involve mainly pulp and paper production, while others focus is in lumber production. Prices for these forest outputs generally move together, but from year to year there are some variations. These may be reflected in the data for the rent retained by the sample firms. This does not, however, appear to explain two periods of particularly marked divergence in firms’ excess returns, 1917-19 and 1947-48. The divergence in returns during these periods, on closer examination, appears to result from the exceptionally high returns of the Victoria Lumber Company and MacMillan Bloedel (then the H.R. MacMillan Export Company) respectively.

In the case of the Victoria Lumber Company, the exceptional returns during the period 1917-19 may have reflected the ability to exploit returns to scale particularly effectively. The company appears to have made significant investments in its logging railroads during the years 1914-16. In 1918 the average railroad operating cost per Mf.b.m. of lumber was especially low according to the company’s own records. The combination of reduced average cost and increasing output prices produced an exceptionally high return.

The outstanding returns earned by the H.R. MacMillan Export Company in 1947-48 produce an apparent divergence in the returns of the sample firms at this time. The firm’s records indicate that this increase was due to an increase
in total revenue which outstripped costs and production. During this period, in addition to producing lumber itself, the H.R. MacMillan Company purchased lumber and timber on contract from other producers and exported it. Contracts to purchase timber were often negotiated in advance of timber sale contracts. This may partially explain the exceptional returns the company experienced in 1947-48, as it was in September 1947 that the price ceiling on lumber imposed during W.W. II was eliminated.\footnote{General war-time price controls were implemented beginning in December 1941; elimination of the controls began in 1944. The Office of the Timber Controller was responsible for implementing price controls specifically applicable to B.C. timber, which was a particularly valuable commodity for war related construction and aircraft production. Prices for coast Douglas fir and western red cedar (Thuja plicata) were regulated by statute from January 1943. However, prices still increased. Between January 1943 and March 1944 prices on various grades of logs and lumber increased from 9% to 15% according to the statutory schedule (T.C. 14A, T.C. 14D.) The homogeneity of firms' experience during the war probably reflects the extensive control over prices at that time. For further discussion of war-time price controls see Taylor [160]. For a list of official sources of controls (Statutes, Orders in Council) see Stewart [159].}

It is the nature of firm level data to reveal the idiosyncrasies in firms' experiences which are most often masked by aggregation or averaging. While I attempt to provide some insight into the two examples above this is not intended to detract from the general point that the behaviour of retained rent and excess returns is remarkably similar across the sample firms.

One question of interest before we leave these firm level results is how the evidence for B.C. forest industry firms might compare with some other Canadian firms? A comparison might help to determine if the positive values during the period from 1940-51 are really resource rent, or simply anomalous W.W. II and recovery related profit. Data for the Steel Company of Canada are compared to an average of those for the B.C. forest industry firms. Stelco is a manufacturing firm with close ties to a primary production industry so provides an interesting comparison with the forest industry in BC.\footnote{The data used are from Stelco's Annual Reports. They were collected as part of a firm level panel described in Keay [104] and generously provided by the author on request.} The results are quite informative and can be seen in Figure 2.13.
One notable difference is in the degree of volatility of the excess returns. The returns to Stelco rarely strayed outside 10% on either side of zero, although they edged above more frequently after the late 1950s. The maximum value was 20%, realized in 1974. This is less than half the forestry firms' maximum average excess return. The Stelco data display what appear to be business cycle related fluctuations which (broadly) match those found in the forestry firms' data. The run up in the excess return to B.C. forestry firms from 1940, however, has no counterpart in the Stelco data. The data for Stelco do not indicate that the period from 1940-59 was one of particularly high profitability for all companies. One other interesting feature is the similarity in the level of excess returns between Stelco and the B.C. firms during the period following the 1940-59 interval.

The comparison with Stelco is not a comprehensive examination of how the returns of the B.C. forestry firms compare with those of other Canadian companies. However, it does provide some evidence to corroborate the finding that these firms successfully retain substantial resource rents during the period 1940-59. The comparison also suggests that the sample B.C. forestry firms did not earn unusually high excess returns after this, at least not if Stelco's figures represent a 'normal' return.

2.4.4 Rent Captured by Labour

As mentioned above, the rent which firms themselves retain is only one piece of the overall rent puzzle. This section addresses the second component of the total rent the sample firms generate, the rent which their labour force captures. The idea that forest industry labour captures rent is based on a strong union presence in the industry combined with relatively high wages. Researchers such as Copithorne [49], [50] argue that the 'union' wage differential represents resource rent capture. In this section I investigate this view in more detail, before
determining how to estimate the rent which labour employed in the sample firms may capture.

Sufficient data are not available to examine the issue of union rent capture at a firm level, so much of this section focuses on industry level data. I use the results of the industry level analysis to determine a figure for the average rent captured in each year per worker in the Logging, Wood and Paper and Allied Industries. I assume that each worker correspondingly employed in the sample firms captures this average in each year. The total rent capture by labour in the sample firms is just the product of the number of employees engaged in logging, wood, or paper operations and their respective individual annual rent capture. The industry level results are of some interest themselves and are used to derive the aggregate industry rent estimates in Section 2.5.

There are two main issues of importance related to rent capture by labour. The first is when it becomes a possibility. Linking the timing directly to union activity makes this question more manageable, but it is still far from easily answered. The reasons relate to the second and perhaps more difficult problem of quantifying union power. One crucial aspect of this is deciding what share of the wage gap between forestry workers and labour in other sectors can legitimately be attributed to union based resource rent capture. Attributing all of the wage differential to rent capture rules out the possibility that skills, degree of risk, isolation and other factors might operate to generate a wage gap even in the absence of unions. The question of union objectives also relates to the interpretation of the wage gap. The association of the wage gap with union bargaining implicitly assumes that wages are the primary variable in a union’s objective function. A broader view of unions would allow for nonwage considerations to play a role. For example, hours, employment, work and safety considerations may be important variables. It is possible that an occupational wage differential could coexist with union bargaining in the industry and yet there may be mini-
mal 'leakage' of rent into wages. A more detailed examination of these issues is the focus of this section.

Union History in B.C.

Union activity is seen as the primary mechanism of rent capture by forestry workers.\(^6^2\) There are three major unions operating in the province. The International Woodworkers of America (I.W.A.) is the major union in the Logging and Wood industries. In the Paper and Allied industries, the Pulp and Paper Workers of Canada and the United Paper Workers International Union are currently the main unions. The former is an independent Canadian union, which formed during the early 1960s. The latter has its roots in the International Brotherhood of Pulp, Sulphite and Paper Mill Workers (hereafter Mill Workers) union. This union formed in 1906, but it is unclear when it established itself in British Columbia.

There is little information on the history of the paper unions in B.C. While the international union established itself in the pulp and paper industry in Ontario before W.W. I and in Quebec and eastern Canada shortly after this. General union histories do not mention the union having a presence in B.C. at this point.\(^6^3\) Logan [113] suggests that even in regions where the Mill Workers union was established the depression all but eliminated this international union. It recovered after this in the East, but again there is no mention of it operating in B.C. Some further information may be obtained from the history of paper industry unions in the U.S. Pacific Northwest. Randall [146] dates the initial formation of local chapters of the Mill Workers union in this region to 1917-18. The first strike was held in 1919. The goal of this strike was union recognition. However, shortly after this the locals dissolved and Randall [146] claims there

---

\(^{6^2}\) This is certainly the implication in Copithorne [49], [50]. Percy [140] also mentions unions in this context.

\(^{6^3}\) See, for example, Logan [113].
was "no semblance of worker representation for any purpose in the Northwest pulp and paper industry." The appearance of a truly established union in the U.S. Pacific Northwest coincided with the passage of legislation facilitating collective bargaining, in 1933. In addition Kerr and Randall [105] suggest that the unions in the Northwest pulp and paper industry were 'coat tail riders' of the I.W.A. The actions of unions in the pulp and paper industry generally followed those the I.W.A. initiated.

While there is no direct information on B.C., some inferences can be drawn from this early history of U.S. Pacific Northwest pulp and paper unions. First, it is unlikely that unions had sufficient power to set wages in the Paper and Allied industries in B.C. during the years before the depression. It also seems likely that a legislative context favorable to collective bargaining would have been important for the establishment of union bargaining power. Finally, the leading role assigned to the I.W.A. suggests that its history may be representative of the potential role for unions in wage setting in B.C.'s forest industries. The history of the I.W.A. and its roots are the main focus of this section.

The influence of unions in the logging and wood industries varied greatly over the twentieth century. The first stirrings of union involvement can be traced back to the early 1900s and the activity of the International Workers of the World (I.W.W.). The 'Wobblies' focused on the logging industry in their involvement in the B.C. forest industry. The I.W.W. never had large numbers, but it was militant and possibly more influential than its membership suggested. The union's activity did result in local strike activity in Port Alberni in 1911 and in Cranbrook in 1924. In spite of this, the union did not appear to wield much real power because the strikes concluded without the union winning any of the concessions they sought. In fact, those identified as union agitators were

---

64 Randall [146], pp. 50.
65 The following description draws on Leier's [110] detailed history of the I.W.W. in B.C.
blacklisted and they did not return to their jobs in the forest sector. The I.W.W. was never able to organize the forest sector *en masse* and virtually disappeared except for a few locals by 1910.

Throughout the 1920s and 1930s unions struggled to establish themselves in the B.C. forest industry. The I.W.W. was followed by the Lumber Workers Industrial Union, which formed in 1919. It led a brief existence, folding in 1926. A new body, the Lumber Workers Union formed in 1928. The number of individuals involved was extremely small. Only seven members were present at the inaugural convention. The lack of members imposed financial constraints and the union largely confined its activities to printing and distributing union literature in an attempt to recruit new members. Declining nominal wages during the early 1930s encouraged a few attempts at local unionization and strike activity. The first large scale strike action by the union occurred in January 1934 and focused on wage increases. The strike spread rapidly and involved many of the major coast timber operations. The situation forced the provincial government to intervene, setting up the Board of Industrial Relations. The strike ended when the Board ruled to uphold the union’s wage demands. This was the first time that the union really succeeded in achieving gains through its actions. Even with this apparent success, the union remained small, with only 2000 members in an industry employing over 20,000.

Conditions in the B.C. forest industry at this time (and earlier) were not particularly conducive to wide scale unionization. The isolation of the logging camps presented one difficulty. The hostility of employers, who were allied through the B.C. Loggers Association, presented another formidable obstacle. Anti-union sentiment was strong and there was no protection for union activists.

---

66 Bergren [7], pp.26. This section on the Lumber Workers Union draws on Bergren’s [7] detailed history of this union.
67 Bergren [7], pp. 34.
68 Bergren [7], pp.54.
from discriminatory labour practices by employers such as firings or blacklisting. In fact, logging camp owners often had the assistance of the police in preventing union activists from talking to their employees. The structure of the labour market itself was not favourable to union organization up to this point. The main threat of dissatisfied workers was quitting, an option which they exercised not infrequently. The firing of employees also seems to have been common for relatively minor 'offenses'. The joint result was a labour force highly mobile across operations and with high turnover rates. This added to the already considerable list of challenges in organizing labour effectively.

Finally, the size of available resource rent may have influenced the scope for union bargaining power. The results so far do not compellingly indicate that forestry firms captured rent in the pre-depression era. The total resource rent which firms were generating may not have been very large. The choice of firms in which early unionization attempts take place is interesting in this context because it supports the idea that, in general, there were no large rents to bargain over. Union organizers focused their efforts on relatively large, well established firms which had access to high quality timber, a great deal of which was held under Crown grant status.\(^{69}\) If any firms in the industry were generating rent these firms were excellent candidates. A lack of rent in the industry overall may have contributed to the absence of broadly based union success.

The formation of the International Woodworkers of America (I.W.A.) in 1937 led to changes for the B.C. unions. The B.C. Lumber Workers Union became a subunion of the Carpenters and Joiners Union in the American Federation of Labor (A.F.L.) in 1935 but the I.W.A. was more identifiably linked with the forest industry. The membership numbers of the I.W.A. spoke clearly of its potential role in the industry. The I.W.A. had 70,000 members overall when it

\(^{69}\)Firms with Crown grant timber often paid little in the way of timber charges, leaving more potential rent for the firm and a union to bargain over. Firms in which these early, ineffective union drives took place include the Victoria Lumber Company and Bloedel Stewart and Welch.
formed independently of the Carpenters and Joiners Union in 1937, although the B.C. contingent still consisted of only roughly 2,500. The link between the B.C. union and the much larger U.S. union reduced the possibility that opposition might eliminate the provincial union altogether.

In spite of the apparent advantages of belonging to a larger family of unions, the I.W.A. did not make great strides in B.C. during the next few years. A number of strikes were initiated, but success was minimal. The financial resources of the B.C. union were drained, and some internal struggles contributed to a lack of effective action, which produced a subsequent decline in membership. In 1938 the I.W.A.’s membership in B.C. had dwindled to 226 members. In spite of its early success, at this point the union really cannot be regarded as exercising any power over the general wage level in the forest industries of B.C.

The pattern of union activity in B.C. began to show some signs of change through the early 1940s. Institutional changes helped to make the growth of the I.W.A. in B.C. possible. The provincial government passed changes to the Industrial Conciliation Act in 1943 which gave a formal legal right to workers to organize and bargain collectively. The major ‘union friendly’ piece of legislation during this period was the National War Labour Order, Order in Council, P.C. 1003, in 1944. This landmark legislation changed the tenor of Canada’s labour laws from neutrality toward the organization of labour to facilitation. This change in the legal climate regarding unions provided the I.W.A. with a firm basis from which to confront the strength of the (anti-union) employers association. The size of overall rent generated was still relevant to the union’s ability to secure large wage gains. The evidence on resource rent retained by firms clearly indicates increasing rent at this time.

The watershed year for the I.W.A. can (arguably) be considered to be 1946.

---

70 Bergren [7], pp.111.
71 Bergren [7], pp.125.
72 Gunderson and Riddell [80], pp. 249.
This was the year in which the union succeeded in achieving substantial wage gains from the point of view not only of the B.C. Loggers Association and other employers, but also the Federal Government's Anti-Inflation Board. The union won a wage increase greater than specified anti-inflation targets and gained additional concessions in a 40 hour week, paid holiday, and union dues checkoff. In addition, the union increased tremendously in size. At the end of the I.W.A. strike in 1946 the union had 27,000 members in B.C.\textsuperscript{73} At this point, the union had both the numbers and legal rights to exercise considerable power in the industry. While a master agreement was first signed between the I.W.A. and the B.C. Loggers Association in 1943, at this point the union was simply not large enough, or dispersed enough to extract substantial concessions on an industry wide basis. From 1946, the I.W.A. was in a position to exert power in determining the general level of wages in the forest industry in B.C. and potentially to extract resource rent through higher wages.

**Union Rent Capture**

The question at this point is how much rent labour captured through union bargaining? It is argued above that unions had the power to alter the general level of wages in the forest industry beginning in 1946. The degree to which this bargaining power translates into the wage differential relative to manufacturing is not clear. The preferred approach for identifying interindustry and union wage differentials uses micro data on individuals' earnings, personal characteristics, occupational characteristics and union status. Wage and selection equations are estimated in order to identify the relevant influences.\textsuperscript{74} In the present case, only aggregate data on average annual earnings in the B.C. forestry and other

\textsuperscript{73} Bergren [7], pp. 236.

\textsuperscript{74} Two standard surveys of the large literature on union-non union wage differentials and interindustry wage differentials are Lewis [112] and Rosen [149] respectively.
<table>
<thead>
<tr>
<th>Period</th>
<th>$w_{LG} - w_{OM}$ (%)</th>
<th>$w_{WD} - w_{OM}$ (%)</th>
<th>$w_{PA} - w_{OM}$ (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1931-45</td>
<td>17.38%</td>
<td>-12.5%</td>
<td>15.29%</td>
</tr>
<tr>
<td>1946-92</td>
<td>21.15%</td>
<td>4.79%</td>
<td>26.77%</td>
</tr>
<tr>
<td>1930s</td>
<td>10.61%</td>
<td>-19.08%</td>
<td>12.97%</td>
</tr>
<tr>
<td>1940-45</td>
<td>22.68%</td>
<td>-8.72%</td>
<td>10.35%</td>
</tr>
<tr>
<td>1946-49</td>
<td>31.87%</td>
<td>-2.65%</td>
<td>22.33%</td>
</tr>
<tr>
<td>1950s</td>
<td>33.63%</td>
<td>-6.04%</td>
<td>22.19%</td>
</tr>
<tr>
<td>1960s</td>
<td>14.34%</td>
<td>-12.43%</td>
<td>23.10%</td>
</tr>
<tr>
<td>1970s</td>
<td>18.65%</td>
<td>10.03%</td>
<td>26.75%</td>
</tr>
<tr>
<td>1980s</td>
<td>13.25%</td>
<td>16.04%</td>
<td>33.66%</td>
</tr>
<tr>
<td>1990-92</td>
<td>22.61%</td>
<td>16.02%</td>
<td>37.33%</td>
</tr>
</tbody>
</table>

Table 2.2: Percentage Difference Between Annual Earnings in Forest Industries vs Other Manufacturing Industries for B.C.

manufacturing sectors are available, so this micro-data approach is not feasible.\textsuperscript{75}

To get some ‘feel’ for the potential effect of unions on earnings Table 2.2 shows the percentage difference between annual earnings in the forest industry occupations (Logging (LG), Wood (WD) and Paper and Allied industries (PA)) and other manufacturing (OM).\textsuperscript{76} Earnings data are available for other manufacturing on an annual basis starting in 1931, so the data from then until 1945 represent the preunion period.\textsuperscript{77} The period from 1946-92 is when unions are considered to have had the power to influence the general wage level in the forest industries.

In one sense the results are unsurprising. The difference in annual earnings appears to be larger after the establishment of unions. This supports the view that the increased bargaining power allowed workers in the industry to capture some of the resource rent which had emerged. More interesting is the hetero-

\textsuperscript{75} ‘Other manufacturing’ is activity in B.C.’s manufacturing sector other than in the main forest industries; the Wood and Paper and Allied Industries.

\textsuperscript{76} Annual earnings are based on data from the Census of Manufactures. Figures are for all workers, rather than based on only production workers employment and earnings. Although this includes employees for whom the union is not likely to influence wages, it is not possible to isolate production workers in early data.

\textsuperscript{77} Observations are also available for the years 1926, 1929.
geneity across the forestry occupations. While there appears to be a difference in earnings between these and other manufacturing even before unions are established, the experience varies across occupations. In the logging and paper and allied industries, there is a fairly large positive gap, while the average annual earnings in the wood industries are below those in other manufacturing. This indicates that in the logging and paper and allied industries a positive occupational wage differential may exist even in the absence of a union.

The limited nature of the available data makes it difficult to test these first impressions more formally. The real annual earnings series are nonstationary, so that regressions in the levels, or even in logs of the series, on one another do not produce results with standard interpretations and inference is not possible using standard distribution theory. However, the percentage difference between wages in the forest sector and other manufacturing is sufficiently 'well behaved' that we can conduct a simple test of the influence of unions by estimating the following equations:

\[
\begin{align*}
\text{wgapi}_L &= \beta_0 + \beta_1 UN + \epsilon \\
\text{wgapi}_W &= \beta_0 + \beta_1 UN + \epsilon \\
\text{wgapi}_P &= \beta_0 + \beta_1 UN + \epsilon
\end{align*}
\]

where \( \text{wgapi}_L \) is the percentage difference between real average annual earnings in the logging, wood, paper and allied industries and those in other manufacturing, \( UN \) is a dummy variable taking on a value of 1 in years when it is likely that unions had an influence on the level of wages in the forest industries and \( \epsilon \) is an error term. Initial estimation indicated serial correlation in the residuals.

---

78 This is the problem of spurious regression. For a good discussion see Banerjee et al. [5], pp. 70-84.
79 By 'well behaved' I mean that the data are stationary. Percentage changes are calculated as log differences.
80 Alternate specifications which included a linear time trend were also estimated, but these were rejected on the basis of F-tests comparing them with the nested models above.
<table>
<thead>
<tr>
<th>Coefficient (Standard Error)</th>
<th>$wgap_{Lg}$</th>
<th>$wgap_{Wd}$</th>
<th>$wgap_{PA}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\beta_0$</td>
<td>0.19116 **</td>
<td>-0.0179</td>
<td>0.17065 **</td>
</tr>
<tr>
<td></td>
<td>(0.05088)</td>
<td>(0.06475)</td>
<td>(0.03322)</td>
</tr>
<tr>
<td>$\beta_1$</td>
<td>0.02068</td>
<td>0.0503</td>
<td>0.10303 **</td>
</tr>
<tr>
<td></td>
<td>(0.05646)</td>
<td>(0.05686)</td>
<td>(0.03755)</td>
</tr>
<tr>
<td>$\rho$</td>
<td>0.67199 **</td>
<td>0.86309 **</td>
<td>0.60804 **</td>
</tr>
<tr>
<td></td>
<td>(0.09257)</td>
<td>(0.06313)</td>
<td>(0.09924)</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.4718</td>
<td>0.7812</td>
<td>0.5931</td>
</tr>
</tbody>
</table>

** = significant at 5% level of confidence

Table 2.3: A Simple Test of Union Influence

The equations were re-estimated using Cochrane-Orcutt GLS to correct for first order autocorrelation. The results are summarized in Table 2.3.

The results of this test are a little unexpected. While the coefficient on the union dummy is positive in all three cases, it is small relative to the constant. Only in the paper and allied industries does the union appear to have a more substantial influence. The union variable is not significant in either the logging or the wood industries. For the wood industries the large number and varying scale of mills in the industry, as well as the lack of barriers to entry and exit relative to the other forest industries suggests that rent capture may be less possible in this industry.\textsuperscript{81} The wood industries are likely more competitive than either the logging industry, in which entry is limited through access to the resource, or the paper and allied industry which requires large capital outlays for entry due to the scale of operations. The closer an industry is to a constant cost competitive industry, the less rent capture through union activity is possible.

The lack of a significant union coefficient is more surprising in the logging industry, since the view that the union has been able to raise wages through its

\textsuperscript{81} These general characteristics of the wood industry are broadly relevant over the full sample. They are a less accurate description of the modern wood industry, as both institutional arrangements and industrial structure have combined to limit entry.
influence is not uncommon. There may be a number of reasons for the apparent failure to find evidence of union influence in this case. The dependent variable in the regressions is based on annual earnings data, rather than hourly wages. Union activity in the sector may focus on hours or employment. Changes may occur which raise the hourly wage, but do not result in higher average annual earnings in the industry. In addition, the method of representing union influence with a dummy is overly simple. In reality, the power of unions evolves over time. The dummy can not capture this aspect of union influence on annual earnings. In general, the evidence I present here can not be used to reject the view that unions may raise wages in B.C.'s forest industries. It illustrates the possibility that this influence does not account for all of the difference between earnings in this sector and others.

The significant constant terms in the simple test regressions provide some evidence for this. In the logging and the paper and allied industries the constant in the regression equations is both significant and positive. In addition, the value of the constant term is relatively large compared with the union coefficient. This indicates that a positive occupational differential should be considered as a possibility in these occupations. Anecdotal evidence suggests that, particularly in the logging industry, working conditions were often harsh and accidents common. Further, there was often a significant degree of isolation involved. The process of making pulp is relatively complex and paper and allied industry labour may require a greater degree of specialization and training than the average other manufacturing occupations. The constant term in the wood industry regression is both negative and insignificant. Since annual earnings in the wood industries are below those in other manufacturing for much of the sample, the sign is not surprising. The lack of significance is also not surprising, since the earnings series of the wood and other manufacturing industries are virtually coincident

See Copithorne [50], Doiron [59], Percy [140], Martinello [125].
for most of the sample.

It is possible to conduct a ‘suggestive’ test of whether earnings in forest industry occupations are different from those in other manufacturing before unions become established.\(^83\) Support for this hypothesis provides further evidence that the influence of unions on forest industry wages may not be responsible for the entire earnings gap. The approach uses a simple nonparametric test of the hypothesis that the distribution of annual earnings is the same for forest industry occupations as for other manufacturing.\(^84\) The alternative for the logging and paper and allied industries is that their distributions lie to the right, versus to the left for the wood industry. The test consists of taking an independent random sample of pairs from the two distributions, obtaining the sign of the difference between them and determining the attained significance level of that number of positive/negative observations under the null that the distributions are the same.\(^85\) This is just the following binomial probability:

\[
Pr(M) = \binom{n}{M} p^M q^{n-M}
\]  

(2.14)

where \(M\) is the number of times the sample difference is greater than zero (less than zero for wood industry), \(p\) is the probability of obtaining a positive difference under the null, \(q\) is that of a negative difference and \(n\) is the sample size. Since the null is that the distributions are the same, \(p, q = .5\) in all cases. The attained significance levels range from \(.09 - .16\) for the wood industry, \(.05 - .09\) for logging and \(.02 - .01\) for paper and allied industries. If we chose a

\(^83\)This period is taken to be before 1946. The use of the word suggestive is due to the limited nature of the available data and the small sample size, both of which reduce the power of any test applied.

\(^84\)See Dudewicz and Mishra [61], Chapter 13, pp. 655-676; Kenkel [106], Chapter 21, pp. 730-769. I use a sign test.

\(^85\)In this case, the sample is time series data, and is small. In order to avoid violating the independence condition, sample points were required to be separated in time by at least 3 years. In an attempt to satisfy randomness, all possible combinations of the maximum sample sizes under this method were used. While resampling from such a small initial distribution is unorthodox, it is hoped that the consistency of the results provides some greater confidence in the conclusions drawn.
standard critical level of significance, $\alpha = .05$, we do not reject the hypothesis that the distribution of annual earnings in the wood industries is the same as that of other manufacturing, but find some indication that the distributions for logging and the paper and allied industries lie to the right.

The factors which contribute to the determination of earnings are many and this simple analysis does not provide a definitive answer to the question of how much resource rent labour in the forest industry captures. It is still possible to draw some conclusions from this 'naive' analysis. The evidence suggests that the 'true' picture of rent capture by labour lies somewhere in between the two extreme views of all or none of the wage gap between forestry wages and other manufacturing wages. A skills or disamenity differential of some sort appears to be plausible for both the logging and paper and allied industries. The evidence suggests that there is no systematic difference between the annual earnings of those employed in B.C.'s wood industries versus other manufactures.

**Implications for the Study of Firm Level Rent**

How are the results above incorporated in the estimation of rent captured by labour? In the absence of microdata, estimation of a union premium as distinct from a skills or disamenity differential is not feasible. While the available evidence suggests that this would be the best way to proceed, the necessary data are simply not available. The measure of rent which labour captures is based on the full earnings gap between the forest industry and other manufacturing industries. This is an upper bound in view of the results discussed above.

The examination of the earnings differentials for the Logging, Wood and Paper and Allied industry components of the forest industry indicates that labour captured different amounts of rent in each of these occupations in each year. Based on the results above, I assume that workers in B.C.'s Wood industry did not capture any resource rent over the full sample period. I assume that work-
ers in the Logging and Paper and Allied industries captured an amount of rent in each year equal to the full value of the differential between average annual earnings in their industry and other manufacturing in B.C. I assume that labour in the Logging and Paper and Allied industries began to capture this rent after 1934. This is the first year in which the Lumber Workers union won a wage concession, so as an upper bound the union is assumed to be responsible for the full earnings differential from this point. All of this 'union' wage differential is attributed to resource rent capture.  

The sample forestry firms are vertically integrated. This implies that they employed labour in logging, milling and pulp and paper production. According to the industry level results discussed above, workers engaged in these various operations captured different amounts of resource rent. I estimate the total rent captured by labour employed in the sample firms in a way which reflects this. I assume that workers engaged in milling operations did not capture any resource rent. Each employee working in logging operations is assumed to have captured rent equal to the difference between average annual earnings in Logging and Other Manufacturing in each year. Similarly, the amount of rent which an employee working in pulp and paper operations captured in any year is the value of the difference between average annual earnings in the Paper and Allied industries and Other Manufacturing. The total rent captured by labour for a sample firm in any year is the product of the number of workers they employ in logging and paper and allied industry operations and the respective average annual earnings differentials.

It is necessary to establish the occupational breakdown of the firms' workforces to implement this approach. This is accomplished by a variety of means. The ABC Lumber Trade Directory [85] provides separate estimates of the work

---

86 Unions could have raised wages in other ways, such as raising productivity. See Freeman and Medoff [70].
force in logging operations for most companies. These data are self-reported by the firm and do not appear to be extremely precise. They are combined with estimates of the allocation of employees based on the firms' output and labour requirements according to aggregate data. For example, a firm's pulp and paper output is used to infer the number of employees in these operations by applying the labour to output ratio from the aggregate industry data. These calculations are made on an annual basis, in other words, the labour to output ratio applied is allowed to change from year to year to reflect technological change, shifts in factor utilization with factor price changes, etc. This method relies on an assumption of constant returns to scale for the industry and also assumes that firms use common technology and face common factor price ratios. While these estimates are not extremely precise, they are sufficient to gain a general perspective on the amount of resource rent which labour captures as an upper bound.

The results of the firm level estimates of rent capture by labour are displayed as the variable 'labour rent' in Figure 2.4-Figure 2.11. By construction, labour does not capture any of the resource rent generated by the firms before 1935. Between 1935 and 1940, while labour did not capture as much rent as firms during 'good years', the level remained steady and did not fall when the rent retained by the firms declined. In contrast, labour captured relatively little resource rent during the period from 1940-59 when the rent captured by firms rose most rapidly and firms' excess returns were relatively largest. The rent which labour captured increased slightly over time and displayed no cyclical fluctuation. This pattern began to change from roughly 1950. The rent which labour retained began to show some of the variability of the rent which firms retained. In addition, the level of rent which was captured by labour became

---

87 These data are not available for every year. The method of linear interpolation is used to predict missing values.
more significant relative to the rent which firms captured

2.4.5 Rent Collected by Government

The objective of this section is to generate the final component of the total rent the sample firms generate; the rent which the provincial government collects. The firm level sources only rarely provide this data so, in general, estimates must be made using available firm data in conjunction with aggregate data and general information on timber charges. A brief introduction to the history of B.C.'s forest policy precedes the estimation of the rent the government collects from the sample firms.\textsuperscript{88}

Forest Policy in B.C.

British Columbia's forest policy has evolved continuously over the province's history. The origins of forest policy per se can be traced to the late nineteenth century. Before this it was possible to purchase timber land outright with no restrictions on the use of the timber or royalty to be paid. Land was regarded as a homogeneous commodity, at least as far as timber was concerned.\textsuperscript{89} The Land Acts of 1884 and 1887 changed this, prohibiting the sale of timber lands for the first time. The effectiveness of these laws was limited by the lack of both a definition for timber lands and the money and manpower for enforcement. The Land Act of 1888, recognizing this failure, was the first legislation to introduce measures for capturing some return on timber which was harvested from Crown granted land. A royalty of fifty cents per thousand board feet (Mf.b.m.) was levied on timber harvested from subsequent Crown grants. An amendment to the Land Act in 1891 implemented the first quantitative definition for timber

\textsuperscript{88}This history is essentially limited to forest policy as it affects resource rent collection by the government.

\textsuperscript{89}The Governor's Proclamations which governed the conditions for the sale of lands specifically reserved the rights to precious metals from 1851, but included all rights to timber as a component of land. See Cail \[26\], pp. 92.
lands, which a further amendment in 1896 made more precise. These further attempts to prevent the outright sale of timber land remained largely ineffective in the absence of adequate inspections. The sale of land through Crown grant was discontinued from 1913, although the appearance of alternative means for securing access to timber made purchasing them a less attractive option by 1905. The critical point is that starting in 1888 a means to collect resource rent was introduced. Even if timber land was purchased a per unit charge was imposed on all timber which was harvested.

Early in its history the province developed arrangements for the forest industry to secure access to timber. These 'old temporary tenures' included timber leases and licenses, timber berths and pulp leases and licenses. The leases served as the initial means of promoting the development of the forest industry in the province. They appeared as early as 1870 as part of the Land Ordinance. To prevent speculation and encourage industrial development a condition of the leases was that a mill of a prescribed capacity (dependent on the size of the leasehold) be constructed and operated. In terms of resource rent collection, the leases were characterized by the reservation of royalty and an annual rental to the Crown. The annual rentals were set at a low level to encourage investment and before 1888 they were rarely paid.

While the province implemented both a fixed charge for the leases and a per-unit charge on harvested timber, these instruments were not particularly effective for capturing resource rent. Part of the reason has to do with the renewable 21 year terms of the leases. Setting the rental and royalty for such long periods obviously limited the government's ability to collect resource rent. This was not really a concern initially, as the province's timber was considered to be virtually worthless and inexhaustible. This perception changed gradually and in 1907 resulted in the province sus-

---

90 See Cail [26], pp. 95.
91 Cail [26], pp. 95.
92 Cail [26], pp. 98.
pending the granting of leases.  

The license component of the old temporary tenures was designed for independent loggers. There was no requirement to operate a mill. Licenses (unlike leases) were always subject to restrictions on the size of the area to which they applied. In addition, before 1903 licenses were not transferable and were valid for only one year. Licensees paid a fixed fee for the license in addition to royalty on the timber which they harvested. A policy change in 1905 permitted transferability of licenses and extended their length of tenure to twenty one years. This increase in permanence and flexibility made this type of tenure so popular that the number held jumped from approximately 1500 in 1904 to 15000 by 1907. This caused the government considerable anxiety about its forest policy and in 1907 the issuing of these old temporary tenures was also discontinued. This type of tenure originated with more flexibility to capture resource rent because of its short term nature. By 1905 the terms of forest licenses made them as potentially ineffective in terms of capturing resource rent as leases.

The arrangements for resource rent capture on these early forms of tenure are important because significant volumes of high quality timber were acquired under their provisions. A total of almost twelve million acres were held under old temporary tenures. The financial instruments for rent collection on these types of tenure consisted of two parts. The fixed component was an annual rental fee. These fees were set at relatively low levels and changed infrequently. The annual renewal fees on licenses, the only form of timber alienation which carries forward from the suspension in 1907, were set at a fixed level for the period

---

93 Fulton [71], pp. 13.
94 From 1903-1905 licenses were valid for up to five years, but remained nontransferable. See Fulton [71], pp. 12.
95 Fulton [71], pp. 28.
96 This figure was taken from the Sloan Report [157]. While it represented only 18.5% of the contemporary estimated stock of 'merchantable' timber, the share of accessible, high quality timber would have been much greater. The disproportionately large share of the harvest drawn from these old temporary tenures (available in the Ministry of Forests Annual Report [13]) illustrates their importance.
The fixed component of government timber charges was responsible for relatively little of the revenue the government collected.\(^97\)

The second instrument for rent collection was a statutory royalty charged on timber harvested. The amount of resource rent the government collected with this instrument varied depending on the size of the annual harvest from a given license or leasehold because it was calculated as a fixed charge per Mf.b.m. harvested. Royalty payments were the largest source of revenue from the old temporary tenures. The original royalty rate for saw-timber was set at fifty cents per Mf.b.m.. The basis for choosing this figure is not clear. The royalty rate remained fixed until the Timber Royalty Act of 1914. This Act attempted to link the royalty charge to the price of the lumber produced and also introduced variation in the royalty rates across species and regions for the first time.\(^99\) This attempt to make royalty charges more flexible and reflective of the market value of timber increased the potential for rent collection. Unfortunately, linking the royalty to price and failing to account for costs posed problems during the inflation of the 1920s. The method of linking royalty rates to the market price of output was abandoned in favor of a revised statutory royalty schedule. The schedule was incorporated into the Forest Act and periodically revised by amendments to the Act. Royalty rates were set substantially below the appraised stumpage charges on similar timber.\(^100\) In general royalties have not proven an extremely effective means by which the government can collect resource rent.

The suspension in the alienation of rights to timber in 1907 was followed in 1909 by the province's first Royal Commission dedicated to its forest resources, the Fulton Commission. Its recommendations, delivered in 1910, were largely

\(^97\)Sloan [157], pp. 95.
\(^98\)This is apparent from the Forest Revenue figures given in the Ministry of Forests Annual Report [13]. The speculative boom in timber licenses in 1905 following the changes in their terms is an important exception to this generalization.
\(^99\)Pearse [136], pp. 18.
\(^100\)See Pearse [136], pp. 65.
transformed into the first Forest Act, in 1912.

In place of the suspended tenures above a new special timber license was created. In order to acquire access to timber an application was made for the area to be licensed. This parcel was surveyed so its timber resources could be established and classified. This allowed the government to establish a minimum (or upset) stumpage charge for the timber. The proposed license was advertised and then publicly auctioned, subject to the established minimum stumpage bid. The eventual licensee paid an annual rental, as well as the minimum stumpage, plus any increase they had bid. The winning bidder was also responsible for paying the cost of surveying, cruising and advertising for the license.\textsuperscript{101} Bids were by sealed tender until 1921 when the method of oral bids at public auction was adopted.

This was the main method for disposal of rights to Crown timber until changes were introduced after the second royal commission, the Sloan Commission, in 1945. From the point of view of resource rent collection this was one of the most effective schemes which the province adopted.\textsuperscript{102} The competitive nature of the bidding process suggests that stumpage bids should have reflected the full value of the rent the resource was expected to generate.

Concern over the long term management of the industry prompted the province’s second Royal Commission to focus on forestry in 1945. The Sloan Commission was largely a response to concerns that available timber was rapidly being depleted.\textsuperscript{103} None of the tenure arrangements discussed above included any restrictions on harvesting. By 1945 it had become apparent that one result was that cutting was unevenly distributed across the province.

\textsuperscript{101}Cruising is the process of inspecting the timber on the site and determining its value.

\textsuperscript{102}Of all the methods adopted for the disposal of rights to B.C. timber and collection of royalty and stumpage, this method is theoretically most likely to yield close to the rent the timber was expected to generate. This could still differ from the rent actually generated.

\textsuperscript{103}See Sloan [157], pp.14-15. The general description of the forest industry at this time is summarised from Sloan [157],[158].
tions, particularly on the Coast, shortage of available timber was an imminent concern. The recommendations of the resulting Royal Commission produced a major shift in B.C. forest policy. The concept of sustainable yield was the cornerstone of this new policy. The primary objective of forest policy was to insure that a constant supply of timber could be harvested annually, in perpetuity. This concept of sustainable yield was applied at a regional level. Each forest management unit was to be operated on the basis of sustained yield. It was thought this would provide the necessary conditions for a regionally stable forest industry and continued prosperity across the province. Policy makers at the time assumed that this would be the natural result of a sustained yield policy.

One consequence of the sustained yield policy shift, probably unintended, was a reduced ability to collect resource rent effectively. The implementation of the new policy imposed restrictions on the allocation of timber which effectively reduced the influence of competition.\textsuperscript{104} Stumpage bids no longer exceeded the minimum upset price established by the forest service. The lack of a competitive check on the appraised value of timber reduced the government's potential to collect the full value of forest rent. There is considerable doubt that the data which were used to establish the appraised stumpage accurately reflected the true value of the timber. The previously discussed problem of collusive pricing on the Vancouver log market was one problem.\textsuperscript{105} The use of the costs of an average operator to determine stumpage created further potential leakage of rent from the revenue the government collected. This would be the case if labour successfully raised costs through union rent capture as in Copithorne [50].

The reorganization of forest tenure has been a subject of perennial interest,

\textsuperscript{104}For example, an established operator was designated as the 'recognized applicant' for an application they submitted. This entitled them to request a sealed bid auction and simply match the highest bid. They also gained the advantage that they did not have to pay the nonrefundable bidding fee. In practice this often eliminated any competing bidders, so the upset stumpage price was all that had to be paid. For further discussion, see Pearse [138], pp. 70-72.

\textsuperscript{105}For further discussion of this problem, see Pearse [137], pp. 32-64.
but not so the method of rent collection.\textsuperscript{106} This has not changed dramatically. Government established stumpage charges were the main method of resource rent collection, particularly during the years following W.W. II.\textsuperscript{107} The method of stumpage appraisal changed in 1987. Before this stumpage was fixed according to a Rothery formula. It was the difference between the value of timber and its average cost of production.\textsuperscript{108} A trade dispute with the U.S. in 1986 resulted in the adoption of stumpage in 1987 which was an \textit{ad valorem} charge. Instead of calculating a separate stumpage rate for each species a single rate for each stand now applies to all timber harvested from it. Stumpage is calculated according to comparative value pricing (CVP), which means that it is based on a selling price index for either the Interior or the Coast.\textsuperscript{109} The important aspect of this method of calculating timber charges is that, like the royalty charges of the 1914 Timber Royalty Act, it is fixed in relation to selling prices in the absence of data on costs. Further changes to the stumpage system in 1987 eliminated the practice of crediting forest management costs such as silvicultural expenses against stumpage owed to the government. This resulted in a significant transfer of resource rent from the private sector to the province.

The policy history above illustrates the complexity of government arrangements for collecting forest resource rent. The basic structure of the system remained stable; firms in the industry paid a fixed annual fee for access to timber harvesting rights and an additional charge (either stumpage or royalty) on each unit harvested. In practice the implementation of changes in this basic structure and the retention of charges set out in long term contracts produced a complex structure of coexisting financial arrangements. These jointly determined the

\textsuperscript{106} See Peel [139], or Burda et al [25] for discussion of multiple uses of forests and their relationship to the tenure system.

\textsuperscript{107} A logging profits tax was imposed in 1953, but this did not capture substantial forest revenue, Pearse [137], [138] suggested eliminating it.

\textsuperscript{108} This is a very general description, see Pearse [137], pp. 14-21 for more detail.

\textsuperscript{109} See Grafton and Nelson [77], pp. 5.
rent the government collected annually on the provincial timber harvest. Timber harvested in B.C. today may be subject to no charges if it is taken from land Crown granted before 1888, or it may be subject to stumpage charges assessed by the forest service. The inflexibility and low level of the charges assessed through older forms of tenure reduce the rent which the government can potentially collect. Tenure on the old temporary tenures is secure only until all timber is harvested, at which point the land reverts to the Crown. As these older, inflexible forms of tenure are extinguished the overall effectiveness of government rent collection will improve.

This brief history of forest policy raises some important points relevant to the measurement of rent the government collects from the sample firms. The first point is that it is impossible to construct an exact figure for the timber charges a firm pays without knowing the details of the (possibly varied) arrangements under which the firm has access to timber. The level of detail required is never present in the available data. This means that any calculation of timber charges for the sample firms is an approximation, rather than a precise estimate, unless the firm itself reports the total payment. The second feature of note in the policy history above is that the variable component of government timber charges is the most important source of revenue. An estimate of this variable component captures the quantitatively dominant source of resource rent for the government.110

**Government Collection of Rent from Sample Firms**

The final element of rent to estimate for the sample firms is what government collected in the form of timber lease and license payments and stumpage and roy-

---

110A number of charges paid by owners of timber land, such as the Wild Land Tax and the Forest Protection Tax are not discussed in the policy history. These were not levied with the intention of capturing resource rent, but discouraged speculation and raised funds for fire protection respectively. These generated little revenue relative to the variable timber charges discussed in any case.
alty charges. This is the most imprecisely generated component of the estimate of total rent for each firm. As mentioned above, unless the firm itself reports the total timber charges the varied tenure arrangements make them virtually impossible to estimate with precision. In most cases timber related charges are included in total costs and not reported separately. I use available aggregate data in conjunction with available firm level data to generate approximate timber charges for the firms.

The policy history above indicates that the variable charges associated with a firm’s timber harvest were most important for determining the total revenue the government collected. The importance of this variable payment is what motivates the strategy for estimating the sample firms’ timber charges. The timber related component of total government revenue from the forest industry is used to determine an average ‘stumpage’ rate. I use figures from the *Ministry of Forests Annual Report* [13] to generate a figure for the total timber revenue which the government collected annually.\textsuperscript{111} This total is then divided by the government figures for the total harvest found in the same source.\textsuperscript{112} The revenue from fixed charges such as lease and license renewals is included in this total. This implies that the fixed component is spread over the harvest to determine an implicit average cost of retaining the right to harvest timber in each year. This calculation generates an average charge per Mf.b.m. which represents the average cost of all timber related charges per unit harvested in the province.

The estimate of timber revenue which the government collects from a sample firm is based on this average charge and the firm’s own output. There are two exceptions. Figures for government timber payments of the Victoria Lumber

\textsuperscript{111}The revenues excluded are range fees, scalers' exam fees and other such items obviously not related to rent capture.

\textsuperscript{112}A variety of measurement units are used, these are converted to the original thousand board foot (Mf.b.m.) measure using conversion factors from the *Ministry of Forests Annual Report* [13]. The Mf.b.m. measure is retained as prices for lumber are still quoted according to it and dimension lumber also commonly sells according to the Imperial measure.
Company and the Columbia River Company are reported with their financial
data, so these do not have to be estimated. For the other sample firms the rent
the government collects is just the product of the quantity of timber the firm
harvests in each year (measured in thousand board feet) and the corresponding
average charge. This is not quite as straight forward to calculate as it sounds
since firms do not usually report their output data this way. Records for Bloedel
Stewart and Welch provide figures for the total timber harvest measured in
thousand board feet. The Canadian Western Lumber Company reports timber
harvested in this way until 1935, after which this only data on timber sales are
available. In the absence of other data these are assumed to be representative
of harvest volumes. For other firms output is reported in the units of the final
products. For example, MacMillan Bloedel reports its output of logs, lumber,
pulp, paper, plywood, etc.\footnote{113}

The quantity of these units of final output determines the thousand board
foot equivalents of timber required to produce them according to conversion fac-
tors implicit in Census of Manufactures data, \textit{Ministry of Forests Annual Report}
\cite{13} and Whitford and Craig \cite{168}. For example, the Census of Manufactures for
the pulp and paper industry includes data on the volume of pulpwood used in the
production of pulp. This is used to calculate the number of cords of pulpwood
per short ton of pulp produced. Cords of pulpwood are converted into Mf.b.m.
of timber according to the conversion rate used by the Ministry of Forests \cite{13}
and Whitford and Craig \cite{168}. Final outputs for the Powell River Company,
Crown Zellerbach Canada and MacMillan Bloedel are converted to timber har-
vest equivalents and multiplied by the average stumpage rate to generate their
government timber charges.\footnote{114}

The method above can not be applied to the British Columbia Pulp and
\footnote{113}Generally when a firm reports data on logs and other outputs 'logs' does not represent the
figure for total timber harvested, but rather for logs sold as a final product.
\footnote{114}Minor products, such as doors, are not included in these calculations.
Paper company, as its output data are unavailable. A series for the labour the firm employs annually is generated with data from the *ABC Lumber Trade Directory* [85].\(^{115}\) I use this series in conjunction with provincial industry level labour force figures for the pulp and paper industry to generate the share of the labour force the B.C. Pulp and Paper Company employs. I then estimate the firm's production by assigning it this same share of industry output. I assume the firm's labour force is equally distributed between pulp and paper production. The output of the firm is converted to a timber equivalent and the firm's government timber charges are estimated as discussed above. The timber charges for the Canadian Western Lumber Company are calculated in the same manner for the years from 1946-53 because the firm reports no output data for these years.

The methods I employ to estimate government timber revenues for the sample firms are inevitably inaccurate. First, they are based on a provincial average timber charge. The policy history indicates that rates which actually apply to a firm's timber can vary substantially according to their tenure arrangements. For the sample firms the average charge probably represents an upper bound on the charges they actually paid. The sample firms held a substantial portion of their timber under Crown grants or old temporary tenures. This implies that they paid less than the average rate on the timber which they harvested from these lands. In addition, a number of the firms ran pulp operations. Pulp timber was subject to lower stumpage rates than saw timber so this would also involve firms paying less than the average rate. In a sense, however, the use of a provincial average stumpage rate may improve the representativeness of the sample firm results for the industry. The second source of inaccuracy is in the measurement of output for the sample firms. While the figures for output may not be too

\(^{115}\)Data are not available for every year, linear interpolation is used to predict the missing values.
precise, there is no reason to suspect that they consistently over or understate firms’ actual output. The measurement problems likely introduce ‘noise’ into the estimates, rather than a systematic bias.

The estimates of government resource rent collected from the firms are accurate enough to draw some conclusions with relative certainty. The estimates of rent collected by the government are shown as the series ‘government rent’ in Figure 2.4- Figure 2.11. The government’s share of total rent was highest during the period in which rents were lowest. In the years before 1940 rent was low on average but government timber revenues were positive. While the level of payments was not high, it remained steady and represented a significant share of the positive rent generated by the firms during this period.\footnote{This is not a result of the estimation of government timber charges, as a similar pattern appears in the data for the Victoria Lumber Company and the Columbia River Company.} During the period from 1940-59 total rent rose rapidly, but the rent which the government collected remained virtually unchanged. Almost none of the increase in total rent was captured in rising ‘stumpage’. The firm level estimates of government rent could be increased several times over without altering this result. This situation began to show signs of change toward the end of the firm level sample period. The data for MacMillan Bloedel, for example, show that increased stumpage charges became the largest share of the firm’s total rent around 1970. By 1976 they had fallen below the firm’s share again. A similar pattern was apparent for Crown Zellerbach. In general, the government did not collect a significant level of rent from the sample firms over the period from 1906-76.\footnote{While the government captured a larger share in earlier years, the level of rent was low on average.}

### 2.4.6 Total Firm Level Rent

The results of the preceding sections can now be combined to produce annual series of the total resource rent which each of the sample firms generated. This is the series ‘Total Rent’ in Figure 2.4-Figure 2.11. These estimates of total...
resource rent represent an upper bound because both the rent which labour and
government collect are upper bound figures.\textsuperscript{118} The data indicate that firms
retained the largest share of rent during the period when it appears to have
been relatively largest and was growing most steadily. Labour does not appear
to have retained a large share of resource rent over the full sample, although
there is some evidence that it secured a relatively more significant share by
the later years of the firm level sample. The government, as noted above, was
least successful at rent collection during the period of rapidly rising, relatively
high, rent from 1940-59. Like the rent which labour captured, rent which the
government collected eventually began to display some of the variability from
year to year apparent over the full sample in the rent which firms retained. It
is difficult to draw further conclusions from the distribution of rent at the firm
level because the components which both labour and government capture are
imprecisely estimated.\textsuperscript{119}

While these estimates are useful in terms of examining the distribution of
resource rent, they do not address the larger issue of what direct contribution
forest resource rent made to provincial income and growth. In order to draw
any conclusions of this nature from the firm level data they must be expressed
relative to an income measure. The output series for the firms (or employment
when output is not available) are used to determine the share of the industry
which each firm represented. A firm is assigned its respective share of industry
value added.\textsuperscript{120} I then calculate rent as a share of value added annually for each
firm. This measures the relative importance of resource rent in each firm’s net
contribution to aggregate provincial income. To obtain figures representative of
the share of rent in income itself these figures are multiplied by the share of forest

\textsuperscript{118} The rent each firm generated is expressed in constant dollars. Each component is deflated
as described in section 2.4.3 which deals with rent which the firms retained.

\textsuperscript{119} Aggregate industry figures are more precisely measured, so support more detailed consid­
eration of the distribution of rent.

\textsuperscript{120} Firm level data are not detailed enough to provide estimates of value added by the firm.
<table>
<thead>
<tr>
<th>Decadal Average</th>
<th>Rent/G.D.P.(%)</th>
<th>Rent/P.Y. (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1920-29</td>
<td>0.85</td>
<td></td>
</tr>
<tr>
<td>1930-39</td>
<td>-0.48</td>
<td>-0.46</td>
</tr>
<tr>
<td>1940-49</td>
<td>3.51</td>
<td>4.00</td>
</tr>
<tr>
<td>1950-59</td>
<td>6.81</td>
<td>7.79</td>
</tr>
<tr>
<td>1960-69</td>
<td>5.98</td>
<td>6.99</td>
</tr>
<tr>
<td>1970-76</td>
<td>2.94</td>
<td>3.29</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Selected Averages</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1920(26)-76</td>
<td>3.25</td>
<td>4.11</td>
</tr>
<tr>
<td>1940-59</td>
<td>5.17</td>
<td>5.89</td>
</tr>
</tbody>
</table>

Table 2.4: Forestry Resource Rent as a Share of Provincial Income: Firm Level Estimates, Decadal and Selected Averages

industry value added in provincial G.D.P. and personal income (P.Y.).\textsuperscript{121} This generates a range of estimates for the relative contribution of forest resource rent to provincial income annually. These estimates are presented in Figure 2.14 and Figure 2.15. I average these annual estimates across the sample firms to obtain an industry average.\textsuperscript{122} The industry averages, based on alternative measures of provincial income, are displayed in Figure 2.1. The data are summarized as decadal and selected averages in Table 2.4.

The results are surprisingly clear. The forest industry made little direct contribution to provincial income through resource rent before 1940. It contributed less than 1% of provincial income in the 1920s and reduced provincial income during the 1930s when rent was negative. The relative importance of the forest industry was greatest during the 1950s. During this decade forest resource rent accounted on average for 6.81% of provincial G.D.P. and 7.79% of personal income, compared with respective averages of 3.25% and 4.11% over the full

\textsuperscript{121} Annual data for provincial G.D.P. are available from CANSIM (Matrix 6950). Estimates were provided by R.C. Allen for years in which CANSIM data are unavailable (decadal figures are published in Allen [1].) Personal Income data are available in the CANSIM data base (Series D11710). G.D.P and personal income are available for B.C. from 1919 and 1926 respectively. These dates determine the starting points for measures of the relative contribution of rent to provincial income.

\textsuperscript{122} This procedure essentially assumes that the sample is representative of the industry in each year. The average is unweighted and arithmetic.
Figure 2.1: Forest Resource Rent as a Share of Provincial Income: Industry Average derived from Firm Level Estimates, 1919-76
sample. Resource rent from the forest industry peaked as a share of provincial income in 1951, at 13.43% of G.D.P. and 15.66% of personal income. The share of resource rent declined unevenly for the last 25 years of the firm level sample.

Judging by these results the direct contribution of the forest industry to provincial income does not appear to have been large. The figures above may even overstate the contribution of the forest industry to provincial income. I assume that all the rent which a firm generated contributed to provincial income. This is likely an overestimate due to significant foreign ownership of forestry firms operating in B.C. The results for the distribution of forestry rent indicate that firms retained a significant share, at least during the earlier years of the sample. The period during which firms most successfully captured rent includes the period during which it made the greatest contribution to provincial income. The contribution of resource rent to provincial income would be reduced if some of the rent retained by firms accrued to foreigners. The figures for the sample as a whole indicate that the direct contribution of the province’s forest assets accounted for a small share of total provincial income. At least directly the forest industry did not live up to the claims presented in the Introduction to this chapter.

These firm level estimates have some limitations. By the end of the sample the data for the individual firms become less highly correlated. This makes it increasingly difficult to derive general implications for the industry by averaging across the sample firms’ estimates. In addition, large multinational firms begin to dominate the industry. It is harder to obtain data from firm level sources which relate to forestry operations only, or predominantly in British Columbia. Firms for which data are available are likely to be large, or successful in order for their records to survive. The lack of assurance of a representative firm level

---

123 Ideally I would adjust the firm based estimates to take this into account. However, I feel the firm level distribution figures are too imprecise. I will return to this point for the industry level estimates as the distribution of rent can be estimated more precisely.
sample makes it desirable to try to make use of industry level data which are more comprehensive in coverage. In addition, estimates of the distribution of rent at the firm level are imprecise. I obtain more certain results with industry level data.

2.5 Measuring Rent at the Industry Level

The objective of this section is to use primarily aggregate data to provide estimates of resource rent for the forest industry. The distribution of resource rent and its direct contribution to provincial income and growth are assessed using these industry level estimates.

Complete provincial industry level data are readily available from roughly 1970, but not for earlier years. The most obvious problem is a lack of provincial industry capital stocks figures before 1955. I use an index of productive capacity to estimate the capital stock in the Wood and Logging industries, adjusting for changes in the nominal value of capital per unit of capacity with an index based on the firm level data. The capital stock for the Paper and Allied industries is based on Dominion Bureau of Statistics figures for the capital stock in the Pulp and Paper industry for the period from 1918-39. For the period from 1940-55 the estimated capital stock is based on data from the firm level sample. An additional difficulty with early data is that the Census of Manufactures data are not reported for the Wood and Paper and Allied industry aggregates, so data from their respective component industries must be aggregated.\(^{124}\) Details of data construction and adjustment may be found in Appendix A.

It may seem that the generation of industry level estimates eliminates the

\(^{124}\)Logging Industry principal statistics data are available only from 1926. As a rough proxy I assume that during the period from 1919-25 rent generated in the Logging Industry was equal to measured rent in the Wood Industry. This may overstate Logging Industry rent because firm level records suggest that integrated firms may have transferred logging profits to their milling operations. Results for the Forest and Logging Industries are calculated and presented incorporating this proxy.
need for the firm based estimates of the previous section. This is not really the case. The firm level data provide a valuable alternative estimate of the relative size of rent during a period for which no estimates other than my own exist. Consistency of the firm and aggregate results provides important confirmation of the general findings. The use of a firm level sample provides an independent alternative to circumvent the problem of incomplete industry level data. Data on capital stocks and the cost of purchased services are also possibly more accurate at the firm level. In general, the use of broadly based evidence reinforces confidence in the reliability of results.

### 2.5.1 Defining Rent at an Industry Level

Forest rent is defined in the same general terms at an industry level as it is at the firm level. Rent is the difference between the revenue generated by the production of the resource good and the costs of its production. This is the definition of Section 2.3. At the industry level this is more precisely defined as follows:

\[
R = P_QQ - wL - iK - P_MM - P_VV
\]  

(2.15)

where \( R \) is the resource rent for the industry, \( P_QQ \) is the industry revenue from production of the resource good, \( wL \) is the cost of labour employed at the opportunity wage, \( iK \) is the opportunity cost of capital employed, \( P_MM \) is the cost of intermediate goods and \( P_VV \) is the cost of purchased services.

One advantage of using industry level data is that it eliminates some of the complications which arise in firm level estimation. The definition above is relatively easy to implement with industry level data. The estimate of rent for the forest industry is derived as the sum of rent generated in each of the component industries; the Logging, Wood and Paper and Allied Industries.\(^{125}\) Census

---

\(^{125}\)While some data from the sample firms are used to estimate the industry capital stocks this connection would not be sufficient to generate consistent results by construction.

\(^{126}\)This avoids the problems of transfer pricing discussed earlier. The rent figure is an upper...
of Manufactures figures for industry value added provide industry revenue net of materials costs.\textsuperscript{127} Data on the number of employees from the same source are used to generate the appropriate cost of labour. The opportunity wage is not the market wage of labour in the forest industry, but its wage net of any rent capture. Following the discussion of this issue in Section 2.3.4 dealing with rent captured by labour at the firm level, the opportunity wage is considered to be the wage in 'other manufacturing' in B.C.\textsuperscript{128} The employees in the forest industry are assigned this wage after 1935, the year when the I.W.A. achieved its first wage concession. Before 1985, Census of Manufactures figures for wages and salaries are subtracted from value added to measure labour's opportunity cost.

There are two complications in the estimation of industry level rent. The first arises from the absence of capital stock data for the period before 1955. Without this the capital cost component cannot be measured. Estimates of the capital stock are constructed for the Logging, Wood and Paper and Allied Industries. Details of the capital stock construction may be found in Appendix A. The annual capital cost is estimated using the rental rate adjusted for depreciation expenses as described in detail in Section 2.4.3.

The second difficulty is that the Census of Manufactures provides no data on the cost of purchased services. I adjust the value added figures for each component industry to net out these costs. The adjustment exploits the fact that G.D.P. at factor cost is net of the cost of purchased services.\textsuperscript{129} I use the bound on resource rent as it may also reflect rent attributable to market power, location, etc.\textsuperscript{127} Census of Manufactures data include the Principal Statistics for the Wood, Logging and Paper and Allied Industries. Further details are available in Appendix A. Materials costs for the Logging industry include government timber charges after 1963 so these must be added to Logging industry value added to calculate rent.\textsuperscript{128} I again assume that workers in the Wood industry did not capture rent through wages. Their opportunity wage is assumed to be the wage they actually earned.\textsuperscript{129} See Firestone [69], pp. 293-294, or Urquhart [164], pp. 395-401 for a discussion of the adjustment of census of manufactures value added figures in the calculation of G.D.P. at factor cost.
ratio of industry G.D.P at factor cost to the Census of Manufactures value added at a national level to determine the share of value added which represents the cost of purchased services annually.\textsuperscript{130} I assume that the share of value added which represents these costs is the same in B.C. as the national figure and deduct this share of value added to measure the cost of purchased services.\textsuperscript{131} This is the final element required to estimate total forest industry rent for B.C. at the industry level. The results for the forest industry and its three component industries are shown in Figure 2.16- Figure 2.19 as the series ‘Total rent’.\textsuperscript{132}

As at the firm level determining the distribution of forest rent between industry, labour and government is an essential aspect of measurement. At the aggregate level it is easier to establish this distribution. The primary reason is that accurate figures for government timber revenue are available at an industry level. The figure for total timber charges levied under the various existing arrangements (which firms rarely report) is obtainable for the industry as a whole from the Forest Service Annual Report [13]. All revenues from timber related charges are included.\textsuperscript{133} This is the measure of the resource rent which the government collected.\textsuperscript{134} It is the series ‘Government rent’ in Figure 2.16.

The resource rent which labour captured is calculated in the same fashion as at the firm level described in Section 2.4.4. I assume that the full differential in

\textsuperscript{130}This share must be calculated with national level data because provincial G.D.P. at factor cost is not available at an industry level over the full sample period.

\textsuperscript{131}I calculate separate adjustment series for the Wood and Paper and Allied Industries. It is not possible to use the same adjustment technique for the Logging Industry due to a discrepancy in definition between the national accounts and the Census of Manufactures. I assume that the cost of purchased services for logging is the same share of value added as for the Wood Industry.

\textsuperscript{132}Industry rent is calculated in nominal terms and deflated with the Canadian G.N.E. deflator to obtain real rent in constant 1991 dollars.

\textsuperscript{133}The figure for government forest rent collection does not include items such as range fees, scalers’exam fees, etc.

\textsuperscript{134}At different points during the sample forest related taxes were also levied on the industry. These do not appear as part of the Forest Service revenue figures. As noted in Section 2.4.5 these taxes raised revenue for specific services, such as fire protection, or provided minor revenue compared with the direct timber charges. Their absence from the measure of government rent collection has no substantive effect on the results.
average annual earnings after 1935 between forest industry wages and wages in 'other manufacturing' in B.C. represented resource rent capture. The aggregate rent captured by labour in a component forest industry is the respective average earnings differential per employee multiplied by the total number of employees in that industry. I use this method to estimate rent capture by labour in the Logging and Paper and Allied Industries. I assume that labour in the Wood Industry captured no rent. As with the firm level estimates, this approach provides an upper bound on the resource rent which labour captured. It is displayed as the series ‘Labour rent’ in Figure 2.16-Figure 2.19.

The rent which firms in the industry retained is the residual once rent which the government and labour captured is subtracted from total industry rent.

2.5.2 Industry Level Results

First consider the real level of forest rent. It is apparent from Figure 2.16 that the results at the industry level are qualitatively similar to those at the firm level. Rent in the industry as a whole averaged close to zero during the period before 1940. The level of rents rose sharply after 1940. There was a strong upward trend, apparent in the rent of all three component industries, from this point through the early 1950s. After this there was no apparent upward trend. Rent became increasingly volatile, particularly from the late 1960s. In some years after the late 1980s measured rent was negative. As was the case with the firm level estimates the only period of strong growth in rents was from roughly 1940-59.

Results for the distribution of rent are very similar to those found in the firm level sample. There does not appear to be strong evidence supporting the view that unions successfully captured a significant share of the rent generated in the industry until after 1970. The share of rent which labour captured reached a maximum of 30% of total industry rent during the years from 1935 to 1970.
It was far below this in most years. However, the rent which labour captured rose to become a more significant share from roughly 1970. Labour captured an average of 37% of positive rent from 1970-92. Although the rent which labour retained became more cyclical from roughly the same point labour still received payment in excess of its opportunity wage when rent was negative. The evidence for rent capture by labour is not especially strong for the sample as a whole. This is particularly true because the estimate of rent which labour captured probably represents an upper bound. One conclusion which can safely be stated is that labour did not capture a significant share of total rent during the period of strongest growth in rent. Only near the end of the sample when rent appears to have been falling did labour’s share begin to rise.

The results for the share of rent which government collected are also similar to those at the firm level. During the years before 1940, while government timber charges were not large, on average they amounted to almost all the rent in the industry. This is because total rent was very volatile and often negative during these years. In contrast, while total rent increased sharply after 1940, the rent which the government collected rose very slowly. From 1940-60 government timber charges did not account for more than 20% of the total industry rent, at a maximum. Over this same period the average share of government rent in total rent was only 11%. The situation appears to have changed from the late 1960s. Government timber charges rose to become a much more important component of total rent. Government rent was also more cyclical and closely correlated with fluctuations in total rent. On average timber charges accounted for 37% of positive rent earned during the period from 1970-92. In addition to this share of positive rent earned the government collected significant timber revenues when rent was negative. For most of this period the government calculated its stumpage charges by evaluating industry labour costs at the market wage and not at an opportunity cost. The government thus appears to have been very
effective at capturing what it considered to be resource rent by the latter years of the sample. The same cannot be said for the sample period as a whole. As was the case with the firm level data, government was least successful at rent collection during the period from 1940-59 when rent was rising rapidly.

An advantage of the industry level analysis is a longer time series for forest industry rent. Extending the sample period from 1918-92 reveals some changes in the distribution of rent which were only hinted at in the firm sample. During the strong growth years of 1940-59 on average government and labour combined captured approximately 30% of rents. In the years after 1970 the corresponding figure was 71% of positive rent earned. In addition there were a number of years during which government and labour together collected more than the total industry rent. This meant firms retained negative rent during some years in which positive rent was generated. The situation was obviously very different at the end of the sample relative to the years from 1940-59 when firms were able to capture most of the increased rent in the industry. By the sample endpoint in 1992 government and labour extracted virtually all the rent in the industry leaving almost none (and sometimes even less than that) to be retained by firms. There is little to indicate that firms in B.C.'s forest industry were receiving an implicit subsidy by retaining resource rent.

How large a contribution does forest resource rent make to provincial income measures? This is the central question I wish to address with the industry level estimates of rent. As with the firm level estimates the measure of rent is expressed as a share of provincial G.D.P. and aggregate personal income (P.Y.) to measure the relative importance of its contribution. Figure 2.2 displays the share of total forest rent in the provincial income measures. Table 2.5 summarizes the results as decadal averages.

These estimates also confirm the findings at the firm level. Forest resource rent does not appear to make a large direct contribution to provincial income.
<table>
<thead>
<tr>
<th>Decadal Average</th>
<th>Rent/G.D.P.(%)</th>
<th>Rent/P.Y.(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1920-29</td>
<td>1.93</td>
<td></td>
</tr>
<tr>
<td>1930-39</td>
<td>-0.16</td>
<td>0.04</td>
</tr>
<tr>
<td>1940-49</td>
<td>5.59</td>
<td>6.41</td>
</tr>
<tr>
<td>1950-59</td>
<td>7.91</td>
<td>9.03</td>
</tr>
<tr>
<td>1960-69</td>
<td>4.16</td>
<td>4.86</td>
</tr>
<tr>
<td>1970-79</td>
<td>3.23</td>
<td>3.56</td>
</tr>
<tr>
<td>1980-89</td>
<td>0.24</td>
<td>0.27</td>
</tr>
<tr>
<td>1990-92</td>
<td>-2.27</td>
<td>-2.21</td>
</tr>
</tbody>
</table>

Table 2.5: Forest Resource Rent as a Share of Provincial Income: Industry Level Estimates, Decadal Averages

Figure 2.2: Forest Resource Rent as a Share of Provincial Income: Industry Level Estimates, 1919-92
over the sample period as a whole. During both the period before 1940 and following 1970 the average contribution of the forest industry through resource rent was negligible. Resource rent was volatile during these periods. In some years rent was large and positive which meant that the industry appeared to make a significant contribution to provincial income via rent. In other years substantial negative rent was realized which reduced income. The period from 1940-59 was when rent made the greatest contribution to provincial income measures. As with the firm level estimates the 1950s were the most important decade in terms of the relative size of forest rent. It peaked as a share of provincial income in 1951 at 11.1% of G.D.P. and 12.9% of personal income. These figures are considerably higher than the respective averages for the decade. Rent as a share of provincial income declined unevenly from its peak in 1951 to the sample endpoint in 1992. The direct importance of the forest industry, in terms of rent generation, achieved its zenith by midcentury.

The results for the distribution of rent show that during the period in which rent was relatively largest firms in the industry retained the largest share. The presence of foreign ownership in the B.C. forest industry is important to consider at this point. The estimates above are based on the assumption that all the rent which firms retained contributed to provincial income. As mentioned in Section 2.4.6, when firms are wholly or partially foreign owned, some of these retained rents may be captured by foreigners. This would reduce the potential contribution to provincial income. How much would the results change if this effect was accounted for? I generate a series of hypothetical provincially retained rent by assuming that 50% of the rent which firms retained accrued to foreign owners of capital.\(^{135}\) The contribution of this 'retained rent' to provincial income

\(^{135}\)This is a somewhat arbitrary figure. However, it is not unreasonable. Pearse [138], pp. 48, indicated that 30-40% of timber rights and manufacturing capacity were fully foreign owned. Four of the five firms with the largest shares of B.C.'s annual timber harvest (allowable annual cut) had minority foreign ownership. Examination of Annual Reports for MacMillan Bloedel indicated that even this 'B.C.' company was 15% foreign owned. If all firms not fully foreign
Table 2.6: Forest Resource Rent Retained in B.C. as a Share of Provincial Income: Industry Level Estimates, Decadal Averages

<table>
<thead>
<tr>
<th>Decadal Average</th>
<th>Rent/G.D.P. (%)</th>
<th>Rent/P.Y. (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1920-29</td>
<td>1.41</td>
<td></td>
</tr>
<tr>
<td>1930-39</td>
<td>0.45</td>
<td>0.60</td>
</tr>
<tr>
<td>1940-49</td>
<td>3.43</td>
<td>3.94</td>
</tr>
<tr>
<td>1950-59</td>
<td>4.98</td>
<td>5.68</td>
</tr>
<tr>
<td>1960-69</td>
<td>2.85</td>
<td>3.33</td>
</tr>
<tr>
<td>1970-79</td>
<td>2.38</td>
<td>2.63</td>
</tr>
<tr>
<td>1980-89</td>
<td>0.72</td>
<td>0.76</td>
</tr>
<tr>
<td>1990-92</td>
<td>-0.43</td>
<td>-0.44</td>
</tr>
</tbody>
</table>

is displayed in Figure 2.3 and summarized as decadal averages in Table 2.6.

In general, potential rent capture by foreign owners does not dramatically alter the results. This is because over much of the sample rent did not make a large contribution to provincial income. The presence of foreign ownership matters most during the period from 1940-59. During this period when rent was relatively largest firms retained the majority of rent. When firms export a share of the rent which they retain to foreign owners the larger the share of total rent which firms retain the greater the impact on the total rent retained in the province. The contribution of rent to provincial income is thus reduced most by adjusting for foreign ownership in the industry during the 1950s. Provincially retained rent accounts on average for only 4.98% of G.D.P. and 5.68% of personal income as opposed to 7.91% and 9.03% respectively when total rent is used. The estimates show that, while forest industry rent at times made a significant individual contribution to provincial income, the income from this natural asset did not raise the level of income substantially over the full sample period.

How does rent affect the growth of provincial income over the sample? I use a simple counterfactual to try to place some bound on this measure. I construct the counterfactual income measures (G.D.P.(cf) and P.Y.(cf)) by subtracting owned had such a level of foreign investment, then the share of foreign ownership in the provincial industry would have been in the range of 38-48%.
Figure 2.3: Forest Resource Rent Retained in B.C. as a Share of Provincial Income: Industry Level Estimates, 1919-92
<table>
<thead>
<tr>
<th>Decadal Average</th>
<th>G.D.P. (%)</th>
<th>G.D.P.(cf) (%)</th>
<th>Contribution of Rent (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1920-29</td>
<td>5.07</td>
<td>5.12</td>
<td>1.0</td>
</tr>
<tr>
<td>1930-39</td>
<td>1.04</td>
<td>0.90</td>
<td>13.5</td>
</tr>
<tr>
<td>1940-49</td>
<td>5.68</td>
<td>5.52</td>
<td>2.8</td>
</tr>
<tr>
<td>1950-59</td>
<td>4.29</td>
<td>4.50</td>
<td>-4.9</td>
</tr>
<tr>
<td>1960-69</td>
<td>5.57</td>
<td>5.61</td>
<td>-0.7</td>
</tr>
<tr>
<td>1970-79</td>
<td>5.71</td>
<td>5.52</td>
<td>3.3</td>
</tr>
<tr>
<td>1980-89</td>
<td>2.60</td>
<td>2.78</td>
<td>-6.9</td>
</tr>
<tr>
<td>1990-92</td>
<td>1.61</td>
<td>2.01</td>
<td>-24.8</td>
</tr>
<tr>
<td>Selected Averages</td>
<td>4.40</td>
<td>4.45</td>
<td>-1.1</td>
</tr>
<tr>
<td>1940-51</td>
<td>5.93</td>
<td>5.60</td>
<td>5.6</td>
</tr>
</tbody>
</table>

Table 2.7: Actual vs. Counterfactual G.D.P Growth and Share of Growth due to Rent: Decadal and Selected Averages

the estimate of forest industry rent retained in the province in each year from the corresponding actual income figure. The difference between the growth of this hypothetical income measure and the growth of the actual income measure captures growth attributable to forest industry rent. I express this as a percentage of actual growth to measure the relative contribution of forest rent to provincial income growth.

This counterfactual can only establish the direct contribution of rent itself to income growth since it is a partial equilibrium measure. In other words, the calculation does not allow other variables which determine income to adjust in response to the counterfactual changes in rent. This assumption and the use of provincially retained rather than total rent produce a lower bound estimate of the influence of forest rent on provincial income growth. Figures for decadal and selected averages are given for G.D.P in Table 2.7 and for personal income in Table 2.8.

The results of this simple counterfactual exercise are quite interesting. Perhaps the most surprising result is that for the sample period as a whole income
<table>
<thead>
<tr>
<th>Decadal Average</th>
<th>Average Annual Growth:</th>
<th>P.Y. (%</th>
<th>P.Y.(cf) (%</th>
<th>Contribution of Rent (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1926-29</td>
<td>2.24</td>
<td>2.33</td>
<td>-4.0</td>
<td></td>
</tr>
<tr>
<td>1930-39</td>
<td>1.54</td>
<td>1.39</td>
<td>9.7</td>
<td></td>
</tr>
<tr>
<td>1940-49</td>
<td>6.39</td>
<td>6.23</td>
<td>2.5</td>
<td></td>
</tr>
<tr>
<td>1950-59</td>
<td>4.29</td>
<td>4.53</td>
<td>-5.6</td>
<td></td>
</tr>
<tr>
<td>1960-69</td>
<td>5.26</td>
<td>5.29</td>
<td>-0.6</td>
<td></td>
</tr>
<tr>
<td>1970-79</td>
<td>5.66</td>
<td>5.46</td>
<td>3.5</td>
<td></td>
</tr>
<tr>
<td>1980-89</td>
<td>2.81</td>
<td>2.99</td>
<td>-6.4</td>
<td></td>
</tr>
<tr>
<td>1990-92</td>
<td>1.65</td>
<td>2.04</td>
<td>-23.6</td>
<td></td>
</tr>
<tr>
<td>Selected Averages</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1926-92</td>
<td>4.71</td>
<td>4.77</td>
<td>-1.3</td>
<td></td>
</tr>
<tr>
<td>1940-51</td>
<td>6.02</td>
<td>5.63</td>
<td>6.5</td>
<td></td>
</tr>
</tbody>
</table>

Table 2.8: Actual vs. Counterfactual Growth of Personal Income and Share of Growth due to Rent: Decadal and Selected Averages

measures grew faster in the absence of rent. This was caused by the relative decline in rent from 1951. Whenever resource rent grew more slowly than other components of provincial income it acted as a drag on the growth rate of provincial income. The magnitude of this effect was very small for the full sample period. Rent accounted for less than 1.5% of total income growth.

Resource rent was extremely volatile from year to year. Its impact on income growth appears larger the shorter the time horizon over which its influence is measured. Examination of the average decadal contributions to growth in comparison with the full sample result illustrates this point. The period during which rent had the greatest influence on growth was the 1930s. This is because the recovery of rent, which began in 1933, was faster than that of the rest of provincial income. Resource rent was a leading component of provincial growth during this period, as it was for the following decade of the 1940s. After this rent grew more slowly than the rest of the provincial economy with the exception of the 1970s. In general, the influence of rent on aggregate income growth appears limited. Even during the period from 1940-51, when forest industry
rent was relatively largest and growing fastest, it accounted for only 5.6% of G.D.P. growth and 6.5% of personal income growth.

Thus far the results are for only aggregate income. Work by other authors, which I discussed in Section 2.1, considers the contribution of rent to per capita income measures. The results for the share of rent in G.D.P. and personal income carry over directly to the corresponding per capita income measures. The results for the growth rates are qualitatively similar to those for aggregate income growth, but differ quantitatively. I perform the counterfactual experiment described above using per capita measures of rent and income to assess the contribution of forest industry rent to per capita income growth for B.C.

Again, the decline in rent from midcentury caused forest rent to marginally slow per capita income growth relative to the counterfactual over the full sample period. Slow growth of rent reduced potential growth by 3.2% and 3.1% for G.D.P and personal income per capita respectively from 1926-92. For the sample period as a whole, rather than leading per capita growth, growth in forest resource rent per capita lagged behind that of other components of per capita income. There were periods during which forest rent per capita did grow faster than other elements of per capita income measures. During the period from 1940-51 forest rent accounted for 11.6% of the growth in per capita G.D.P. and 13.3% of the growth in personal income per capita. While the forest industry did provide a significant direct contribution to per capita income and its growth during this period of relatively high and rising rent, the same cannot be said of the sample as a whole.

Confidence in these results is reinforced by their consistency. First consider the relationship between the estimates at the firm and industry levels. I present the decadal averages for the share of rent in provincial G.D.P based on the firm and industry level estimates in Table 2.9. Results for the share of forest industry rent in personal income are consistent across the firm and industry
Table 2.9: Comparison of Firm Based and Industry Level Estimates of the Share of Forest Industry Rent in G.D.P.

<table>
<thead>
<tr>
<th>Decadal Average</th>
<th>Firm Rent/G.D.P. (%)</th>
<th>Industry Rent/G.D.P. (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1920-29</td>
<td>0.85</td>
<td>1.93</td>
</tr>
<tr>
<td>1930-39</td>
<td>-0.48</td>
<td>-0.16</td>
</tr>
<tr>
<td>1940-49</td>
<td>3.51</td>
<td>5.59</td>
</tr>
<tr>
<td>1950-59</td>
<td>6.81</td>
<td>7.91</td>
</tr>
<tr>
<td>1960-69</td>
<td>5.98</td>
<td>4.16</td>
</tr>
<tr>
<td>1970-76</td>
<td>2.94</td>
<td>3.23</td>
</tr>
</tbody>
</table>

levels. These results are for total rent which the forest industry generates. Both include any rent which may have accrued to foreign owners of capital. The figures tell a similar, now familiar story. Rent made relatively little contribution to provincial income before 1940. Its importance rose during the period from 1940-59. The peak share of rent in G.D.P occurred in 1951 in both the firm based (13.4%) and industry level (11.1%) estimates. Rent declined as a share of provincial income during the period from 1960-76 according to both estimates. While the results based on the firm sample and the industry level data are not identical, they are remarkably similar.136

My results are internally consistent and they reflect the findings of other authors. It is not possible to compare my results exactly with those of Copithorne [50] or Percy [140] because of differences in the construction of the rent estimates, however, the results are broadly similar.137 Copithorne [50] estimated

136 The smaller firm based estimates are a little surprising. In Section 2.4.2 I suggest that the sample firms are more likely to earn rent than omitted firms, which should result in an upward bias. Unfortunately the firm sample is not perfectly representative of the industry. Pulp and paper operations are over represented. These use low quality timber and consequently generate relatively little rent. This likely explains the lower figures for the firm sample relative to the industry level estimates.

137 Copithorne [50] and Percy's [140] results are not directly comparable with one another either. Percy included only the Logging and Wood Industries in his estimate, while Copithorne also included the Paper and Allied Industries. In addition, Copithorne adjusted for rent retained by foreign investors. The rent figures which I calculate to compare with these authors' results reflect these differences.
that forest industry rent averaged $192 per capita annually for 1970-73 and it accounted for 24% of the differential between average per capita income in B.C. and the Canadian average. The corresponding figures for my estimate are $132 and 17%. Percy [140] estimated that the Logging Industry generated rent of $680 million in 1979, while rent for the Logging and Wood industries combined was $1,112 million. Government captured 41.2% of this total rent. I estimate 1979 Logging Industry rent at $614 million and rent in the Logging and Wood Industries combined at $1,001 million. I estimate that government collected 37% of this total rent. These comparisons indicate that my results are generally similar to existing estimates.

While the results above are of the same general magnitude, there are some important differences between the estimates. Neither Copithorne [50] nor Percy [140] deducted the cost of purchased services from their estimates of resource rent. This results in an overstatement of the resource rent which the forest industry generated. In addition, both Percy and Copithorne used the B.C. manufacturing wage to measure the opportunity cost of labour exclusive of resource rent. However, this average includes the wages of employees in the Wood and Paper and Allied Industries who were assumed to capture resource rent through union bargaining. I use the wage in ‘other manufacturing’ in B.C. (manufacturing exclusive of forest related industry) to measure the opportunity cost of labour in my rent calculations. Both Copithorne and Percy assumed that labour in the Wood Industry captured resource rent through wages. Based on the analysis of Section 2.4.4, I do not make this assumption. The results of other researchers, such as Denny Fuss and May [56], Doiron [59] and Schwindt and Heaps [152],

\[138\] My estimate of the relative importance of forest industry rent in explaining per capita income differentials is a ‘best guess’. I cannot adjust the national average figure in Copithorne’s calculation to regenerate his result precisely using my estimate of forest rent. Instead I use the difference between his figures and my own to adjust his estimate proportionally. Note that Copithorne [50], pp. 86-87 reports results only for all resource windfalls. I derive the contribution of forest industry rent alone from his disaggregate results.
generally support the view that labour in this industry captured little or no resource rent. These are the main differences between my estimate of forest rent and these existing estimates.\(^{139}\)

The general conclusions which can be drawn from the results of this chapter support the research of other authors. For example, Grafton and Nelsons' [77] view that the provincial government is relatively effective at resource rent collection is supported by my findings. The time series evidence which I generate helps to rationalize conflicting evaluations of the contribution of the forest industry to the provincial economy. Substantial rent was generated during the 1970s, the period during which Copithorne and Percy made their calculations. During the period from 1988, when Schwindt and Heaps [152] evaluated the contribution of the forest industry, little rent was generated.

### 2.6 Conclusion

The view that the B.C. forest industry has provided a critical contribution to provincial income and growth is widely held. As the quotes in the introduction to this chapter illustrate, this belief is not restricted to participants in the industry, nor has it been expressed during only a limited period of the province's history. The objective of this chapter was the construction of an empirical measure of the contribution of the provincial forest industry to income and growth. Resource rent captures the direct contribution of the resource itself to provincial income. This is only a partial equilibrium measure because the level of rent may influence other economic variables and consequently affect provincial income indirectly. However, Percy [140] and Norrie and Percy [132] note that only returns to immobile factors influence per capita income in the long run for a small open

\(^{139}\)I also calculate the cost of capital more crudely than these authors. I cannot consider structures, machinery and equipment separately and my estimates are based on the historic cost of capital. Consistency over time and across the firm and industry levels precludes more sophisticated estimation of the cost of capital. My estimates reflect a lower bound for the true cost of capital.
economy. In this context, the importance of rent looms larger in evaluating the forest industry’s contribution to provincial income.

I constructed measures of forest industry rent using data from a firm level sample and aggregate industry level data. I estimated both the level of rent and its distribution between firms, government and labour. A set of consistent general results emerged. During the industry’s early history rent was relatively small and on average government collected a significant share. Rent rose rapidly from roughly 1940 through the early 1950s. During this phase government’s share fell significantly. Organized labour also did not succeed in capturing a large share of industry rent during this period. This pattern was broken by a number of changes. Forest industry rent became increasingly volatile beginning in roughly the 1960s. Any apparent trend in the level of rent was negative. Government captured a more significant share of rent over time. Its timber revenue became much more cyclical, reflecting the variability of total rent. The estimate of rent which labour captured fluctuated slightly. By the sample endpoint labour appeared to capture a significant share of rent.\textsuperscript{140} In relative terms rent declined over the second half of the century.

The main results of the chapter relate to the size of the direct contribution of forest rent to provincial income and the estimated impact on provincial growth. The results are unexpected because they do not fully support the conventional wisdom regarding the role of the forest industry in the B.C. economy. Over the period from 1919-92 forestry resource rent was a relatively small component of provincial income measures. In addition, it made a negligible contribution to both aggregate and per capita provincial income growth. These results for

\textsuperscript{140} The rent which labour captured is an upper bound and crudely measured as there is no distinction between occupational skills or disamenity differentials and resource rent capture. More detailed analysis based on microdata is necessary to draw precise conclusions about the capture of forest industry rent by labour. It is notable that even employing the upwardly biased estimates of rent capture by labour, it is only in latter years of the sample when this rent was a significant share of the total.
the period as a whole were partially driven by the decline in resource rent from roughly mid-century. Rather than driving the growth of the provincial economy, growth in the direct contribution of the forest industry lagged behind that of other components of provincial income.

Even if the period during which rent was relatively largest and increasing most rapidly is isolated, rent peaked at a maximum of 11.1% of provincial G.D.P. and 12.9% of personal income. Forestry rent accounted directly for 5.7% of G.D.P. growth and 11.8% of per capita G.D.P. growth during this same period from 1940-51.\(^{141}\) This is not an insignificant contribution, however, it leaves generous room for other forces to have influenced provincial income and growth. At least in terms of their direct contribution the forests of British Columbia do not appear to have been: "...the broad base upon the continuance of which depends the prosperity and high standard of living of this Province."\(^{142}\)

When periods of shorter duration were examined the relative importance of the forest industry appeared larger. This was due to the extreme volatility of the rent which the industry generated. Relative to G.D.P. rent varied a great deal from year to year. At short horizons rent appeared to account for a large share of the evolution of provincial income. Over the longer term, however, the growth of G.D.P. was primarily determined by other factors. If rent measures the long run contribution of the forest industry to per capita income growth in the province, then over the sample period as a whole, this contribution has not been large.

While the direct measure of the importance of the forest industry in the provincial economy was smaller than anticipated it may be that the industry's influence arose through general equilibrium effects. In the short run there were likely additional general equilibrium effects generated in the provincial economy.

\(^{141}\) The corresponding figures for personal income and personal income per capita are 6.5% and 13.4% respectively.

\(^{142}\) G.M. Sloan, see Sloan [157], pp.8-9.
through the operation of the forest industry. There is also potential for the forest industry to have produced long run general equilibrium effects if extensive and intensive growth were related. I explore this potential in Chapter 4, addressing the issue of whether the industry influenced provincial growth by acting as a leading export sector. Before considering alternative channels through which the forest industry may have influenced the provincial economy in Chapter 4. I investigate the forces responsible for the observed behaviour of rent in the next chapter.
Figure 2.4: Victoria Lumber Company: Resource Rent and Distribution, 1906-35
Figure 2.5: Columbia River Lumber Company: Resource Rent and Distribution, 1913-26
Figure 2.6: Canadian Western Lumber Company: Resource Rent and Distribution, 1913-53
Figure 2.7: Bloedel Stewart and Welch: Resource Rent and Distribution, 1918-51
Figure 2.8: B.C. Pulp and Paper Company: Resource Rent and Distribution, 1926-49
Figure 2.9: Powell River Company: Resource Rent and Distribution, 1943-58
Figure 2.10: MacMillan Bloedel: Resource Rent and Distribution, 1945-76
Figure 2.11: Crown Zellerbach Canada: Resource Rent and Distribution, 1954-76
Figure 2.12: Excess Rates of Return to Capital: B.C. Sample Forest Industry Firms, 1906-76
Figure 2.13: Excess Returns: B.C. Sample Forestry Firms' Average vs Stelco, 1906-76
Figure 2.14: Forest Resource Rent as a Share of G.D.P.: Firm Level Estimates, 1919-76
Figure 2.15: Forest Resource Rent as a Share of Personal Income: Firm Level Estimates, 1926-76
Figure 2.16: Rent in All Forest Industries, 1919-92
Figure 2.17: Rent in Logging Industry, 1919-92
Figure 2.18: Rent in Wood Industry, 1919-92
Figure 2.19: Rent in Paper and Allied Industry, 1919-92
Chapter 3
Resource Rent in the B.C. Forest Industry: Driving Forces

3.1 Introduction

In the previous chapter I generated a time series of resource rent for B.C.'s forest industry which spans most of the 20th century. This evidence revealed a pattern of little or no rent before the end of the Great Depression followed by rapidly rising rent through the mid-century mark and finally a secular decline. Forest industry rent was highly volatile despite following these rough trends. Rent was highly variable from year to year over the entire century but much more so before W.W. II and after 1970. The objective of this chapter is to investigate the forces driving the observed behaviour of rent.

In Section 3.2 I consider the general results of Chapter 2 and make some preliminary identification of the forces underlying them. While there was considerable variation from year to year in both output and rent per unit of timber harvested, the broad trends in aggregate rent reflected changes in the shadow value of B.C. timber.

I return in Section 3.3 to the stylized model of renewable resource rent of Chapter 2 to identify the factors which theoretically influence the level and evolution of B.C. forest rent. I expand the basic model of Chapter 2 to include technological change and uncertainty (both on the demand side and in the evolution of technology.) This provides a more complete and realistic theoretical framework. In the previous chapter the theory was introduced largely as a means of deriving a consistent definition for aggregate resource rent. In this chapter I
focus on the level and evolution of the shadow value itself in order to investigate the behaviour of rent over time. The evolution of rent is determined by a number of variables. Firms choose their output to maximize the expected value of their profits. A necessary condition for this is that the shadow value of the resource on which their production is based evolves in a way which provides a return competitive with other assets. Consequently the natural growth of the resource, the return on alternative assets, factors reflecting undiversifiable risk and the effect of depletion of future costs all affect the behaviour of rent over time.

With the theoretical structure in place, I turn in Section 3.4 to a review of the evidence on rent in its historical context. In Section 3.5 I focus on assessing the empirical importance of the identified forces. I first examine the level of the average rent per unit of timber harvested in B.C. and the movements in price and average cost which determine it. I then address the evolution of the average rent over time. Final conclusions close the chapter in Section 3.6.

I find that the behaviour of aggregate rent for B.C. timber reflected a combination of forces. The broad trends in rent were the result of similar movement in value of rent per unit of B.C. timber. The rapid rise in rent during the period from 1940-51, identified in Chapter 2, reflected a marked increase in the price of forest products. The secular decline from midcentury was the result of both a declining output price and rising harvesting costs. Price movements were primarily driven by forces exogenous to the B.C. industry, but may also have been influenced by the quality of timber harvested in B.C. The behaviour of cost reflects firms' attempts to choose output to maximize their expected returns. Real costs are theoretically a function of output, the state of technology,

---

While I examine the level and rate of change in the 'average shadow value' of B.C. timber individually, they are theoretically jointly determined. The movements in cost which determine the level of rent (in conjunction with the output price) reflect an endogenous profit maximizing choice of output by the firms. A necessary condition is that the return on the resource appreciates at a rate comparable with other assets.
and the availability of the resource.

The B.C. forest industry shifted gradually from the exploitation of stands of temperate rainforest on the coast to harvesting primarily in the interior of the province. The industry began by cutting timber which was located in easily accessible areas such as river valleys but progressively drew timber from increasingly remote locations. To investigate the possibility that this transition influenced cost I regress real harvesting costs for the Logging Industry on current output, the level of technology and the cumulative harvest. The real cost of harvesting per unit of timber rose at an average of 4.83% over the period from 1926-92. The estimated effect of technological change was to lower costs by an average of 0.566% annually. Depletion, as measured by the cumulative harvest, accounted for an estimated increase of 3.792% annually. This provides some evidence that the secular decline in the average rent per unit of B.C. timber reflected depletion of the resource.

A striking characteristic of B.C. forest rent is its variability from year to year. The theoretical model identifies variables which should determine the dynamic behaviour of the shadow value of B.C. timber. I regress the percentage change in the average rent per unit of B.C. timber on these variables to investigate the forces driving the observed variation in rent. I find that the variables which reflect market risk are most significant. This suggests that forest resource rent in B.C. included a substantial premium for risk in order for the expected return on the resource to compare favourably with other assets. It also implies that B.C. forest rent was highly sensitive to market conditions which were beyond the influence of the industry during the sample period.

3.2 Reviewing the Empirical Evidence

The main results from Chapter 2 indicated that there was little or no rent before the end of the Great Depression, followed by rapidly rising rent through the mid-
century mark and finally a secular decline.\textsuperscript{2} In addition, rent was highly variable from year to year, particularly during the period preceding W.W. II and from 1970. In this chapter the focus is on identifying the forces which underlie these results of Chapter 2.

First consider the results on the relative size of forest industry rent. Recall that aggregate forest industry rent is the sum of marginal rent on each unit of timber harvested. Changes in the measure of aggregate rent over time may be driven by changes in either marginal rent, the quantity of timber harvested, or both. To investigate the relative contribution of these two possible forces I examine the changes in forest industry output and provincial income. I begin with these variables as data are readily available. I construct indices of forest industry output and real G.D.P. to compare the evolution of the two variables over time.\textsuperscript{3} While forest industry output shows considerably more variability from year to year than provincial G.D.P. the two variables appear to grow at roughly the same rate. I plot the difference between the growth rate of provincial G.D.P. and forest industry output in Figure 3.2. In years when provincial income grows more rapidly than forest industry output the difference between the series is positive.

Two features of this series are striking. The first is that there is a great deal of volatility in the series. This is the result of the variability in forest industry output from year to year. This indicates that the industry adjusts its annual output significantly. This is not unexpected, as theory predicts that firms' output choice is implicitly a function of variables, such as the market rate of return, which may be highly variable from year to year. The second feature

\textsuperscript{2}These trends in rent are defined in terms of its size relative to provincial income measures.

\textsuperscript{3}Forest industry output is measured by the figure for total timber scaled in the province annually, given in the \textit{Ministry of Forests Annual Report} \textsuperscript{[13]}. Provincial G.D.P. data are obtained as in Chapter 2 (Section 2.4.6). I do not use personal income as an alternative measure of provincial income in this chapter, because it generates results which are not substantively different than those for G.D.P.
to note is the absence of a pattern in the data which could produce the broad trends in the relative size of forest rent. Consequently, these must originate with changes in the marginal rent per unit of B.C. timber.

The difficulty at this point is that there are no data for marginal rent. It is, however, possible to derive a figure for the average rent per unit of B.C. timber from the data which I generate in Chapter 2. The behaviour of this ‘average shadow value’ is influenced by changes in the true shadow value. While the average measure of rent is not a perfect reflection of the marginal measure, it is the best empirical estimate which can be obtained. I generate the average shadow value of B.C. timber by dividing the annual aggregate forest industry rent by the total harvest in each year. The resulting figure is implicitly equivalent to the per unit price of forest industry output less the average harvesting cost. This average realized rent is shown in Figure 3.1. As noted, this variable does not perfectly reflect the true shadow value, since it is the difference between price and average rather than marginal cost.

What is immediately notable about this series is that it reflects the broad pattern of the results found in Chapter 2. During the period of low rent before 1940 the average shadow value was very low. It rose rapidly from 1940-51 corresponding to the rise in the relative size of aggregate forest industry rent. Finally, the average rent per unit of timber harvested in B.C. declined unevenly from 1951 until the sample endpoint in 1992. This accurately matches the behaviour of aggregate industry rent. The causes of the changes in rent per unit must be identified to understand the forces which produced the broad trends in

---

4The method for constructing theoretically consistent measures of resource rent requires the estimation of a cost function as in Young [169], Farrow [65], and Halvorsen and Smith [83]. Unfortunately, the data required to estimate a cost function at either the firm or the industry level are simply not available.

5This is assuming that the empirical measure of rent reflects only resource rent which is implicitly generated in the Logging Industry although it may appear in the Wood Industry or Paper and Allied Industries as a result of vertical integration and transfer pricing.

6The measure also pertains to timber harvested rather than in situ when marginal and average costs differ.
aggregate rent found in Chapter 2.

In order to understand the relevant variables to consider I return to theoretical models of renewable resources. These stylized models can help to clarify which variables are important in determining the level and evolution of rent per unit over time and implicitly the choice of output level as well. While the models relate to the marginal measure of rent, rather than the average measure for which data are available, they are still useful. As noted, the behaviour of the average reflects the influence of changes in the marginal measure. The same set of variables is thus relevant to the behaviour of both.

3.3 Extending the Depletable Resource Model

A brief review of the theory clarifies the discussion of the empirical measure of B.C. forest rent. A simple stylized model of resource rent for the forest industry was introduced in Chapter 2. In this section I first review an extended version of that model which incorporates technological change, emphasizing both the definition of resource rent and the equation which governs its dynamics. I then expand on the simple model by introducing uncertainty, both on the demand side and in technological progress. This does not alter the definition of resource rent derived in the simpler model but provides a richer, more realistic set of variables which are expected to determine the level and evolution of rent over time.\textsuperscript{7}

3.3.1 Incorporating Technological Change

In this section I review the simple depletable resource model, abstracting from considerations of risk and uncertainty. The model is essentially the same as that which was introduced in Chapter 2, with a slight modification in the addition

\textsuperscript{7}Theoretically, resource rent is defined as the marginal revenue generated by the production of a unit of the resource less the marginal cost of producing that unit. This is a basic definition which is not altered by the specifics of this model.
of technological change as an argument of the cost function. The technology of
forest harvesting in B.C. has changed dramatically over the 20th century. Partic­
ularly during the 1920s and 1930s innovations associated with the development
of the internal combustion engine, such as logging trucks and chainsaws, reduced
harvesting costs and expanded the range of accessible timber. The addition of
 technological change to the model does not affect the basic definition of rent but
does influence the level and evolution of rent over time.

As before I assume that firms in B.C.'s forest industry do not have price
setting power. This implies that they take prices as given exogenously. Firms
choose a sequence of harvests which maximizes the present discounted value of
their profits over an indefinite horizon. Mathematically we can represent this
problem as follows:

\[
\max_{q} \int_{0}^{\infty} e^{-rt} [P(t)q(t) - C(q(t), S(t), \tau(t))] dt
\]  

subject to

\[
\dot{S} = f(S(t)) - q(t)
\]

where \( P(t) \) is the exogenous price of output at time \( t \), \( q(t) \) is the resource harvest
at time \( t \) chosen by the firm, \( C(q(t), S(t), \tau(t)) \) is the total cost of harvest to the
firm modeled as a function of the current harvest, \( q(t) \), the level of the stock,
\( S(t) \), and the state of technology, \( \tau(t) \) and \( S(t) \) is the resource stock which grows
naturally according to the function \( f(S(t)) \). Harvesting costs are an increasing
function of current output, \( C_q > 0 \), and a decreasing function of both the stock
size, \( C_S < 0 \), and state of technology, \( C_\tau < 0 \). As in Chapter 2 the first condi­
tion implies that costs rise with output and the second condition represents the
depletion effect. The last effect captures the ability of technological innovations
to reduce the cost of harvesting.

The problem above is reformulated as a current value Hamiltonian:

\[
\max_{q} H = Pq - C(q, S, \tau) + \lambda[f(S) - q]
\]
Solving the maximization problem leads to the following system of necessary conditions:

\[ H_q = 0 \Rightarrow P - C_q(q, S, \tau) - \lambda = 0 \]  \hspace{1cm} (3.4)

\[ \dot{\lambda} = r\lambda - H_S \Rightarrow \dot{\lambda} = r\lambda + C_S(q, S, \tau) - \lambda f'(S) \]  \hspace{1cm} (3.5)

\[ H_S = \dot{S} \Rightarrow \dot{S} = f(S) - q \]  \hspace{1cm} (3.6)

From Equation 3.4 the shadow value, or marginal rent per unit of the resource, is just the difference between the price of the resource output and the marginal harvesting cost. The level of the stock and the state of technology influence the level of rent through their effect on marginal harvesting cost. The definition of rent is essentially unchanged relative to the model of Chapter 2.

The dynamic behaviour of the shadow value is determined by Equation 3.5:

\[ \frac{\dot{\lambda}}{\lambda} = r + \frac{C_S(q, S, \tau)}{\lambda} - f'(S) \]  \hspace{1cm} (3.7)

This implies that a necessary condition of firms optimally choosing their sequence of harvests is that the shadow value of the resource evolves in a way which provides a return comparable to other alternative assets. The shadow value of a unit of the forest resource should appreciate at the net rate of interest. This is simply the rate of interest adjusted for the natural growth of the asset and depletion effects. The growth of the resource can increase or decrease the net rate of return relative to the rate which alternative assets earn. If the stock is growing \((f'(S) > 0)\), then the shadow value of the asset rises more slowly relative to the interest rate, as the growth of the asset itself contributes to the overall return. If the stock is declining \((f'(S) < 0)\), then the shadow value of the resource must appreciate relatively faster than the interest rate in order to offset the loss of the principal this implies.\(^8\)

\(^8\)For some timber stands the rate of growth is negative. Once natural growth slows sufficiently loss of volume from insect pests, disease and decay can produce a negative rate of growth in timber volume. This is the case for some 'decadent' stands of B.C. old growth.
The net rate of increase in the shadow value of a unit of the forest resource also reflects the effect of depletion on costs. The term \( \frac{C_{st}}{\lambda} \) measures the effect of current period harvests on future costs through the influence on the level of the stock remaining. As the stock is depleted \( (\dot{S} < 0) \) costs rise. This means the shadow value of standing timber will be lower in the future, so the rate at which it appreciates is reduced by depletion. In terms of arbitrage relative to other assets, the depletion term represents the future return to leaving timber unharvested today through reduced future costs. This internal benefit is netted from the return which could have been earned had the timber been harvested and held as an alternative asset. The scarcity value of the resource may grow more slowly than the return on alternative assets due to the stock effect, or even fall.\(^9\)

This depletion term is a function of the level of technology. The strength of the depletion term could change over time through the influence of this variable. For example the development of silvicultural technology and genetic enhancement in forest management may reduce the effect of depletion on future costs. The initial technological advances which expanded the timber frontier likely reduced the effect of depletion on future harvesting costs.\(^10\)

According to this simple model of the forest industry the variables which should influence the evolution of rent over time (and implicitly determine its level) include the return on other assets, the growth rate of the forest asset and depletion. One shortcoming of the model at this point is that it does not reflect the uncertainty which characterizes markets in general and resource markets in particular. In the following section I expand the model to see how uncertainty

---

\(^9\)Theoretically the shadow value should not fall below zero.

\(^{10}\)Technological change which produces only decreasing marginal harvesting costs results in U-shaped price paths, as in Slade [156] and Farzin [66], but does not alter the evolution of rents in the industry if it has no influence on the depletion term \( C_{st} = 0 \). This result assumes that technological change is broadly applicable, so that induced changes in output affect the world price.
affects the level and evolution of the shadow value of the resource.

3.3.2 Modeling Risk

Up to this point all variables in the model have been represented as deterministic. This is not a particularly realistic representation for some of the variables. Demand for resource commodities, including forest products, is notoriously volatile. This makes investment in forest assets a risky proposition. As seen in the previous section returns are also influenced by the state of technology. In practice technology evolves in a stochastic fashion, introducing an additional random element in the determination and evolution of rents. The effect of these kinds of uncertainty is to transform resource rent into a random variable; this implies that it is impossible to derive a deterministic expression for its actual behaviour.

Stochastic uncertainty of various types relevant to problems in resource economics has been addressed in existing literature. Pindyck [145] investigated the implications of stochastic fluctuations in the growth of a renewable resource for the evolution of rent. He found that such ecological uncertainty introduces a risk premium. The rent on the resource must appreciate more rapidly to compensate for this uncertainty and provide a competitive return relative to (risk free) alternative assets. Gaudet and Khadr [73] incorporated technological uncertainty in the extraction of a nonrenewable resource (as well as the production of a reproducible composite commodity) in a general equilibrium model. They showed that if consumers are risk averse and productivity changes are positively correlated across sectors, then the rate at which resource rent appreciates includes a positive premium for risk. The size of the premium depends on the correlation between the risk associated with the two alternative investments in the model. These examples, drawn from a larger literature, illustrate that additional variables reflecting risk must be included to explain the behaviour of resource rent

Pindyck [144] considered demand and reserve uncertainty for a nonrenewable resource in a partial equilibrium setting.
when uncertainty is present.

Slade and Thille [155] provided an important bridge between theoretical models of resource rent determination which incorporate risk and the empirical analysis of resource rent estimates. The authors developed a partial equilibrium model for a nonrenewable resource which incorporates both demand (price) and technological uncertainty. This uncertainty is stochastic in nature and the evolution of price and technology is assumed to be characterized by generalized Brownian motion. According to this specification agents know the current value of these variables but are uncertain about future values. This uncertainty increases linearly with time. Because agents are uncertain only about the future, and not the present, they can continually adjust in response to realizations of price and technology. Slade and Thille derived an expression for the expected rate of change in the shadow value of the resource which reflects the return on alternative assets, depletion and a risk premium. This expression is derived as a partial equilibrium no-arbitrage condition and holds both on and off a competitive equilibrium path.

Slade and Thille then developed an estimable equation on the basis of their model. The rate of change in resource rent is a function of the risk free return, a depletion term, the 'market' rate of return, the rate of return on a hedging asset and variables which reflect undiversifiable market risk, such as deviations from trend in G.D.P. growth and the Canada-U.S. exchange rate. They applied this model to data on resource rent for a panel of Canadian copper mines and found that it significantly improved explanatory power when compared to a model which did not incorporate variables which measure risk.\(^{12}\)

There is little doubt that demand (price) uncertainty is a relevant consideration for firms in the B.C. forest industry. Similarly, there is uncertainty associated with the technology available to the industry over the 20th century.\(^{12}\)

\(^{12}\)The rent and depletion data were provided by Young [169].
Can the estimable model Slade and Thille [155] developed help to suggest relevant variables to include in the empirical analysis of the dynamic evolution of B.C. forest rent? The obvious problem with Slade and Thilles' model is that it applies to a nonrenewable resource. This is important for two reasons. First, the possibility of exhaustion coupled with uncertainty about future aggregate reserves is what motivates the representation of prices (demand) by generalized Brownian motion. Second, the finiteness of the resource stock is what is assumed to be driving the depletion effect on cost.

Could the model still apply to the evolution of rent in B.C.'s forest industry? While the renewable nature of forests seems to rule out the demand specification, it may still be appropriate.13 Historically, forestry has been characterized by the 'mining' of mature forests which were abandoned for new sources when exhausted.14 Natural regeneration is a slow and uncertain process and historically concern over the exhaustion of potential reserves has been a medium term concern.15 Prices of forest products have been found to display patterns consistent with those suggested by the Hotelling [92] model of exhaustible resources.16 While not exhaustible in the long run like mineral or oil reserves, forests can certainly be depleted to the point where medium term reserves are limited relative to demand. The potential for severe depletion combined with the uncertainty about potential alternative sources resembles the nonrenewable case more closely than the inexhaustible renewable ideal. The presence of a depletion effect on costs is less problematic, since it occurs at a disaggregate level.17 The possibility of exhaustion coupled with uncertainty about future aggregate reserves is what motivates the representation of prices (demand) by generalized Brownian motion. Second, the finiteness of the resource stock is what is assumed to be driving the depletion effect on cost.

13 According to Slade and Thille [155] their specification of the price dynamics "can approximate any continuous price path regardless of the model that underlies its generation," pp. 693.

14 See Lyon and Sedjo [115].

15 The Fulton Commission [71] contains considerable discussion of the limits of future timber supply, particularly in the United States. Future scarcity was seen as a factor responsible for fuelling timber speculation in British Columbia around the turn of the 20th century.

16 See Brown and Field [21].

17 The uncertainty regarding timber supply must be broad enough to influence the price in world markets, while the depletion effect can relate to regional timber supplies.
ity that depletion of B.C.'s forest resources led to rising costs seems plausible given the historical context.\(^{18}\) A variant of this model could be applied to the evolution of rent in the B.C. forest industry.

I modify Slade and Thilles' \(^{155}\) model slightly to include a forest growth term.\(^{19}\) Resource rent itself remains the difference between the price and the marginal extraction cost.\(^{20}\) The expression for the dynamic evolution of rent is given by the following:

\[
\frac{\dot{\lambda}}{\lambda} = r + \frac{C_S(S)}{\lambda} - f'(S) + \beta(r^m - r) \tag{3.8}
\]

where

\[
\frac{\dot{\lambda}}{\lambda} = \frac{1}{\lambda} \frac{dE_d\lambda}{d\lambda}
\]

The expression above indicates that the average expected rate of change in the shadow value of timber is equivalent to the net risk free rate of interest, plus an industry specific risk premium \((\beta(r^m - r))\).\(^{21}\) This industry specific risk factor is a convex combination of the risk free rate, \(r\), and the expected return on a set of fundamental assets which span the space of returns. In other words, these fundamental assets can be used to determine an expected market rate of return, \(r^m\). In implementing the model I adopt essentially the same set of variables Slade and Thille \([155]\) use to measure risk.

The size of the forest industry risk premium depends on the degree to which volatility in the industry is correlated with the market, measured by \(\beta\) in the expression above. If much of the volatility in the value of forest assets is not correlated with the market return, then this risk could be diversified away and the risk premium would be small. If risk in the forest industry is correlated

\(^{18}\)I will discuss this more fully below.

\(^{19}\)Details of Slade and Thilles' model and my adaptations may be found in Appendix B.

\(^{20}\)Again, the level of rent will reflect the choice of output necessary to satisfy the second necessary condition.

\(^{21}\)The expression for the risk premium in Equation 3.8 is based on the intertemporal capital asset pricing model (ICAPM), but as noted by Slade and Thille \([155]\), it can also represent less restrictive models of asset pricing, such as the Arbitrage-Pricing Theory of Ross \([150]\).
with market risk, then the variables which measure risk will help to explain the evolution of the rent on B.C. timber.\textsuperscript{22}

Two assumptions underlying the model above merit some discussion. The first is that firms in the industry are assumed to choose harvest levels. This was clearly the case in the B.C. forest industry before 1945 as there are no restrictions on harvesting. Following the Sloan Commission in 1945 the concept of sustainable yield becomes a cornerstone of B.C. forest policy. This implicitly requires the government to control harvest levels, which it attempts to do on a regional basis. I assume that the controls are not sufficiently restrictive to prevent firms from choosing their optimal harvest level. There is some flexibility in the implementation of allowable annual cut.\textsuperscript{23}

The other assumption of note is that the expression for rent reflects the variable which the firm chooses its harvests to maximize. The discussion of the distribution of rent in the previous chapter indicates that this is not total rent, as a share is collected by government and possibly labour. As long as there are not major changes in the share which firms capture the expression for $\frac{x}{y}$ is unaffected.\textsuperscript{24} I assume that any changes in the share of rent which firms retained were sufficiently incremental that this is the case.\textsuperscript{25}

At this point a model is established which identifies the theoretical factors governing the level and evolution of the shadow value of timber in British Columbia. Before using the model to investigate the empirical behaviour of re-

\textsuperscript{22}If it were the case that the volatility of forest assets was negatively correlated with the market, then individuals would be willing to earn a lower return on this asset in order to protect themselves against market fluctuations. Forest assets in this case would be a hedging asset.

\textsuperscript{23}For example, see Sloan [158], pp. 222-223. Firms will attempt to choose an optimal harvest according to the necessary conditions of the model within the flexibility which A.A.C. allows. If the cut controls bind, then firms will be forced to harvest a suboptimal level. In this case the necessary conditions above will not hold with equality.

\textsuperscript{24}Slade and Thille [155] discuss mining profits taxation, which is the corresponding problem in their model and come to this conclusion. See pp. 706.

\textsuperscript{25}The discussion of forest policy in Section 2.4.5 indicated that methods of government rent collection evolved slowly over the 20th century. New arrangements overlapped with existing contracts. The results of Chapter 2 also showed that the share of rent which labour captured increased over the sample, but gradually.
source rent in the forest industry I review the evidence in its historical context.

3.4 Forest Rent in B.C.: Historical Context

The rent on B.C. timber was volatile and low on average during the period before approximately 1940. The absence of rent during this early phase of the historical record seems somewhat surprising. General histories of the province stress the contribution of the industry to provincial development at this stage. In particular, the industry was seen as a means by which the province was able to acquire capital. This is consistent with the 'staples-based' view of the role resources played in Canadian development. Certainly the sale of timber leases and licenses raised funds for the province. The rapid expansion of the industry during the period before W.W. II in combination with the even earlier rush to acquire access to timber suggests that there were rents to be had. While some firms may have earned resource rents, the evidence suggests that this was not the norm before 1940. Why?

The evolution of technology may play a role. During the earliest years of the 20th century the technology of logging limited the economically viable supply of timber. Logging in BC at the turn of the century was just experiencing the transition to steam power. While this innovation opened up new supplies of timber relative to that which could be harvested by man and animal alone, it had limitations. Transporting the trees to a milling site still required either location in proximity to water or the construction of extensive logging railways.

---

26 Rent began its rapid rise in 1933, but did not recover to its predepression level until 1940.
27 Recall that the firm level estimates of Section 2.4.6 indicate that rent was highly volatile and low on average from roughly 1906-39.
28 For example, see Barman [6], pp. 183, 240.
29 During the years 1900-09, when the boom in timber acquisition was at its height, revenue from forest sources contributed an average of 22% of total provincial revenues. See Fulton [71], pp. 28, 31.
30 Prior to this man and animal were the sole supply of power for the harvesting of timber and water for milling.
Even locomotives specifically designed for use in logging operations could not climb grades in excess of 10 degrees, making it impossible to reach much of the potential timber supply.\textsuperscript{31}

The development of the internal combustion engine began a technological revolution which profoundly altered methods of production in the forest industry. During the mid 1920s logging trucks first began to appear. These early vehicles, with hard tires and minimal mechanical assistance in steering or braking, proved dangerous and difficult to control, still they allowed the frontier of logging activity to expand into areas previously inaccessible.\textsuperscript{32} The severe geography of the province in combination with expensive and primitive logging technology made much of the province's timber essentially worthless during the early years. Without the development of more flexible, powerful and cheaper technologies it is possible that the increase in costs associated with depletion would have caused the industry to shut down. Technological improvements which relieved this pressure allowed the industry to continue operating and may have eventually caused rents to increase at a faster rate.

Another factor which may have played a role in the absence of rents before the 1920s was the relative ease of entry in combination with local product markets. Expansion of the industry in the very early phase was largely related to local market conditions. For example, the increase in the demand for lumber in the prairies due to the wheat boom (1898-1914) and consequent settlement resulted in great expansion of interior forestry operations.\textsuperscript{33} While the alienation of timber was officially suspended in 1907, timber could still be accessed via Timber Sale Licenses. There was no restriction on the ability to apply for these and it remained relatively easy for small scale operators to gain access to timber if they wished. A large number of mills, most of which were small scale, appeared in

\textsuperscript{31}See MacKay \cite{120}, pp. 189.
\textsuperscript{32}See MacKay \cite{120}, pp. 193-196.
\textsuperscript{33}See Barman \cite{6}, pp. 183.
the interior during the wheat boom to serve the essentially ‘local’ market of the prairies.\textsuperscript{34} The ease of entry and the competitive nature of this market suggest that any potential rent may have been dissipated. As long as rent was positive there would be an incentive for firms to enter the market. The result of the entry of additional firms would be increased supply. This depresses prices when they are determined in the local market. Theoretically such a process continues until rent is completely dissipated and there is no longer an incentive for entry.

The model of Section 3.3 does not address the issue of rent dissipation because it assumes that prices are determined exogenously. Entry in the domestic industry has no effect on the evolution of prices. During the period over which the empirical analysis of this chapter is conducted (1926-92) this is a reasonable assumption. Large operations on the Coast, which formed the stable core of the industry from its beginnings in the 19th century, served world markets.\textsuperscript{35} The opening of the Panama canal in 1914 initiated a further shift in the industry’s orientation toward external markets. These became increasingly important.\textsuperscript{36} Once the provincial industry served world markets in which it had no effect on prices, supply and demand in local markets would have had little effect on prices or rents.\textsuperscript{37}

The period from the beginning of W.W. II until the early 1950s stands out because of the rapid increase in both the average shadow value of B.C. timber and the relative size of aggregate industry rent.\textsuperscript{38} Another change in the evolution of rents which began at roughly the same time was a marked decline in the

\textsuperscript{34} Again, see Barman [6], pp. 183.

\textsuperscript{35} For a history of the B.C. forest industry’s 19th century origins, see Lamb [108].

\textsuperscript{36} According to figures published in the Ministry of Forests Annual Report [13] waterborne lumber shipments accounted for 3.7% of the provincial timber harvest in 1913. By 1920 this figure climbed to 7.0% and by 1925 it reached 22.1%. This figure for exports does not include shipments by rail to the U.S.

\textsuperscript{37} Transportation and its associated cost introduce some friction in the workings of the market and this argument.

\textsuperscript{38} The average shadow value of timber peaked in 1951 at $279 (1991 dollars) per thousand board foot (Mf.b.m.) equivalents.
volatility of rent. This continued through the late 1960s. What factors help to explain these changes?

Changes in trade conditions may have played a role. In the early years of the 20th century tariff revenues were a significant source of government revenue. This left little scope for wide scale tariff reduction. After W.W. I the introduction of income tax relieved the fiscal burden borne by tariffs and it became feasible to reduce them. In fact the encouragement of freer trade and the reduction of trade barriers was one of the goals of interwar diplomacy espoused by U.S. President W. Wilson.\textsuperscript{39} In spite of any desire to promote freer trade the 1920s and particularly the early 1930s were characterized by increases in tariffs and protective barriers, both in the U.S. and overseas. The U.S. increased tariffs in both 1921 and 1922, but the most notable shift in trade policy coincided with the Smoot-Hawley tariff. Work began on this legislation in 1928 and it was passed in 1930. It resulted in a dramatic increase in effective ad valorem rates charged by the U.S. At the same time tariff and protective barriers were erected in other countries as retaliatory measures and as a domestic response to the Depression.\textsuperscript{40}

The decline in world trade, precipitated by the Depression and exacerbated by the trade practices adopted, generated a break in trade policy. Hoping to stimulate domestic economies countries began to seek multilateral agreements to restore trade. Britain and the Commonwealth nations established preferential tariff rates for Commonwealth members, beginning in 1932. In 1934 the Reciprocal Trade Agreements Act (R.T.A.A.) was passed in the U.S., shifting the power for control over tariffs from Congress to the President. The result

\textsuperscript{39}See Irwin [97], pp.332. Wilson's influence extended well beyond the U.S. during the interwar years. For example, he helped to establish the League of Nations, precursor to the current United Nations.

\textsuperscript{40}This point is raised by Irwin [97], pp. 336-337. He cites Jones [101] in identifying Canada, Spain, and Switzerland as countries which clearly enacted retaliatory tariffs.
was a decline in U.S. tariffs from over 50% in 1933 to less than 40% by 1939.\textsuperscript{41}

While W.W. II disrupted trade, tariffs and barriers continued to fall in its aftermath, particularly with the establishment of the General Agreement on Trade and Tariffs (G.A.T.T.) in 1947. Tariffs fell significantly in the initial round and subsequent rounds continued to break down the barriers to world trade.\textsuperscript{42}

How might these developments in trade policy have affected rent in B.C.'s forest industry? The establishment of preferential Commonwealth trade during the early 1930s appears to have been important in expanding markets for B.C. timber. Waterborne exports of B.C. timber to major Commonwealth trading partners increased by over 50% in 1933. At the same time waterborne exports began to account for a greater share of industry production.\textsuperscript{43} Preferential tariff treatment increased the price received for B.C. forest exports, which would also have increased rent. The expansion of trade and increased access to markets may also have stimulated demand for B.C. forest products, particularly in the early post-W.W. II period with the rebuilding of Europe. Increases in world demand relative to supply would have raised prices, particularly over the short run when the supply of forest output was less elastic. Increases in the price of forest products led to a higher shadow value for B.C. timber. More generally, the liberalization of trade reduced uncertainty about market access and potential demand, not only for B.C. timber producers but for all involved in international trade. Any decrease in overall market risk should have been reflected in a reduced risk premium component in the evolution of the shadow value of B.C. timber.

Freer trade in the post-W.W. II era coincided with a period of general economic growth and stability.\textsuperscript{44} According to NBER methods of identifying and

\textsuperscript{41}Irwin [97], pp. 350.
\textsuperscript{42}Caves and Jones [37], pp. 218-224.
\textsuperscript{43}Figures are from the Pacific Lumber Inspection Bureau Annual Report [134], and Ministry of Forests Annual Report [13].
\textsuperscript{44}In some sense freer trade may be a consequence rather than a cause of economic growth. Countries experiencing healthy rates of growth may be more inclined to reduce trade barriers.
dating business cycle turning points recessions in Canada and the U.S. were milder and of shorter duration following W.W. II than before. Periods of expansion were longer in the post-war era, lasting an average of 59 months as opposed to 29 months during the period preceding the second World War.\footnote{Sources for business cycle dates are Chambers [38], [39], Hay [88], Cross and Roy-Maynard [52] and Statistics Canada.}

While there is some uncertainty due to possible measurement error, economic aggregates such as G.D.P. and the unemployment rate appear to be less volatile since W.W. II.\footnote{The claim that business cycles have become less severe in the post-WWII era is not uncontested. Romer [147] suggests that methods of measurement before 1929 rely on data which over-represent more volatile sectors of the economy, producing exaggerated measurements of business cycles. Backus and Kehoe [3] look at evidence from a range of countries and conclude that business cycles have become less severe since W.W. II.}

The real value of new residential construction, a measure of investment as well as agents’ expectations of future economic performance, began to climb in the post W.W. II era, as shown in Figure 3.7.\footnote{The nominal value of new residential construction in Canada is taken from Urquhart [164], Table 8.20, pp. 572 for the period from 1906-20. This series is extended forward to 1925 using an index of National Urban Building Activity (Table O) in Buckley [23]. From 1926-51 the value is taken from the Historical Statistics of Canada (Leacy [106], series K136.) From 1952 to 1992 the CANSIM series D804600 for New Residential Construction, Total Value is used. The deflator for residential construction is taken from Urquhart [164], Tables 8.21-8.22, pp. 575-6, for the period 1906-20, and is the CANSIM series D617001A and D20567 for the periods 1926-84 and 1984-92 respectively.}

The real value of stock prices, shown in Figure 3.8, also began to increase more steadily and rapidly. The period following World War II was generally one of growth and reduced economic volatility. In terms of the model of forest rent evolution this corresponds to a likely reduction in the undiversifiable risk component of forest returns.

The pattern in both the level and rate of change of rent altered substantively once more before the sample endpoint in 1992. Beginning in the early 1950s the level of rent per unit of timber harvested began to decline, although unevenly. By 1992 rent appears to have returned to the low level seen in the industry before W.W. II. In addition, there was a return to increased volatility in the

45Sources for business cycle dates are Chambers [38], [39], Hay [88], Cross and Roy-Maynard [52] and Statistics Canada.

46The claim that business cycles have become less severe in the post-WWII era is not uncontested. Romer [147] suggests that methods of measurement before 1929 rely on data which over-represent more volatile sectors of the economy, producing exaggerated measurements of business cycles. Backus and Kehoe [3] look at evidence from a range of countries and conclude that business cycles have become less severe since W.W. II.

47The nominal value of new residential construction in Canada is taken from Urquhart [164], Table 8.20, pp. 572 for the period from 1906-20. This series is extended forward to 1925 using an index of National Urban Building Activity (Table O) in Buckley [23]. From 1926-51 the value is taken from the Historical Statistics of Canada (Leacy [106], series K136.) From 1952 to 1992 the CANSIM series D804600 for New Residential Construction, Total Value is used. The deflator for residential construction is taken from Urquhart [164], Tables 8.21-8.22, pp. 575-6, for the period 1906-20, and is the CANSIM series D617001A and D20567 for the periods 1926-84 and 1984-92 respectively.
evolution of the shadow value of B.C.'s timber. This change came later in the sample, beginning in the early 1970s. What was responsible for the declining level and increased volatility in the value of B.C.'s forest resources?

The fall in rent may have reflected declining supplies of high quality, accessible timber. Up until the late 1940s B.C.'s forest resources were harvested by simply drawing down the asset of an enormous volume of mature standing timber. However, in the 1940s questions began to emerge about potential limits to supply. In 1945 estimates of the remaining stock of Douglas fir in the coast region ranged from a 5 to 30 year supply. At the time Fir was the raw material for well over 60% of all lumber produced in the province and the coast region produced the bulk of this. It was contemporaneously accepted that the high quality of the province's Douglas fir lumber was a uniquely valuable asset in export markets. Western hemlock (Tsuga heterophylla), the next best alternative supply of wood, is considered an 'ugly duckling' by comparison. The long rotation age of Fir combined with the lack of reforestation at this time meant the supply of this input was truly limited in the short run. The fact that the optimistic estimates of available supply were based on 90% of all timber in the coast region being economically accessible and available illustrates the relative scarcity of this high quality resource at this point.

The harvest policy of essentially mining the virgin forests was followed throughout the industry's early history. The technological advances of the 1920s and

---

48 While the concept of sustainable yield was adopted for the management of B.C.'s forests following the Sloan Commission in 1945, some authors (Burda et al [25]) argue that this ideal did not translate well in forest practices for some time, if at all.
50 Sloan [157], pp. 60.
51 This is mainly because of negative associations in the export market, explained by the poor properties of wood made from its eastern relative. See Sloan [157], pp. 61-63. In fact western hemlock produces good quality lumber.
52 The maximum yield rotation age for Douglas fir is 120 years, although a period of 60 years to commercial viability was used in the calculations in the Sloan Report. See Sloan [157], pp. 34.
53 Sloan [157], pp. 31.
1930s allowed the economically viable timber supply to expand, but by the 1940s the finiteness of the resource base was all too apparent. The scarcity which emerged meant that current harvesting involved implications of increased future costs. As illustrated by the model in Section 3.3, this depletion effect can cause rent to rise more slowly, or to fall should the effect become strong enough.\(^{54}\)

The depletion of traditional timber supplies on the coast forced the industry to adapt. Starting in the mid 1950s, the production of forest products in B.C. shifted increasingly to the interior region, particularly the North. This was a result of both limited accessible supply on the coast and a deliberate policy to develop a sustainable forest industry on a regional basis. During the 1950s when the policy of sustainable yield management was implemented, it was implicitly assumed that all that was required to have a permanently sustainable forest industry in an area was a biologically sustainable yield of the raw material.\(^{55}\) This retrospectively naive view helped to promote the regional dispersion of the industry, perhaps beyond the margins of long term economic viability.\(^{56}\) The sharp increases in prices and apparent profits in the immediate post-W.W. II era may have prompted an overly optimistic view of the future. Both policy makers and investors may have suffered from this in pushing the geographical boundaries of the industry. In any case, it is certain that in expanding into previously marginal areas the B.C. forest industry was operating with lower quality resources than it had previously benefitted from.

Increased competition, like rising costs and lack of accessible timber, is iden-

\(^{54}\)Scarcity in terms of the depletion of B.C. timber does not result in increases in rent if the province is a small player in world markets. Depletion raises costs to B.C. timber producers, but does not cause global timber scarcity so does not cause the price of forest products to increase.

\(^{55}\)Sloan [157], pp. 127-128, 144.

\(^{56}\)Sloan [157], suggests that the Crown should build roads to open up access to timber supply in the Interior. He argues that such a policy will, by establishing a sufficient supply of timber at a sustained yield, insure the permanence of Interior operations. See pp. 148.
tified as a factor responsible for the recent (post 1980) slowdown of B.C.'s forest industry. It may also have contributed to the long term decline.\textsuperscript{57} The U.S. is the most significant producer of softwood lumber products in the world.\textsuperscript{58} It is also the largest market for B.C.'s softwood exports. The U.S. forest industry moved to the Pacific Northwest by the turn of the century, having decimated timber reserves in most of the rest of the country. In fact, the boom in timber speculation in B.C. during 1905-07 was largely fueled by U.S. investors concerned that even this remaining source of U.S. timber might prove inadequate.\textsuperscript{59} Anxiety over timber supply led to the removal of significant timber reserves from private supply in the establishment of the U.S. National Forests. Forests do regenerate naturally to some degree, more so in areas such as the southern and eastern U.S. which do not suffer from the severe geography and climate of mountain regions. Data from the U.S. Forest Service indicate that the growth rate for Southern forests far exceeds that of B.C. timber.\textsuperscript{60} At the beginning of the 20th century the remaining timber reserves of the U.S. were limited.\textsuperscript{61} By mid-century there was considerable recovery in areas previously denuded and these forests were growing fast. Areas such as South America and Asia also entered global forest product markets in the post W.W. II period, exploiting previously unharvested timber reserves.\textsuperscript{62} Essentially 'increased competition' meant that forest resources became less scarce globally. If increased competition lowered the price of forest products on world markets, then this would imply a reduction in the shadow value of B.C.'s forest resources.\textsuperscript{63}

\textsuperscript{57}See Marchak [123], pp. 85-116.
\textsuperscript{58}See Marchak [123], Table 3.3, pp.72.
\textsuperscript{59}Fulton Commission [71], pp. 19-20, 48.
\textsuperscript{60}See The Outlook for Timber in the U.S. [162], pp. 273,240-241.
\textsuperscript{61}Fulton [71], pp. 18.
\textsuperscript{62}Marchak [123], pp. 5-8.
\textsuperscript{63}Competition may simply have slowed the rate of increase in world prices relative to potential increases in the face of rising demand if supply was less elastic. This would have caused B.C. forest rent to appreciate more slowly than otherwise. The implication in discussions of competition in world forest product markets is that it results in lower prices.
The last development in the evolution of B.C.'s forest rents to consider is the increase in volatility beginning in the early 1970s. This period of the sample contains the most substantial business cycle fluctuations following W.W. II. Macroeconomic events such as the oil shocks and recessions of 1982 and 1991 disrupted the relative stability of economic growth. While trade liberalization continued to be a factor during this period, regional agreements became more prominent. Non-tariff barriers also became more important as countries sought to protect specific sectors while pursuing generally freer trade.\textsuperscript{64} In general, compared to the exceptional growth and stability of the 1950s and 1960s, recent decades have offered up a more uncertain economic future. This uncertainty appears to be reflected in increasingly volatile behaviour of variables such as real residential construction and stock market returns, shown in Figure 3.7 and Figure 3.8. It may also have influenced the shadow value of B.C.'s forests.

### 3.5 Empirical Investigation of B.C. Forest Rent

The primary objective of this section is to explain the observed behaviour of measured resource rent on B.C. timber. I focus on the average shadow value of timber because this reflects the behaviour in rent per unit which is driving the broad trends in total rent. In addition, the model of resource rent discussed in Section 3.3 indicates that the changes in output from year to year are driven by firms' desire to equate the expected appreciation in the shadow value of timber and the return on alternative investments. The dynamic behaviour of output and the shadow value are linked because firms choose to adjust output until they expect the shadow value of timber to evolve according to Equation 3.8. This means that the variables which influence the behaviour of the shadow value of timber over time also determine the way output changes over time.

\textsuperscript{64} Some examples are the U.S. automobile and softwood lumber industries and agriculture in the E.E.C.
The investigation in this section is carried out in three stages. In Section 3.2, I established that changes in rent per unit of B.C. timber drive the broad pattern of results revealed in Chapter 2. The first step of the more detailed investigation breaks the average shadow value into its price and cost components. This allows some of the more elemental forces driving the behaviour of per unit rent to be identified. In the next stage I investigate the behaviour of costs in greater detail to assess the role of depletion. Finally, I consider the evolution of the average shadow value to investigate the relative importance of the theoretically relevant variables in explaining observed changes in rent per unit over time.

3.5.1 Decomposing the Average Shadow Value of B.C. Timber

Section 3.2 showed that the average shadow value of B.C. timber was low before 1940, rose rapidly through the early 1950s and declined unevenly thereafter. In this section I decompose the average rent into the two components which define it; price and average cost per unit of timber output. This allows for the identification of the more basic forces responsible for the behaviour of rent. The behaviour of prices and industry average costs reveals the interaction between these two factors in determining the level of rents at different points in the sample.\textsuperscript{65} Figure 3.3 shows the average cost and price per thousand board foot equivalents of timber harvested and processed in constant 1991 dollars.\textsuperscript{66}

These data are helpful in explaining the pattern of rent over the sample. The rise in rent which began in the early 1930s and carried through to the

\textsuperscript{65}Recall that the level and rate of change of rent are simultaneously determined by the firm's optimal output choice. The changes in cost which affect the level of rent implicitly reflect the influence of variables which determine the rate of change in the shadow value.

\textsuperscript{66}The real average cost is just total real harvesting costs divided by the annual timber harvest. Total harvesting costs are the sum of materials, labour and energy costs (as reported in the Principal Statistics for the Logging industry) and the estimated capital cost for the logging industry constructed in Chapter 2. I deflate these by the Wholesale Price Index to obtain real costs. The real price relates to a composite forest output. I recover the implicit nominal price series by reflating the price index of Appendix C. The real relative price of the forest composite is obtained by deflating the nominal price series by the Wholesale Price Index.
early 1950s coincided with relatively slowly rising costs and a rapidly increasing output price. The failure of costs to rise rapidly during this period is consistent with the view discussed above that technological change may have allowed the timber frontier to expand sufficiently to offset depletion effects. The rise in the real price is difficult to explain. It perhaps reflects war demand or the release of pent up consumption expenditure and the immediate post war reconstruction boom.\textsuperscript{67} The price for B.C. timber is set in world markets so to a large extent the behaviour of the output price reflected forces external to the B.C. forest industry.

The secular decline in rent from 1951 reflects both a slowly declining output price and more rapidly rising harvesting costs. The decline in price is consistent with the suggestion that increased competition in the international forest industry played a role in explaining the fall in rent on B.C. timber. In particular, as lower cost producers enter the market the world price of timber falls (ceteris paribus). Marchak \cite{123} suggests the development of plantation forestry in areas such as Brazil, New Zealand and the U.S. South had such an effect.\textsuperscript{68} The fall in the price for B.C. timber may also have reflected the depletion of the province's own old growth reserves. As discussed above, the timber harvested from these stands, particularly the Douglas fir, was a superior quality product. As more of the provincial harvest was drawn from lower quality timber, the average output price fell.

It is difficult to get a measure of the overall quality of timber harvested in B.C. or the potential effect of harvesting from coast old growth versus interior

\textsuperscript{67}During the war demand for B.C. timber was high as Continental supplies of timber to the U.K. were cut off. In addition, B.C. Sitka spruce (Picea sitchensis) was a valuable commodity as it was used extensively in the construction of airplanes. See Drushka \cite{60}, pp. 193-207. As previously noted, general price controls were implemented in Canada in December 1941 and Coast timber prices were governed by statute from 1943. These controls were eased beginning in 1944 and eliminated by September 1947. The process of price control and its subsequent deregulation may have interfered with firms' ability to develop accurate price forecasts. This could have contributed to an increase in realized rent driven by unanticipated price increases.

\textsuperscript{68}See Marchak \cite{123}, pp. 6-8.
or second growth timber. I examine data on the grade of log exports, presented in Figure 3.4, and the share of the provincial cut coming from the coast region, shown in Figure 3.5, as respective proxies.\(^{69}\) Perhaps not surprisingly the two series move similarly over time.

The quality of log exports falls over the sample period as a whole.\(^{70}\) Interestingly, quality appears to have been lowest during the period when prices and rents were high and the highest quality levels are observed during periods of low prices. This may reflect the practice of 'high grading'. When prices are low, it is profitable to export only relatively high quality grades of logs.\(^{71}\) Changes in the quality of log exports from year to year likely reflect such endogenous grade selection by producers at least to some degree. The broad decline in overall quality, however, may be indicative of resource depletion.

The coast forest region contains some of the highest quality timber in the province and it is the source of most of the old growth timber for such species as Douglas fir. This species is universally identified as premier quality timber.\(^{72}\) The share of the provincial harvest drawn from this region was highest initially, began to decline from 1940 and continued to fall throughout the remainder of the sample period. The decline in the coast share during the 1940s and early 1950s may be explained by the increase in prices; which may have made it profitable to

---

\(^{69}\)Data on volume of log exports and the distribution of volume by grade, as well as the regional distribution of the total cut are given in the *Ministry of Forests Annual Report* [13]. Data on the grade of log exports are reported only up to 1982.

\(^{70}\)Haley [81] uses the share No.1 and No.2 grade timber as a measure of timber quality in comparing the resources of the U.S. Mount Baker/Snoqualmie Forest to those of the Quadra Public Sustained Yield Unit in B.C. Haley and Constantino [46] construct indices of log quality for the Vancouver Forest Region and Vancouver Log Market which also show a decline in log quality during the period from 1925-82.

\(^{71}\)This assumes that log grades and harvesting costs are negatively correlated.

\(^{72}\)See Haley [81], for example. Further evidence that the timber in the coast region is of higher quality than that in other regions of the province can be found in data published in the *Ministry of Forests Annual Report* [13]. The average stumpage rate for coast fir is higher than those of all other rates, except interior white pine. This latter species accounts for only a tiny fraction of the total provincial harvest. The maximum stumpage rate applies to coast fir. The average stumpage rates for other species, such as hemlock, are also higher in the coast region than elsewhere.
exploit more marginal sources of provincial timber. The continued decline in the share of the harvest from the coast region must reflect something else, however, as prices fall after the 1950s. The decline is consistent with the possibility of depletion in coast timber stocks. As discussed above, this possibility was raised as a concern as early as the Sloan Commission in 1945. The behaviour of log export quality and the share of the provincial harvest accounted for by coast production are consistent with a decline in the quality of timber harvested. Such a decline in quality could have contributed to the fall in the price received for B.C. forest output in the period after 1951.

During the period of declining rent from midcentury not only did the price of output fall but harvesting costs also rose. The average cost of harvesting timber in British Columbia climbed steadily over the sample period, but particularly during the latter years of the sample. The abruptness of the increase in average harvesting costs from 1962-65 raises the question of whether this reflects a real increase or is an artifact of the data. While there was a revision in the statistical classification in 1963, it appears unlikely that this produced the increase in average cost. The increase from 1963-65 occurred within the context of the new parameters. The revisions themselves involved changes with potentially offsetting effects on average harvesting cost as measured here. The data from 1958-62 were taken from D.B.S. rather than provincial sources. They appear to be low relative to the apparent trend from 1926-57, which may exaggerate the apparent increase in average cost.

Real forces were likely at work in producing the increasing trend in average costs. Production by small operators mushroomed in the immediate post W.W. II period and new sources of timber were exploited both in terms of geography (interior regions) and species previously unharvested (hemlock). This expansion by small operators often involved the use of portable mills. When the timber which was accessible in one location had been harvested, the mill was simply
moved to a new location. Larger operators generally practiced a similar 'forest management' strategy. This was certainly a low cost method of harvesting in the short term; however, it was one which rapidly encountered limits. At a purely physical level, the reduction in average costs realized as new sources of timber were exploited was eroded as quickly as the most accessible stands were razed. The industry as a whole was experiencing a transition from reliance on traditional coast timber supplies to interior resources. It is likely that this was partly a result of physical supply constraints.

At another level, both small and large operators began to face increasing constraints in the implementation of the province's new sustained yield policy. This policy resulted in increasing provincial control over access to timber and also imposed additional costs on the industry as it (theoretically) required replanting and management of a specific timber area. While the policy had its origins in the two Sloan Commissions [157], [158], provincial timber inventory did not begin until after 1950, so the 'bite' of the policy seems to have been more apparent during the 1960's. Regulations governing the process for access to timber and the requirements of licensees became increasingly restrictive at this time.\(^{74}\)

The model of Section 3.3 suggests that harvesting costs are influenced by the level of output, available technology and the size of the stock. The discussion of the historical context indicated that technological change occurred over the sample period. This facilitated harvesting and expanded the range of accessible timber reserves. The annual timber harvest of the B.C. forest industry also increased steadily over the sample period. The industry progressively exploited more remote and geographically dispersed sources of timber.\(^{75}\) What were the

---

\(^{73}\) See Barman [6], pp. 286-287.

\(^{74}\) See Pearse [138]. In fact they are credited with driving many small operators out of the industry. See Barman [6], pp. 286-287.

\(^{75}\) As noted above, this was a joint result of necessity and policy. To the extent that policy itself (not necessitated by resource scarcity) was responsible for increased costs, the analysis
implications of each of these transitions for harvesting costs? The answer to this question will further clarify the forces driving the secular decline in forest resource rent.

3.5.2 Harvesting Costs and Depletion

The objective of this section is a more detailed investigation of timber harvesting costs. This will help to sort out the relative importance of technological change, harvest levels and depletion in determining the behaviour of average harvesting cost. The most theoretically desirable way to address the issue would be the estimation of a cost function, such as the following:

\[ C = C(q, S, \Theta; \omega) \]

where \( q \) is current output, \( S \) is the forest stock, \( \Theta \) is the state of technology and \( \omega \) is a vector of input prices. The depletion effect in each year is just \( C_S \) evaluated at the annual observations on the data for that year.\(^{76}\) Unfortunately, data limitations prevent the full adoption of this approach. Costs of harvesting in the B.C. forest industry can be broken down into materials, capital and labour costs over the full sample period.\(^{77}\) The difficulty arises in producing appropriate price series for these inputs. While national data can be used to generate price indices for capital and labour, this is not possible for materials. The composition of the materials costs shifts over the sample and also includes items such as the costs of contract logging services for which it would be difficult, if not impossible, to obtain an appropriate price index.

It is possible to circumvent these data problems by adopting a slightly different approach. A general deflator, such as the G.N.E. deflator or wholesale below will overstate the effects of depletion.

\(^{76}\)This is the approach Young [169], Farrow [65], and Slade and Thille [155] use to measure depletion in their tests of the Hotelling [92] model for mining firms.

\(^{77}\)Fuel and energy costs are reported separately from 1963, but included in materials costs prior to this.
price index may be used to deflate nominal costs.\textsuperscript{78} This accounts for the effect of input price changes exactly if the prices and weightings in firm level costs and the deflator are the same. While this condition is unlikely to be satisfied in practice, it is hoped that deflating costs in this way accounts for most of the variation in nominal costs due to input price changes. The series of real harvesting costs is regressed on the remaining variables; output, depletion, and the level of technology, to determine their effects independent of price changes.\textsuperscript{79}

While investigating real costs circumvents the problem of measuring input prices, the question remains of how to measure the remaining variables of interest. The variable most easily dealt with is output. The costs in this section are for harvesting and data are available in Forest Service Annual Reports \cite{13} for the total quantity of timber harvested in the province. A measure of output is obtained for the period 1926-92 from this source.\textsuperscript{80} Measuring the state of technological progress is more difficult. Generally, either index number or regression methods are used to obtain measures of total factor productivity (T.F.P.). In this case the absence of good data on materials, a major component of costs, precludes the generation of T.F.P. estimates.\textsuperscript{81} Data are available on the number of employees in the industry on an annual basis and I use these in conjunction with the output series to generate a partial factor productivity index for labour. I also use a time trend as an alternative proxy for technological development.

The final variable to be measured is the level of the stock. Unfortunately, this is impossible to do with any accuracy over the sample period under consideration. Systematic inventory of B.C.'s forests did not begin until the mid-

\textsuperscript{78}I use the wholesale price index to deflate costs. While it is not as general as the G.N.E. deflator, it is likely that it includes a marginally more relevant set of prices with respect to the forest industry.

\textsuperscript{79}This real cost regression is not equivalent to a cost function unless input prices are multiplicatively separable and the match is perfect between the components and weights in the wholesale price index and the factor inputs and their shares in harvesting costs.

\textsuperscript{80}This is the same output measure discussed in Section 2.4.

\textsuperscript{81}Estimates of T.F.P. have been generated for segments of the Wood and Paper and Allied Industries, but not for the logging industry. See for example, Constantino and Haley \cite{47}.
1950s. Only a few estimates of the stock exist before that date. Even with data generated more recently a great deal of uncertainty remains about the size of B.C.'s forests in terms of the available supply of commercial timber they contain.

This difficulty can be overcome by slightly recasting the analysis. The question of interest is whether or not depletion has led to rising harvesting costs. The evolution of the stock is governed by Equation 3.6

$$\dot{S} = f(S) - q$$

where $f(S)$ is natural growth, and $q$ is harvest. This means that the current value of the stock compared to the initial level is determined by cumulative growth versus harvests. While cumulative growth is as difficult to measure as the stock itself, data on cumulative harvests can be readily obtained. These measure the depletion of the stock of timber exactly in the absence of natural growth. The larger the natural increment, the less important this record of cumulative extraction is in determining the available stock. The approach I adopt is to use the cumulative harvest as of time $t - 1$ to measure depletion at time $t$. If natural growth is sufficient to offset these withdrawals from the stock of timber, then the variable should not have a significant effect on costs.

The estimated cost equation takes the following form:

$$TC = \alpha_0 + \alpha_1 q + \alpha_2 Q + \alpha_3 LPR + \epsilon$$

(3.9)

where the variables are the log of total real costs, annual output, previous period cumulative output and labour productivity respectively. This specification allows the level of the variables to jointly determine the value of depletion and the coefficients can also be interpreted as elasticities. Initial estimation of Equation 3.9 yielded significant autocorrelation in the residuals. I re-estimated the equation using iterative Cochrane-Orcutt generalized least squares to correct for first order autocorrelation. The results are given in Table 3.1. All the variables
have the expected signs. The level of current output has a positive influence on total costs ($\alpha_1 > 0$), rising cumulative output leads to higher harvesting costs in the next period ($\alpha_2 > 0$) and the influence of technological change reduces costs ($\alpha_3 < 0$). All the variables are statistically significant.

What is striking about the estimates is the strength of the estimated depletion effect. Costs rose by an average of 4.83% annually over the sample. The estimated effect of depletion increased costs by an average of 3.792% annually. This figure is derived using the estimated elasticity, and the average annual change in depletion as measured in the data. Using the same approach, technological improvements lowered costs by 0.566% on average annually, while increases in output accounted for a 1.811% increase in total costs annually.\(^82\) Although forests are theoretically a renewable resource, cumulative harvests seem to play a significant role in explaining rising costs of harvesting in B.C.'s forest industry. Neither technological improvements, nor natural growth appear to have been able to prevent real costs from rising with cumulative extraction.\(^83\)

The presence of this strong depletion effect on costs is somewhat surprising. Forest resources are renewable, which suggests cumulative output should bear little relation to future costs. Given the history of B.C.’s forest industry, however, the importance of cumulative extraction is less unexpected. Up until W.W. II, and arguably beyond, the forest industry in B.C. operated by harvesting the most available, accessible, already mature timber. Denuded areas were often allowed to revert to the Crown during the industry’s early history. Firms moved on to new sources of virgin timber rather than replanting and waiting

---

\(^{82}\)The parameter estimates indicate that there were increasing returns to scale in harvesting operations. This seems plausible, given the adoption of technology capable of handling increasingly large volumes of timber. Increasing the scale of operations reduced average cost per unit of harvesting, but increasing costs resulting from depletion could not be completely avoided.

\(^{83}\)As noted, I use a time trend as an alternative to labour productivity as a measure of technological progress. I re-estimate the cost equation using this alternative. The results are qualitatively and quantitatively similar to those reported. The effect of technological change is slightly reduced, and that of cumulative extraction slightly stronger. The signs and significance of all variables are unchanged.
for a new 'crop'. The gradual exhaustion of the most accessible, highest quality timber combined with the policy shift to regionally sustainable yield meant that more remote, lower quality timber had to be used. In addition, the replacement of harvested, mature timber required replanting, management and silvicultural investment. None of these costs were associated with harvesting the original stands of the province's timber. Given this history, it is unsurprising that costs rose along with the cumulative harvest.

The interpretation of the depletion effect requires some caution. It has been noted above that some changes in costs may have been the result of policy implementation. The shift to sustained yield management on a regional basis after 1945 incorporated an annual allowable cut policy. While this policy was flexible to some degree, it may have forced firms to alter their cut levels and increased costs. For example, if firms were required to cut more than their desired volume in the move to open up the interior industry this may have pushed costs up with the cumulative harvest. To the extent that provincial policy rather than necessity led to increased cutting of lower quality timber, the cumulative harvest variable will over represent the influence of depletion.

The adoption from the 1960s of close utilization standards is another policy change which may be reflected in the empirical estimate of depletion. This pol-

---

Table 3.1: Regression Results: Harvesting Costs

\[
TC = \alpha_0 + \alpha_1 q + \alpha_2 Q + \alpha_3 LPR + \epsilon
\]

<table>
<thead>
<tr>
<th>Coefficient</th>
<th>Estimate</th>
<th>Standard Error</th>
<th>T-Stat(63 d.o.f.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\hat{\alpha}_0)</td>
<td>-10.32</td>
<td>2.42</td>
<td>-4.27*</td>
</tr>
<tr>
<td>(\hat{\alpha}_1)</td>
<td>0.69</td>
<td>0.13</td>
<td>5.32*</td>
</tr>
<tr>
<td>(\hat{\alpha}_2)</td>
<td>0.70</td>
<td>0.14</td>
<td>5.08*</td>
</tr>
<tr>
<td>(\hat{\alpha}_3)</td>
<td>-0.34</td>
<td>0.15</td>
<td>-2.20**</td>
</tr>
<tr>
<td>(\hat{\rho})</td>
<td>0.91</td>
<td>0.05</td>
<td>17.810*</td>
</tr>
</tbody>
</table>

* = significant at 1% confidence level  
** = significant at 5% confidence level

---

84 For a discussion of this policy, see Pearse [138], pp. 221-240.
icy required firms to harvest all trees down to a certain size and remove waste material from logging sites. Much of the material was previously unharvested, as it was considered sub-marginal timber. This policy would obviously have some effect in causing harvesting costs to rise with cumulative extraction. The policy was motivated in part by a desire to increase the volume of timber available for harvest in the province, so to some extent it may represent a response to perceived scarcity and resource depletion. To the extent it does not, the measured effect of depletion will over estimate the true effect.

The results of this section help to explain the behaviour of harvesting costs. The results point to depletion of B.C. timber reserves as a factor contributing to rising harvesting costs (and consequently declining rent). The technological developments which occurred throughout the sample period were found to lower harvesting costs significantly. It is difficult to draw more precise conclusions with only aggregate data. More detailed data are necessary to identify the importance of virgin versus second growth timber, location, managerial and silvicultural expenses and the effects of forest management policies in determining costs. Assembling such data to further analyse the behaviour of costs is beyond the scope of the current work.

3.5.3 Risk and the Variability of Forest Industry Rent

The analysis of the previous sections revealed the interaction between price and harvesting cost which determined the the broad evolution of B.C. forest industry rent from 1926-92. One aspect of rent which remains unexplained is its variability from year to year. The results of Chapter 2 indicated that rent was extremely volatile over the period from 1906-92, but particularly before and after the period from roughly 1940-69. The evidence on the price and cost components of rent indicate that much of this variation in rent was driven by

---

85 For a discussion of this policy, see Pearse [138], pp. 242-247.
fluctuations in average cost. In this section I exploit the models of resource rent reviewed in Section 3.3 to identify forces which may help to explain this variability. I use the equations which govern the rate of change of the shadow value to suggest the variables which should influence the movement in rent from year to year.\(^86\) I regress the observed annual rate of change in the average shadow value on these variables to determine their relative importance in explaining the variability of B.C. forest industry rent.\(^87\)

The most general estimating equation is based on the expression for \(\frac{\dot{\lambda}}{\lambda}\) derived from the theoretical model which incorporates risk:

\[
\frac{\dot{\lambda}}{\lambda} = r + \frac{C_S(t)}{\lambda} - f'(S) + \beta (r^m - r)
\]

where \(r\) is the risk neutral rate of return on alternative assets, \(\frac{C_S(t)}{\lambda}\) measures the effect of current harvests on future costs through depletion, \(f'(S)\) is the natural rate of growth of the forest asset and \(\beta (r^m - r)\) is the industry specific risk premium. I also construct a more restrictive estimating equation based on the subset of variables which are suggested by the deterministic model of a depletable resource. This excludes variables which are used to measure the risk premium component from the equation above. An even more restrictive model can also be applied. The analysis so far suggests that it is reasonable to include a depletion term in a model of the B.C. forest industry. Forestry is, however, sometimes viewed as akin to an agricultural operation with a long time horizon.\(^88\) If this is an accurate description of B.C. forestry, then depletion

---

\(^86\) Theoretically firms choose output to achieve the desired appreciation in the shadow value of the resource. This is implicitly responsible for the observed variation in average cost from year to year.

\(^87\) Note that this estimation of the models using data on the average shadow value of resource rent does not provide a test of the models. This is because the models apply to marginal rather than average rent. The presence of a wedge between average and marginal cost causes the estimated regression coefficients to be biased away from those which would be derived using marginal rent. The parameter restrictions implied by the theoretical model cannot be tested when estimation is based on average rent.

\(^88\) See Sloan [158], pp. 3.
should play little role in explaining the behaviour of resource rent in the industry. In this case the estimating equation would be based on only the risk free rate on alternative assets and the rate of growth of the forest asset itself. I estimate three alternative regression equations based on these three models for comparison.

Data

In order to implement any of the models empirically some additional data are required. The dependent variable is calculated as the percentage change in the estimates of the average shadow value per thousand board foot equivalents of B.C. timber. Some discrepancies between the theoretical measure of rents and the estimated average shadow value have been mentioned previously. These prevent the current estimation from serving as a test of the theoretical models of resource rent determination. The objective here, however, is not a test of the models but rather to use them as a guide. The models suggest which variables are relevant in explaining changes in B.C. forest industry rent over time. The evolution of average rent reflects the volatility of the shadow value of B.C. timber. The relative significance of the estimated coefficients and the explanatory power of alternative specifications of the model are sufficient to suggest an answer to the question of what causes rent to be so variable from year to year.

To estimate any of the models it is necessary to obtain empirical measures of the theoretically relevant variables. Particularly in implementing models which use asset pricing arbitrage conditions this can be a difficult step. The measurement of the market rate of return and the appropriate variables to include to measure market risk is the most contentious aspect of translating the theoretical model to an estimable form. I follow the lead of Slade and Thille [155] closely. Their work provides a valuable illustration of how the theoretical model can be

\footnote{The measured value of the dependent variable is also a realized rather than expected rate of change. Since expected values of variables cannot be observed, this measurement error is unavoidable.}
implemented empirically.

All models require an estimate of the risk free rate of return on alternative assets. The risk free rate is measured by the rate of return on ninety day Canadian T-Bills. The annual figure is derived as an average of the monthly rates. There is a break in this series, as data are unavailable before 1934. I use data on ninety day Prime Bankers' Acceptances for the U.S. as a proxy for the Canadian rate during the period 1926-34. All variables in the estimating equations are expressed in real terms. I adjust the nominal rate of return for expected inflation using the method described in Section 2.4.1 of Chapter 2. The 'risk-free' ninety day rate thus contains some element of risk because the return is only guaranteed in nominal terms. The time horizon is sufficiently short that agents' expectations of inflation should be quite precise, limiting the degree of risk.

The most general model also requires data on the market rate of return. To measure this rate I use the rate of appreciation of the T.S.E. 300 stock price index from 1956 to 1992. Before 1956 the T.S.E. 300 is not available. I use the Index of Common Stock Prices for Canada found in the Historical Statistics to determine the market return for the period from 1926-55. Again, the annual figures are obtained as an average of monthly values and the nominal appreciation of the index is adjusted for expected inflation.

These rates of return are sufficient to estimate the model if the stock price composite is an adequate measure of the market return. In order for this to be true it must include a range of assets which spans the space of asset returns. A difficulty in empirically implementing CAPM, or Arbitrage Pricing Theory based models of asset pricing, is that the number and identity of the assets required

---

90 This is the series B14007 in the CANSIM data base from 1950-92. From 1934-49 the data are Series J471 of the Canadian Historical Statistics [109].

91 The source for the U.S. data is the series X449 in the U.S. Historical Statistics [163].

92 The T.S.E. 300 is available as series B4237 in the CANSIM data base.

93 This is the series 'Index of Common Stock Prices, Total', Series J494.
to do this are unknown. Slade and Thille [155] suggest that the properties which fundamental assets should have help to identify candidates for inclusion. Possible changes in future investment opportunities are relevant to current asset demand. Therefore, a hedging asset should be included. The rate of return on a long term bond is a good candidate for a hedging asset. The rate of return on Canadian Government Bonds with terms of ten or more years was used in the estimation.94 The volatility in the fundamental assets should explain most of the volatility in the returns on all traded assets. This property leads to the empirical use of financial and macroeconomic aggregates as fundamental factors which capture undiversifiable market risk.95 In this empirical application I use G.D.P. growth for Canada and the rate of change in the exchange rate relative to the U.S. as macroeconomic aggregates which capture market risk.

In addition to rate of return data, all models require an estimate of the natural rate of growth of B.C.'s forest assets. I estimate the growth rate of B.C.'s forests using fragmentary existing data and the variable is likely measured with substantial error.96 I use estimates of incremental volume per acre of growing stock in conjunction with data on the area of immature timber in the coast and interior regions to develop regional growth rate estimates.97 A provincial growth rate for forest resources is constructed as a weighted average of these regional growth rates.

A number of alternative weighting schemes are possible. The variable which

---

94 This series (B14013 in the CANSIM data base) is available only from 1936. For the period from 1926-35 I use the series for 'Long Term Canadas', Series H605 in the first edition of the Historical Statistics of Canada [22].
95 See Chen, Roll and Ross [42], Slade and Thille [155].
96 Detailed surveying of the provincial timber stock did not begin until the 1950s. Current surveys of the forest base produce data on annual incremental increases in timber volume by species and region. Time series data for the increment and volume for the province as a whole are unavailable.
97 The sources for the annual increment and volume on a regional basis are: Fulton [71], pp. 95; Sloan [157], pp. 20-22, 34, 41-42; Sloan [158], pp. 211-214; Pearse [138], pp. 220. The growth rate is measured as the annual increment in volume as a percentage of total regional volume. I use linear interpolation to estimate data for years between the point estimates.
I use in the reported estimates is constructed using weights based on the share of the total harvest from each region. The advantage of this weighting scheme over the alternatives is that it allows indirectly for accessibility and economic viability to play a role in determining the stock of the resource. It is the measure of forest growth which is most closely related to the forest region actually being harvested at any point during the sample. Alternative measures of forest growth (which use weights based on the geographic area in the coast and interior and a simple arithmetic average) assume that all forest land in the province is part of the economically viable stock, at all points in the sample. Fortunately the results do not appear overly sensitive to the choice of weights, since these alternatives produce results qualitatively similar to those which I report.

The only remaining variable for which data are required is the depletion term. This is difficult to measure because a theoretically consistent estimate must be derived from a cost function. For reasons discussed above full estimation of a cost function is not feasible. I use the results from the real cost regression, Equation 3.9, to construct a proxy for the theoretical measure of depletion. The specification for estimated real harvesting cost implies that the following equation determines the predicted level of real costs:

\[
\hat{C} = e^{\hat{\alpha}_0 q \hat{\alpha}_1 Q \hat{\alpha}_2 LPR \hat{\alpha}_3} \tag{3.10}
\]

In the theoretical model the depletion effect is defined as \( \frac{\partial C}{\partial S} \). In this section we have estimated costs as a function of cumulative extraction, essentially assuming that \( q = -dS \). In this case the depletion effect is represented by \( \frac{-\partial C}{\lambda \partial Q} \). Natural growth may drive a wedge between extraction and the change in the stock, however, the estimated equation captures the empirical link between cumulative harvests and future harvesting costs. The estimated depletion effect is given by the following:

\[
DEPN = -\frac{\hat{\alpha}_2 e^{\hat{\alpha}_0 q \hat{\alpha}_1 Q \hat{\alpha}_2 LPR \hat{\alpha}_3}}{\hat{\lambda}} \tag{3.11}
\]
where \( \lambda \) is the calculated average shadow value of B.C. timber. The estimated effect of depletion depends on the level of all the variables in each year, as well as the shadow value. The estimated depletion term is negative for almost all years, as expected. This indicates that an increase in the stock size (as represented by a reduction in cumulative harvests) in the previous period would lower current costs.

This measure is a proxy for true depletion costs. The use of a general deflator to account for price changes may not produce the appropriate industry cost function. In addition, it is necessary to use cumulative harvests rather than a measure of changes in the stock itself. Because of possible measurement error I consider alternative proxies for depletion. The depletion term captures cost effects which arise due to diminished resource quality, at least when quality is broadly defined to include accessibility, timber volume, species, etc. As an alternative measure of depletion I employ a direct measure of resource quality. The change in the share of log exports which are either Number 1 or 2 grade is used as a measure of changing resource quality.\(^98\) I do not use the share of the harvest from the coast region as a depletion proxy because it is closely correlated with the measure of forest growth by construction.

**Estimation and Results**

In this section I investigate the empirical contribution of the variables above to the observed variation in forest rent. The objective is to see which, if any, of the variables help to explain the extreme variability of rent. The most general estimable model incorporates both variables from resource theory and those relevant to asset pricing and risk. The estimating equation takes the following

\(^98\) Data are obtained from the *Ministry of Forests Annual Reports* [13], but are available only to 1982.
where the variable mnemonics correspond to the measured values of the theoretically relevant variables discussed above. In addition to this most general model more restrictive estimating equations are derived based on the depletable (D.R.) and strictly renewable (R.R.) resource models. The following list summarizes the restrictions which are imposed a priori on the general model to get these various nested models. A test of whether or not the stock market variable is sufficient to measure the market return is also included. The restricted model which assumes that this is true is the CAPM model. To compare the performance of each of these models in explaining the variation in rent on B.C. timber I examine the \( R^2 \) as a measure of fit and conduct F-tests for the significance of the regressions.\(^99\)

1. Renewable Resource Model (R.R.)
   - Restrictions Imposed: \( \beta_3 = \beta_4 = \beta_5 = \beta_6 = \beta_7 = 0 \)

2. Depletable Resource Model (D.R.)
   - Restrictions Imposed: \( \beta_4 = \beta_5 = \beta_6 = \beta_7 = 0 \)

3. Depletable Resource and Capital Asset Pricing Model (D.R./CAPM)
   - Restrictions Imposed: \( \beta_5 = \beta_6 = \beta_7 = 0 \)

4. Depletable Resource and Multi-Factor Asset Pricing Model (D.R./MULTI)
   - Restrictions Imposed: no a priori coefficient restrictions.

\(^99\)The null for an F-Test of regression significance is that the coefficients on all variables except the constant are zero.
Table 3.2: Models of Forestry Rent Evolution: Fit and Regression Significance

<table>
<thead>
<tr>
<th>Model</th>
<th>$R^2$</th>
<th>Regression Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>R.R.</td>
<td>0.0018</td>
<td>$F_{(2,64)} = 0.057$</td>
</tr>
<tr>
<td>D.R.</td>
<td>0.0376</td>
<td>$F_{(3,63)} = 0.819$</td>
</tr>
<tr>
<td>D.R./CAPM</td>
<td>0.2077</td>
<td>$F_{(4,62)} = 4.06^*$</td>
</tr>
<tr>
<td>D.R./MULTI</td>
<td>0.3456</td>
<td>$F_{(7,59)} = 4.45^*$</td>
</tr>
<tr>
<td>CAPM restriction</td>
<td></td>
<td>$F_{(4,62)} = 4.14^*$</td>
</tr>
</tbody>
</table>

* = significant at 1% confidence level

Restriction Tested:

- CAPM: $\beta_5 = \beta_6 = \beta_7 = 0$

The results of these tests are displayed in Table 3.2. The variables suggested by standard resource theory do not do a good job of explaining the observed variation in rent. The F-statistic for the overall significance of the regression is not significant for either the renewable (R.R), nor depletable resource models (D.R.) This is unsurprising considering the low $R^2$s for these two regressions. Less than 5% of the variation in the rate of change of the average shadow value of B.C. timber is explained by the risk free rate of return, forest growth and depletion taken together. The failure of the variables of standard resource theory to explain observed variation in resource rent is perhaps not surprising. The fit for these models in my estimation is not much different from that obtained by Young [169] in an equivalent estimation for a nonrenewable resource. The volatility of forest rent must be explained by other forces.

The performance of more general models suggests that factors measuring risk may be important. When even a single measure of market returns is included (D.R./CAPM) the regression becomes highly significant. The fit of the estimating equation improves dramatically. Now the model accounts for over 20% of the observed variation in the rate of change of the average shadow value.\footnote{Young [169] has the benefit of sufficient data to estimate a cost function. Therefore, her measures of rent and the depletion effect were consistent with the theoretical model.}
\[ LDOT = \beta_0 + \beta_1 r_{90} + \beta_2 FGR + \beta_3 DEPN + \beta_4 r_{MKT} + \beta_5 r_{LT} + \beta_6 GDP_{dt} + \beta_7 EXCH_{dt} + \epsilon \]

<table>
<thead>
<tr>
<th>Coefficient</th>
<th>Estimate</th>
<th>Standard Error</th>
<th>T-statistic (59 d.o.f.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\beta_0)</td>
<td>-23.6</td>
<td>57.0</td>
<td>-0.4144</td>
</tr>
<tr>
<td>(\beta_1)</td>
<td>-13.49</td>
<td>10.91</td>
<td>-1.236</td>
</tr>
<tr>
<td>(\beta_2)</td>
<td>-98.95</td>
<td>168.6</td>
<td>-0.5869</td>
</tr>
<tr>
<td>(\beta_3)</td>
<td>-1.76</td>
<td>1.40</td>
<td>-1.258</td>
</tr>
<tr>
<td>(\beta_4)</td>
<td>1.93</td>
<td>.80</td>
<td>2.411*</td>
</tr>
<tr>
<td>(\beta_5)</td>
<td>16.3</td>
<td>12.18</td>
<td>1.338</td>
</tr>
<tr>
<td>(\beta_6)</td>
<td>6.68</td>
<td>2.50</td>
<td>2.671*</td>
</tr>
<tr>
<td>(\beta_7)</td>
<td>-7.45</td>
<td>3.45</td>
<td>-2.160**</td>
</tr>
</tbody>
</table>

* = significant at 1% confidence level  
** = significant at 5% confidence level

Table 3.3: Regression Results, Multi-factor Model of Forestry Rent Evolution

of B.C. timber. The performance of the most general model is even better. It explains 35% of the variation in the rate of change of rent. The restriction which limits the set of factors agents use to evaluate market risk to one variable (the rate of change in the TSE 300) is rejected at the 1% level of significance. The measure of market returns in combination with the measures of undiversifiable market risk help to explain a substantial portion of the variation in rent over the sample period.

The coefficient estimates from the estimation of the unrestricted model are given in Table 3.3. Examining these results the performance of the model appears somewhat less impressive. The coefficients generally have intuitively appealing signs, but they are not always significant or of believable magnitude.\(^{101}\)

First consider the results for the coefficients on the variables suggested by the simple resource models. The estimates for \(\beta_0\) through \(\beta_3\) are insignificant, but generally have the expected sign. The estimated coefficient on the risk free rate of return is negative, however, this is a reduced form for the structural

\[^{101}\text{Recall that the coefficients in the regressions are not expected to be equivalent to those predicted by the models due to the use of average rather than marginal rent as the dependent variable.}\]
parameters on the risk free rate alone and those used to weight it in the risk premium. The implicit estimate of the coefficient on the risk free rate alone is positive, which is as expected. When the risk free rate of return is higher the average rent per unit of B.C. timber must appreciate more quickly for it to provide a comparable return. Forest growth appears to reduce the rate of return required on forest assets, which is also the anticipated effect. The natural growth of the asset provides an internal return, this makes a slower appreciation in the average rent per unit harvested equivalent to the return on other assets. The forest growth parameter is very imprecisely estimated. This is quite possibly a result of the poor measurement of the variable itself.

The only variable for which the estimated coefficient does not have the expected sign is the depletion term. According to the model this variable should have a positive coefficient. According to the estimated coefficient rising costs due to depletion are associated with rapid growth in rent. One possible explanation for this may be that the theoretical sign on the depletion term relates to the value of rents on standing timber (i.e. in situ), while the measure of rent is for timber which is harvested. The effect of depletion is to increase future harvesting costs and depress rents on remaining standing timber as a result. In order to actually harvest timber it must be the case that realized rents are high enough to offset the higher costs incurred because of depletion.

The decline in the quality of forest resources, which is assumed to be driving generally rising costs, should still result in slower growth of resource rents over time. I re-estimate the models (both the restricted resource and more general

---

102 I construct an estimate of the coefficient on \( r_0 \) alone according to theory. The coefficient on the risk free rate alone is the sum of the coefficients for the risk free rate and all other variables used to measure market returns and risk. This is the sum of the estimated parameters \( \beta_1 \) and \( \beta_4 \) through \( \beta_7 \).

103 This is not intuitively obvious. It is because the value of the depletion variable is negative. If depletion is to lead to falling rents as costs rise, then the coefficient in the regression should be positive.

104 This is somewhat analogous to the apparent contradiction of 'high grading' discussed earlier.
models) using timber quality as an alternative measure for depletion. In this case the coefficient has the expected sign in all regressions and it is marginally significant in the most general model. This provides some evidence that depletion plays its expected role in explaining the variation in the rate of change of the average shadow value of B.C. timber. However, examination of the coefficients for the other variables indicates that it is dominated by other factors.

The most significant variables in the regression are those which reflect the market return and undiversifiable risk. The coefficient on the market rate of return indicates that forest assets are very risky. The rate of change in the average shadow value of B.C. timber is almost twice that of the market return. The significance of this coefficient suggests that changes in the market return are important in explaining the variation in the average shadow value of B.C. timber. The coefficient on the long term rate has the expected sign, but it is insignificant. Correlation between this rate and the risk free rate may be causing some imprecision in their individual coefficient estimates. The remaining coefficient estimates indicate that rent in the forest industry appreciates faster when G.D.P. is growing and when the Canadian dollar is appreciating relative to the U.S. currency. These estimates are intuitively plausible. When general economic conditions are favourable rent in the forest industry increases more rapidly because when there is an economic downturn, forestry rent declines more precipitously.

A substantial portion of the output of the forest industry is best described as an investment good. Much of the timber which B.C. harvests is converted to dimension lumber and used in building construction. Like investment, the rent on B.C. timber is extremely volatile relative to other economic variables. Perhaps it should not be surprising that the rate of change in the average rent for
B.C. timber is influenced by variables which reflect general economic conditions.

Factors which agents use to assess market, or undiversifiable, risk appear to be important in explaining the variability of forest industry rent. This is consistent with the observed variation in the data, set in its historical context. The decline in the volatility of rent during the period from roughly W.W. II through the 1960s is consistent with the decline in market risk associated with these ‘boom’ decades. The economic uncertainty associated with the 1920s and the depression era, as well as the return of major recessions in recent decades, is consistent with the increased variability of rent during these periods.

In a sense the results of this empirical investigation of rent are hardly surprising. The vulnerability of the forest industry to market conditions exogenous to the industry is one of its distinguishing characteristics. Agents operating in B.C.’s forest industry are well aware of this. In order to compensate for this uncertainty, given that it is correlated with market risk and cannot be diversified away from, a risk premium is a required component of returns. The return to the owner of the resource, the appreciation of the shadow value of timber, should include a risk premium which reflects this vulnerability. The finding that variables which represent risk help to explain the variability of the average rent on B.C. timber confirms that this is so.

3.6 Conclusion

In Chapter 2 I generated a time series of resource rent for B.C.’s forest industry. This evidence indicated that there was little or no rent before the end of the Great Depression, followed by rapidly rising rent through the mid-century mark and finally a secular decline. In addition, forest industry rent was highly volatile. Rent varied significantly from year to year over the entire century, but especially before W.W. II and after roughly 1970. The results of this chapter illuminate some of the forces which were driving this observed behaviour of resource rent in
the B.C. forest industry.

A combination of influences were notable. The broad trends in rent were the result of changes in value of rent per unit of B.C. timber. The examination of the average shadow value of B.C. timber, broken down into its price and average cost components, provides further explanation for the behaviour in rent. The rapid rise in rent during the period from 1940-51 coincided with a marked increase in the price of forest products. The secular decline from midcentury was the result of both a declining output price and rising harvesting costs. Price movements reflected the influence of forces exogenous to the provincial industry, but were also possibly influenced by the quality of timber harvested in B.C. The behaviour of cost also reflected an interaction of variables, including harvest level, technological change and depletion. To investigate the possible influence of these variables in more detail I regressed real harvesting costs on measures of current output, the level of technology and the cumulative harvest. The results indicated that depletion, as measured by cumulative harvests, played the most significant role in explaining rising harvesting costs.

Rent was very volatile over the sample period. Examining the price and average cost components it appears that fluctuations in cost were driving much of this volatility. Theoretically these variations in cost reflected profit maximizing choices of output, as firms tried to achieve a rate of return on their forest assets equivalent to the return on other assets in the economy. I used the theoretical model of Section 3.3 to suggest variables which should have determined the rate of change in the shadow value of B.C. timber. I regressed the percentage change in the average rent per unit of B.C. timber on these variables to investigate the forces underlying the observed variation in rent. I found that the variables which reflected market risk were most significant. This indicates that forest resource rent in B.C. included a substantial premium for risk in order for the expected return on the resource to compare favourably with other assets. It also
implies that B.C. forest rent was highly sensitive to market conditions which were beyond the influence of the industry.
Figure 3.1: Average Shadow Value of B.C. Timber, 1926-92
Figure 3.2: Difference between Growth of B.C. G.D.P. and Forest Industry Output
Figure 3.3: Prices and Costs in B.C.'s Forest Industry, 1926-92
Figure 3.4: Share of B.C. Log Exports Classified as Grade 1 and Grade 2 Timber, 1926-82
Figure 3.5: Share of Provincial Timber Harvest Originating from Coast Forest District, 1926-92
Figure 3.6: Rate of Change in Average Shadow Value of B.C. Timber, 1926-92
Figure 3.7: Real Value of New Residential Construction, 1906-92
Figure 3.8: Index of Real Stock Prices (TSE), 1919-92
Chapter 4

Export Led Growth and the Forest Industry in B.C.

4.1 Introduction

The forests of British Columbia have been long taken for granted as the engine driving the economic growth of the province...

A.L. Peel, 1991

British Columbia's geography is dominated by forest landscapes. The province's forest resource endowment provides a natural focus in the search for factors explaining the region's economic growth and development. In Chapter 2 I calculated forest industry resource rent, which measured the direct contribution of the forest resource to provincial income and growth. This measure was smaller than anticipated. During the period from 1919-92 rent neither accounted for a large share of provincial income measures nor drove provincial growth. Nevertheless, the view that B.C.'s forests were responsible for provincial growth is persistent, as the quote above illustrates. Is it possible that the forest industry played such a role, despite its relatively modest direct contribution? It may be the case that the forest industry's influence was felt through induced general equilibrium effects. In this chapter I investigate one such possible connection.

Trade played an important role in British Columbia's economy over the 20th century. Both recent and historical work confirm the relatively international

---

1 Peel [139], pp. 8.
2 Recall that this measured the contribution of the forest only as an industrial commodity and did not include aesthetic or environmental contributions.
orientation of the provincial economy. Previous work by Allen [1] established an apparent relationship between provincial exports and G.D.P. over the late 19th and 20th century. Forest exports are the dominant component of B.C.'s total exports. They account on average for some 40% of the total value. The view that B.C.'s forest exports drive the provincial economy is prevalent in both historical and contemporary analysis. This is an obvious channel through which the province's forest endowment may have been responsible for provincial growth and economic development. This chapter addresses the nature of the empirical link between B.C.'s forest exports and its G.D.P.

In order to establish a meaningful relationship between variables which trend upward over time, as B.C.'s forest exports and G.D.P. do, the time series properties of the data must be taken into account. I find that these variables are best characterized as having stochastic trends. This implies that they are stationary in their first differences. I look for a stable long term relationship between forest exports and provincial growth by testing to see whether the series share a common stochastic trend. This is the objective of testing for cointegration. I employ both single equation and systems approaches to testing for cointegration. In spite of an apparent relationship between the levels of these two variables, they are not cointegrated. This means that forest exports and provincial income

---

3 Helliwell [90] examines the 'border effect' in determining Canadian regional trade patterns. Preliminary results indicate that the 'border effect' is much smaller between B.C. and the U.S. than for other Canadian regions. Blain, Paterson and Rae [10] investigated interwar business cycles in B.C. and found that they were more closely attuned to those in the U.S. than Canada. The measure of exports includes 'regional' exports, which are shipments from B.C. to other Canadian provinces. Annual data are provided courtesy of R.C. Allen (1919-82), decadal summary of B.C. export data published in Allen [1]. Data are also obtained from Selected Forest Industry Statistics [34].

4 Marchak [123], [122] casts the forest industry as a leading export sector in a staples framework of development. Barman's [6] history of B.C. emphasizes the contribution of staple exports to economic development and reserves a central role for the forest industry, see for example pp. 326, 280-81, 240. The link between forest exports and provincial economic growth is not confined to academic writing. The popular press also assumes a direct connection between forest export performance and provincial growth ("Growth Forecast for B.C. Reduced" Vancouver Sun, Nov.14, 1997.)

170
have different stochastic trends and there is no deterministic long run relationship between the levels of these variables.

In addition to testing for a stable long term relationship between B.C.'s forest exports and G.D.P., I also examine the short term interaction between the variables. I estimate a bivariate vector auto regression (VAR) to examine the dynamic interaction between forest export and G.D.P growth. This allows the empirical relationship between the variables to be more completely revealed. Growth of forest exports could have positive, or negative consequences for B.C.'s G.D.P. growth. Theory suggests that either outcome is possible. Vector auto regressive methods are used to reveal the nature of the empirical connection.

The results are of general, as well as regional interest. The role of primary exports in promoting growth remains an open question. A class of models characterized as the 'Dutch disease' literature suggests that primary export booms can only lead to a negative effect on growth in the long term. Other work suggests that primary export growth can stimulate overall economic growth. Theory yields no clear conclusion about the effect of such exports on economic growth. Empirical evidence may help to illuminate the relationship between primary exports and general economic growth.

The rest of the chapter is organized as follows. I briefly discuss related literature in Section 4.2. Section 4.3 provides an introduction to the data under study. The basic patterns in the data are discussed. Apparent trends, correlations and univariate time series properties of the data are the focus of this section. In Section 4.4 I test for a long term relationship between B.C.'s forest exports and G.D.P. I first employ single equation methods to test for cointegration between the levels of B.C.'s forest exports and G.D.P. Subsequently I address the same

---

6See Brander and Taylor [12], McAusland [116]. More precisely, the indeterminacy of the results in these papers relate to welfare. The observable variable of G.D.P. per capita is referred to in discussing empirical evidence relevant to the models.

7See Corden [51] for a survey.

8For example, see Buffie [24].
issue using the systems approach of Johansen and Juselius [100]. In Section 4.5 I estimate a bivariate VAR in the growth rates of forest exports and G.D.P. This allows me to examine the short term dynamic interaction between the variables and further investigate the nature of the relationship between the growth of forest exports and G.D.P. in B.C. The conclusions of this chapter are summarized in Section 4.6.

4.2 Motivational Literature

The idea of export led development is far from new. The origins of the literature can perhaps be traced to early work in Canadian economic history. Harold Innis [93] and W.A. Mackintosh [121] were the first scholars to focus on the role of 'staple' exports in Canadian development. Their work emphasized a complex web of connections between export producing sectors and the rest of the economy. More formal descriptions of this staple 'theory' of economic development characterized these linkages as belonging to three broad types.\(9\) Backward linkages reflected the stimulation of domestic industry supplying inputs for the export industry. Forward linkages represented the stimulation of industries which use the export good as an input. Final demand linkages referred to the additional demand generated in all other sectors of the economy through the income which the export sector generated. The critical feature was that the export sector served as the base for economic growth and diversification.\(10\) This central idea proved broadly compelling to economists. It forms the core of Douglas North’s [130] work on U.S. economic development.

The idea that exports and growth were related served as fertile ground for

\(9\)See Watkins [167], Bertram [8].

\(10\)Unfortunately if a staple did not generate these linkages effectively, a situation referred to as a 'staple trap' developed. In this case the economy specialized in the production of the staple and the benefits of diversification and development did not follow. Marchak [122] suggests that this may be an accurate view of the forest industry’s role in the B.C. economy.
theories of endogenous growth. Unlike the earlier literature, much of the 'new' export led growth literature focused on manufacturing exports. Some models of development still offered indirect possibilities for primary exports to act as a stimulus to economic growth through contributions to market size effects. Murphy, Schleifer and Vishny [128] developed a model in which a primary leading sector provided the critical stimulus to domestic demand necessary to promote industrialization and growth.

As noted above, the theoretical literature is somewhat divided on the possibility of primary export growth stimulating export led development. The 'Dutch disease' literature established a negative role for primary export booms in economic growth due to the diversion of factors of production out of the tradeable manufacturing sector. The result of primary booms in these models was deindustrialization. Corden [51] provides a survey of the early literature. Sachs and Warner [151] is an example of a more modern 'Dutch disease' growth model which incorporated learning by doing in the tradeables sector. It generated a familiar negative effect on growth from resource trade stimulation. Other work holds out the possibility that under certain conditions resource exports can lead to growth. Buffie [24] outlined cases in which positive price shocks or improvements in production technology in the resource sector could produce export led growth.

A large empirical literature addresses the connection between exports, growth and development. One strand of this work is largely historical. The empirical debate over the importance of the wheat boom in Canadian economic history is a central component of this historical literature. As discussed in Chapter

---

11 Grossman and Helpmans' [79] work on the links between trade and growth is one well known example.

12 This accommodated the obvious empirical examples of resource poor regions which seemed to have achieved growth through export orientation (Korea, Taiwan, Singapore, Hong Kong). The failure of some primary exporters (Kenya, Zambia, Honduras) to achieve lasting growth reinforced the perception that it was manufacturing exports which drove self sustaining growth.

13 This is one particularly well known example of a debate over the empirical relevance of the
2 (Section 2.2.1) Chambers and Gordon [40] ignited this debate through their innovative use of a general equilibrium model which showed that the change in land rent in the prairies accurately captured the contribution of the wheat boom to per capita national income growth. Their results, which indicated that this effect was small, were unbelievable to proponents of the staple theory of Canadian development. A heated exchange between Dales, McManus and Watkins [54] and Chambers and Gordon [41] generated minor revisions to the original estimates. Subsequent work by Lewis [111] and Bertram [9] involved substantive revision of the model and generated far larger effects.\(^1\) Other investigations of the wheat boom period, such as Ankli [2], suggest that this external stimulus was less important for growth than the investment boom and factor accumulation which preceded it. The wheat boom debate failed to produce unequivocal evidence of export led growth in Canada's economic development, but this view, along with the staple theory, remained pervasive.

Developing countries are the focus of another strand of the empirical literature on export led growth. Much of this literature involves cross-sectional comparison of developing countries and their characteristics. Chenery and Syrquin [43] established empirical patterns of development, which provided some support for an export-growth connection. Michaely [126] tested for (and found) statistically significant correlations between export growth and per capita G.N.P. growth among developing countries. Balassa [4] used single equation regression applied to a pooled cross section of developing countries and demonstrated a positive contribution by exports to G.N.P. growth. This effect was significant even allowing for more traditional sources of growth, such as labour and capital accumulation. Feder [67] constructed an analytical framework and implemented staple thesis to Canadian economic development. Some other examples were noted in Chapter 1.

\(^1\) Lewis finds that "prairie wheat expansion accelerated the growth rate of per capita income in Canada by 33.2-42.1%." See Lewis [111], pp.1255.
it econometrically. He found evidence that exports promoted growth due to a resource re-allocation effect. Factors were more productive when employed in the export sector. Chow [45] used single equation methods to address the issue of causality between export and G.N.P. growth directly. In his sample of newly industrialized countries the evidence indicated a bidirectional causality. Exports and G.N.P. growth reinforced one another in a virtuous cycle. The empirical evidence from developing countries seems to point more clearly to an export-G.N.P. growth connection than the historical literature.

More recent empirical work focuses on evidence for developed countries. Kunst and Marin [107] examined the causal link between exports and productivity growth for Austria. They found that exports did not cause productivity, but rather the opposite. Marin [124] subsequently examined this issue for a panel of developed countries and found evidence that there was causality running from exports to productivity for all countries in the sample, which included: the U.S., Japan, Germany and the U.K. These more recent papers adopt multivariate time series methods. Earlier analysis generally failed to consider the long run properties of the data, or the possibility that exports and growth were simultaneously determined. This undermines confidence in the results of early work on the connection between exports and growth. Advances in time series methods have stimulated a re-examination of the evidence for export led growth.

The debate on the role of exports in Canadian development has not been immune to this influence. Serletis [153] used annual Canadian data on exports, imports and G.D.P. to re-examine the export led growth hypothesis. While he did not find a cointegrating relationship between exports and G.D.P., growth in exports was found to Granger cause G.D.P. growth. Serletis interpreted this result as demonstrating that export growth promoted the growth of national income. More recently Henriques and Sadorsky [89] used a cointegrating systems approach to test for cointegration and causality between exports and G.D.P. for
Canada. This approach eliminates the possibility of simultaneity bias, which may have affected Serletis' results. Henriques and Sadorsky established that there was a cointegrating relationship between Canadian exports and G.D.P., however, it was G.D.P. which drove exports rather than the reverse. This finding is at odds with the 'staples' view of Canadian development, which laid the foundations for the theory of export led growth.

In spite of the inconclusive evidence for export led growth for Canada, this is the entrenched view of the role played by forest exports in the BC economy.\(^{15}\) Evidence such as the share of forest exports in B.C.'s total exports, forest sector employment and estimated 'induced' effects are cited in support of this view. However, the export led growth hypothesis has not been tested in a systematic fashion for B.C. Without assessing the empirical evidence in this way it is impossible to know if the connection is as strong as has been suggested. The results of recent research using aggregate Canadian data do not generally support the level of confidence in the staple model implicit in evaluations of the forest industry in B.C.\(^{16}\) However, work by Wakerly [166] indicates that averaging across cross sections (in this case regions) can alter the time series properties of the data because disaggregate information is lost through averaging. This opens up the possibility that regional results may differ from those generated with national data.

The nature of the link between forest exports and provincial income in British Columbia is of interest for a number of reasons. At a purely regional level the answer to the question of whether or not forest exports are deterministically related to the level of provincial income (or cause provincial growth) has obvious policy significance. If this is the case, then resolving problems such as the softwood lumber dispute with the U.S. to secure access to key export markets is

\(^{15}\)See, for example: Marchak [123], [122]; Edgell [62]; Peel [139].

\(^{16}\)Recent research discussed above, in the Introduction and in Chapter 2 provides examples.
of great significance to the regional economy. In addition, addressing potential forest resource depletion becomes an even more pressing concern for the province.

At a general level recent literature has examined the theoretical possibility for renewable resource exploitation to be coupled with sustainable growth. While the initial results seem to indicate that this is unlikely, the theoretical models developed so far focus on the case of an open access resource. The issue of whether or not managed resource exploitation can be coupled with growth has not been addressed in the theoretical literature. B.C. provides an opportunity for an empirical case study of this question. The evidence which this chapter generates may serve as a useful reference in further theoretical development. As mentioned above, the question of whether or not primary exports can contribute to sustained growth remains open in terms of existing theory. The generation of a body of empirical evidence addressing this question helps to determine which models are consistent with the facts.

4.3 A First Look at the Data

It is not hard to understand the emphasis placed on the forest industry's role in B.C.'s economy when looking at the data. Figure 4.1 illustrates the movement in real forest exports and provincial G.D.P. for the period 1919-1992. Forest exports constitute a substantial portion of G.D.P. overall and in general the two variables appear to move together over most of the sample period. Both exhibit a strong upward trend. The two series are highly correlated. The contemporaneous correlation between real forest exports and G.D.P. for B.C. is 0.98. There certainly seems to be a strong link between the levels of the two variables based on existing theory. The generation of a body of empirical evidence addressing this question helps to determine which models are consistent with the facts.

---

17 See Brander and Taylor [12], McAusland [116].
18 Data for the current dollar value of B.C. forest industry exports are courtesy of R.C. Allen (1919-82). I also obtain current dollar values of B.C. forest exports from Selected Forest Industry Statistics [34]. I construct a forest industry price index to deflate the nominal series and generate real forest exports. I construct the price index for all forest exports as a weighted index of price indices for the Logging, Wood and Paper and Allied Industries. For details see Appendix C. Sources for provincial G.D.P are as previously described.
<table>
<thead>
<tr>
<th>Years</th>
<th>FOREX</th>
<th>B.C. GDP</th>
</tr>
</thead>
<tbody>
<tr>
<td>1920-29</td>
<td>4.54%</td>
<td>4.30%</td>
</tr>
<tr>
<td>1930-39</td>
<td>1.78%</td>
<td>2.17%</td>
</tr>
<tr>
<td>1940-49</td>
<td>3.43%</td>
<td>6.53%</td>
</tr>
<tr>
<td>1950-59</td>
<td>5.28%</td>
<td>4.57%</td>
</tr>
<tr>
<td>1960-69</td>
<td>5.78%</td>
<td>5.50%</td>
</tr>
<tr>
<td>1970-79</td>
<td>4.24%</td>
<td>5.80%</td>
</tr>
<tr>
<td>1980-89</td>
<td>1.15%</td>
<td>2.78%</td>
</tr>
<tr>
<td>1990-92</td>
<td>2.48%</td>
<td>2.80%</td>
</tr>
</tbody>
</table>

Table 4.1: Decadal Average Growth Rates of the Forest Exports and G.D.P. of British Columbia

on this first glance at the evidence.

There also appears to be a connection between growth in forest exports and provincial output. Table 4.1 presents decadal averages of the growth rates of the two variables.\textsuperscript{19} Casual observation of these figures suggests that G.D.P. growth and forest export growth for British Columbia are not unrelated. Turning to a more objective measure, the two variables have a correlation of 0.31.

Previous work by Allen [1] noted the apparent link between exports and G.D.P. growth in British Columbia. Allen investigated the relationship between the variables by constructing the ratio of exports to provincial G.D.P. over the period 1880-1980. He found that this ratio was "remarkably constant" over the period.\textsuperscript{20} Forest exports were the dominant component of B.C.'s exports throughout the years from 1919-92, accounting for over 40% of the real value on average. During this period the ratio of forest exports to G.D.P. behaved similarly to that of all exports. While there appears to have been a moderate decline following W.W. II, overall the ratio of forest exports to G.D.P. remained relatively stable. This also suggests that there may be a long term link between

\textsuperscript{19}Annual growth rates are calculated as the log differences of the variables as measured in the data described in the previous footnote. Decadal average growth rates are calculated as the average of the annual figures.

\textsuperscript{20}See Allen [1], pp. 15.
the variables.

Does the evidence described so far provide support for the theory that growth in forest exports leads overall G.D.P. growth in B.C.? Not really. While none of the features of the data contradict this view, there are potentially serious problems in interpreting the evidence presented so far as support for the hypothesis of export led growth.

Perhaps the greatest obstacle to clear interpretation of the relationship between exports and G.D.P. is the strong upward trend in the variables. Both these series are clearly nonstationary. It is well established that statistical analysis which uses nonstationary variables without taking this property into account can lead to misleading conclusions. It is necessary to deal with the trend component of the data explicitly in order to establish the real relationship between the variables. In order to do this it is necessary to determine the long run properties of the data.

Nonstationary time series data may have a trend component which is deterministic, or stochastic. Determining which type of trend best characterizes the data matters both for interpreting the effect of disturbances to the series and practically in terms of how to transform the data to make it stationary. If a variable can be characterized as having a deterministic trend, then shocks have temporary effects and in the absence of disturbances the variable reverts to its trend. Detrending the data is the appropriate way to achieve stationarity for these variables. Alternatively, if a series has a stochastic trend, then the effect of shocks is permanent. This implies that there is no trend reversion. Differencing the data is the appropriate method for achieving stationarity.

Tests of the long run properties of time series are referred to as unit root

---

21 This problem is particularly obvious in the case of spurious regression. When one nonstationary series is regressed on another the results can indicate apparently significant relationships which are generated by the common upward movement in the series and not due to any real relationship between the variables. For more discussion of this problem, see Banerjee et al [5], pp. 69-84.
Variable | $\tau$-statistic | $k$
---|---|---
BCGDP | -2.3561 | 0
FOREX | -2.6919 | 0
$\Delta$ BCGDP | $-5.4595^*$ | 1
$\Delta$ FOREX | $-5.6043^*$ | 2

$^*$ = significant at 1% confidence level

Table 4.2: Dickey-Fuller Unit Root Tests; Real B.C. G.D.P. and Forest Exports
tests.$^{22}$ In order to test for trend versus difference stationarity of a series a
general model which nests the two hypotheses is estimated for the data. The
following specification is estimated for each of the series:

$$
\Delta y_t = \beta_0 + \beta_1 t + \beta_2 y_{t-1} + \sum_{k=1}^{\bar{k}} \gamma_k \Delta y_{t-k} + \epsilon_t
$$ (4.1)

This model generates augmented Dickey Fuller [57] $\tau$-tests for a unit root, which
are consistent in the presence of error terms which follow an autoregressive
process. The addition of the $\bar{k}$ lagged terms adjusts for this possibility. $\bar{k}$ is
chosen so that the $\epsilon$ are serially uncorrelated. A test of the alternative of linear
trend stationarity against the null of a random walk with drift is simply a one
sided test of the hypothesis that $\beta_2 = 0$ against the alternative $\beta_2 < 0$.$^{23}$ This is
calculated as an ordinary t-statistic, but it has a nonstandard distribution, given
in Dickey and Fuller [57], because of the nonstationarity under the null. The
results for the tests on the log levels and log differences of real B.C. G.D.P. and
forest exports are given in Table 4.2. It is impossible to reject the null of a unit
root in the log levels of the variables at any conventional level of significance. For
the log differences the null can be rejected at the one percent level. The levels

$^{22}$This terminology is derived from the conditions for an autoregressive process to be sta­
tionary. The roots of the autoregressive process must lie outside the unit circle for stationarity.
Only in this case will the effect of shocks diminish over time. The finding of a unit root implies
permanency of disturbances and nonstationarity of the autoregressive process.

$^{23}$This is not the only possible specification. For example, I also estimate more restric­
tive models which do not include constant or trend terms. The results for these models are
qualitatively identical to those which I report.
of both B.C.'s G.D.P. and its forest exports are nonstationary and characterized by a stochastic trend, while the first differences of the two series are stationary. This implies that the two series follow integrated of order one I(1) processes. In other words, the data must be differenced once to achieve stationary.

The analysis of the long run properties of the data indicate that both B.C.'s G.D.P. and its forest exports have stochastic trends. The question remains whether there is a long term connection between the variables (i.e. whether they share a common stochastic trend) and, if so, what direction the causality takes. The search for a stable relationship between I(1) variables is the object of cointegration testing and it is to this I now turn.

4.4 Testing for a Cointegrating Relationship

Cointegration occurs when a linear combination of two I(1) variables is stationary, or I(0). The standard interpretation of a cointegrating relationship between variables is that it represents a long term equilibrium connection between the variables in question. While the data will not necessarily obey this relationship at all points in time, in the long run it characterizes the joint evolution of the variables. In the absence of a cointegrating relationship I(1) variables will diverge over time \( t \to \infty \) because their variance is proportional to \( t \). The tests above establish that B.C.'s forest exports and G.D.P. are I(1) variables. If their levels are linked in a stable deterministic way in equilibrium, then they must be cointegrated.

A system of cointegrated variables can be represented as follows:

\[
y \eta = X \beta + \epsilon \tag{4.2}
\]

where \( y \) is the vector of I(1) variables considered, \( \eta \) is the cointegrating vector, \( X \) is a vector of nonstochastic elements such as a constant or time trends, and \( \epsilon \) is a vector equilibrium error term. The error term is I(0) when the variables are
cointegrated. The question now is how to test for the existence of cointegration and estimate the cointegrating vector when this relationship is present.

4.4.1 Single Equation Method

The simplest approach is based on the estimation of a modified version of Equation 4.2 by OLS regression. This is the approach pioneered by Engle and Granger [63]. If it is assumed that the first element of the cointegrating vector is normalized to one, then a cointegrating relationship between B.C.'s forest exports and G.D.P. can be represented by the following regression model:

\[ GDP = X\beta + FEX\eta + \epsilon \]  

where \( GDP \) is the vector of B.C.'s G.D.P., \( FEX \) is the vector of forest exports, \( \eta \) is the second element of the cointegrating vector, \([1, \eta]\) and \( \epsilon \) is the vector of error terms. If forest exports and G.D.P. are not cointegrated, then the autoregressive process for \( \epsilon \) will have a unit root. A test of the null of non-cointegration is then equivalent to testing the null of a unit root in the estimated equilibrium errors from the OLS estimation of Equation 4.3. This is just a test of the null that \( \hat{\alpha} = 0 \) in the following regression:

\[ \Delta \hat{\epsilon}_t = \alpha \hat{\epsilon}_{t-1} + \sum_{k=1}^{\bar{k}} \gamma_k \Delta \hat{\epsilon}_{t-k} + \epsilon_t \]  

This Engle-Granger cointegration test is immediately recognizable as analogous to the augmented Dickey-Fuller [57] unit root test of the previous section. The statistic has a distribution dependent on the form of the cointegrating regression (in this case Equation 4.3.).

24 Unlike ADF tests Engle-Granger residual based cointegration tests do not include constant or trend terms in Equation 4.4. These deterministic terms are included in the cointegrating regression, so they should be orthogonal to \( \epsilon \). This is not exactly true in a finite sample, but it holds asymptotically.

The results of the residual based cointegration tests are presented in Table 4.3. The form of the cointegrating regression is varied to include a constant
Table 4.3: Engle-Granger Cointegration Tests: B.C. G.D.P. and Forest Exports

<table>
<thead>
<tr>
<th>X Matrix</th>
<th>1919-92</th>
<th>1919-45</th>
<th>1946-92</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>-3.0674***</td>
<td>-0.67694</td>
<td>-3.0404***</td>
</tr>
<tr>
<td></td>
<td>(k = 0)</td>
<td>(k = 0)</td>
<td>(k = 0)</td>
</tr>
<tr>
<td>1, t</td>
<td>-2.7781</td>
<td>-2.6311</td>
<td>-2.9175</td>
</tr>
<tr>
<td></td>
<td>(k = 0)</td>
<td>(k = 1)</td>
<td>(k = 1)</td>
</tr>
</tbody>
</table>

*** = significant at 10% confidence level

and a constant and trend in the X matrix of nonstochastic regressors. In addition, the cointegrating regression is estimated for both the full sample period and for pre and post W.W. II subsamples. The evidence for a cointegrating relationship between the variables is weak, at best. The null of cointegration is rejected for all specifications and subsamples at either the 1% or the 5% level of significance. It is possible not to reject cointegration between B.C.'s G.D.P. and forest exports at the 10% level of significance if the nonstochastic elements of the cointegrating regression are restricted to a constant. The evidence does not appear to support a stable long term relationship between B.C.'s G.D.P. and its forest exports.

4.4.2 Cointegrating Systems Approach

The tests for cointegration conducted to this point use a single equation. If B.C.'s forest exports and G.D.P. are determined jointly this will introduce simultaneity bias in the single equation estimates. The OLS estimates of the previous

---

25 This decision to split the sample is partially motivated by the apparent drop in the share of exports relative to G.D.P. in the post war era, combined with relative stability in the sub-periods.

26 The Engle-Granger τ-test which I present in this section is straightforward and intuitive. However, there are additional residual based tests for cointegration. Estimation of test statistics for z-statistics and Phillips and Ouliaris [141] nonparametrically autocorrelation consistent z* and τ* statistics produce results qualitatively similar to those reported. Cointegration is rejected at the 5% level in all cases. Estimation is also carried out using B.C. personal income data as an alternative to the G.D.P. series as a measure of output. The results of these tests are identical to those reported. The weakness of the evidence for cointegration based on the reported τ-tests is reinforced by the results of these alternative tests.

27 For an illustration see Davidson and MacKinnon [55], pp. 717-718.
section are super consistent. Therefore, this bias does not matter asymptotically when the series are cointegrated.\textsuperscript{28} In a finite sample, however, this may not be the case.

It is possible to conduct tests for cointegration within a system of equations which allows for the joint determination of variables explicitly. Johansen and Juselius \cite{100} develop a vector autoregressive approach to the estimation of cointegrated systems. The maximum likelihood estimates which this method produces have better properties than OLS or NLS estimates under certain conditions.\textsuperscript{29} I use this approach to further investigate the possibility that B.C.'s G.D.P. and its forest exports are deterministically linked in the long run.

To begin with, consider the following vector autoregression (VAR) in the levels of the variables:\textsuperscript{30}

\[ Y_t = \mu + \sum_{\tau=1}^{p} \Pi_{\tau} Y_{t-\tau} + \epsilon_t \]  
\hfill (4.5)

where \( Y_t \) is the \( n \times 1 \) vector of variables, in B.C.'s case G.D.P. and forest exports, \( \mu \) is an \( n \times 1 \) vector of constants and \( \epsilon_t \) is an \( n \times 1 \) vector of residuals. It is assumed that \( \epsilon_t \sim IN(0, \Omega) \). Johansen and Juselius' \cite{100} approach is based on a reparameterized version of this initial VAR.

\[ \Delta Y_t = \mu + \sum_{\tau=1}^{p-1} \Pi_{\tau} \Delta Y_{t-\tau} + \Pi Y_{t-p} + \epsilon_t \]  
\hfill (4.6)

where \( \Pi_{\tau} = \sum_{i=1}^{\tau} \Pi_i - I \) and \( \Pi = \sum_{\tau=1}^{p} \Pi_{\tau} - I \) are \( n \times n \) matrices.

In this context the matrix \( \Pi \) determines whether or not the system is cointegrated. The explanation is relatively intuitive. If the first differences of the series are stationary and the error terms are stationary, then every element in

\textsuperscript{28}This means that they approach their true values with a rapid rate of convergence. The convergence rate is proportional to \( n^{-1} \) rather than \( n^{-4} \), where \( n \) is the sample size.

\textsuperscript{29}See Gonzalo \cite{75}.

\textsuperscript{30}The exposition in this section closely follows Henriques and Sadorsky \cite{89}, pp. 545-546 and Davidson and MacKinnon \cite{55}, pp. 726-730.
Equation 4.6 is stationary except for $\Pi Y_{t-p}$ and it must be stationary by implication. There are a number of different ways in which this term may be stationary and they have different consequences for the cointegration properties of the system. One possibility is that $\Pi$ is a matrix of zeros. This is the case when there are no cointegrated series in the system. This implies that the first differences are stationary and any linear combination of the variables is I(1). Another possibility is that $\Pi$ has full rank. In this case, all linear combinations of the variables in $Y$ are stationary. This is only possible if $Y$ is I(0) and all variables in the system are stationary. The case in between these extremes is when $0 < r < n$. In this case the rank, $r$, of $\Pi$ determines the number of cointegrating vectors in the system. The matrix $\Pi$ can be written as a combination of matrices $\alpha \eta$. This indicates that $\eta$ is proportional to the cointegrating vector(s) and $\alpha$ contains adjustment parameters.\footnote{Cointegrating vectors are not unique, since the relationship is invariant to any scalar transformation.}

The linear combination of the cointegrating vector(s) and $Y$ is stationary, so the term $\Pi Y_{t-p}$ is stationary.

It is possible to obtain maximum likelihood estimates of the parameters of the above system.\footnote{Details of the estimation procedure are explained in Davidson and MacKinnon [55], pp. 727-729.} Tests for the cointegrating rank of $\Pi$ are based on the eigenvalues of the estimated matrix. The Trace test considers the null of at most $r$ cointegrating vectors against the alternative $r < n$ and is given as follows:

$$TR_r = -T \sum_{i=r+1}^{n} \ln(1 - \hat{\lambda}_i)$$

\hspace{1cm} (4.7)

The number of cointegrating vectors is $r + 1$ when the statistic for $TR_r$ is significant. The test proceeds by considering the sequence $r = 0, 1, ..., n$ in turn. The test statistic is distributed as a functional of a multivariate Weiner process.\footnote{Critical values appropriate when the system includes a constant term can be found in Osterwald-Lenum [133], Table 1.}

The results of the Trace test applied to B.C.'s G.D.P. and forest exports are given in Table 4.4. Values are reported for various choices of $p$, the order of the
Table 4.4: Johansen-Juselius Cointegration Tests; B.C. G.D.P. and Forest Exports

VAR. In Johansen and Juselius [100] the choice of the lag length is assumed to be optimal. In practice there is no way to know which value of $p$ is optimal. Monte Carlo evidence indicates that in small samples the Trace test is sensitive to underparameterization of the lag length, but not to overparameterization.\(^{34}\) In addition, the lag length should be sufficient to insure that the assumption that the $\epsilon$ are serially uncorrelated holds. I estimate the model using a number of alternative lag lengths. The results of the test are insensitive to the lag length in this case. The results of the test fail to provide evidence that the series for G.D.P. and forest exports are cointegrated. The null of a single cointegrating vector is rejected even at the 10% level.\(^{35}\) The evidence for a cointegrating relationship between B.C.'s forest exports and its G.D.P. is further weakened by the failure to establish cointegration in the context of this multi-equation framework.

The results of the cointegration tests provide little or no support for the

\(^{34}\)See Cheung and Lai [44].

\(^{35}\)Since it has been established that the two series are nonstationary, the only relevant hypothesis to test in this case is the null of one cointegrating vector against the alternative of no cointegration.
hypothesis that a stable long term relationship exists between the level of B.C.'s forest exports and the province's G.D.P. Should this be surprising given the apparently close ties between the series discussed earlier? After examining the data more carefully, the answer is no. First consider the apparent stability in the ratio of forest exports to G.D.P., shown in Figure 4.2. If a cointegrating relationship of the proposed forms exists between the variables, then this ratio should not have a strong time trend. Earlier observation that this ratio 'appeared' relatively stable was based on imprecise casual observation of the series. Regression of the ratio on a constant and trend produces a negative, statistically significant time trend. While the coefficient is relatively small (-0.15% annually) the predicted change in the series over the sample would cut the ratio of exports to G.D.P. in half.

Finally, the levels of the data appear to be diverging over time. This is a property one would expect in two I(1) series which are not cointegrated. It is more apparent when looking at the data without the log-transform, as in Figure 4.3. Cointegration requires linear combinations of the I(1) variables to be stationary. While taking logs of the data and including deterministic elements such as constant and trend terms allows for some nonlinearity in the relationship, the degree of divergence between B.C.'s forest exports and its G.D.P. can not be accommodated.

4.5 Dynamic Links Between Growth in Exports and G.D.P.

The tests above indicate that there is not a stable deterministic link between the levels of B.C.'s G.D.P. and forest exports in the long run. It is still possible that there are dynamic interactions between the variables. Some of the literature reviewed earlier suggests that primary exports may serve as an initial catalyst to
development. The market size externalities and linkages which are stimulated result in economic growth in other sectors of the economy. These may eventually overwhelm the resource export sector in terms of its importance in the regional economy. In this scenario the relationship between the primary export sector and G.D.P., while real and important, does not take the form of cointegration.

In this section I use a vector autoregressive model to characterize the dynamic relationship between growth in B.C.'s G.D.P. and its forest exports. This reveals the effect of shocks in the growth of forest exports on B.C.'s G.D.P. growth in the short run. To examine how this relationship may have changed over time I also estimate the model for two subsample periods, 1919-45 and 1946-92. If growth in B.C.'s forest exports served as a trigger for the growth of G.D.P., then the strength of the interaction between the two variables should have changed over time. The influence of forest exports should be strongest initially and become less important over time. The results can perhaps help to explain why so much emphasis is placed on the implications of fluctuations in B.C.'s forest sector, in spite of the absence of an equilibrium relationship between the levels of G.D.P. and forest exports.

4.5.1 VAR Methodology

The popular use of vector auto regressions to investigate the dynamic behaviour of economic systems originated with the work of Sims [154]. VARs allow the interaction between the variables in a system to be investigated while imposing minimal restrictions. This initial application of VARs was referred to as atheoretical because the methods for identifying orthogonal shocks were not based on theory driven assumptions. The interaction between the variables was explored in terms of their reactions to these 'average' shocks. Researchers gradu-

36See Murphy, Schleifer and Vishny [128]; Innis [93]; or Watkins [167] for example.
37The relationship suggested here reflects ideas about regional development which are explored in some detail in Jane Jacobs' *Cities and the Wealth of Nations* [98].
ally expressed interest in identifying the orthogonal disturbances in a way which allowed them to be interpreted as independent innovations to the variables in the model. These are structural VARs. The methodology of VARs is explained briefly below.\(^{38}\)

Let \( y_t \) be an \( n \times 1 \) vector of the variables we are interested in. If the process for \( y_t \) is jointly covariance stationary, then according to Wold's Theorem it can be represented as an infinite vector moving average process as below:

\[
y_t = \Phi(L)u_t
\]

where \( \Phi(L) \) is a matrix lag polynomial and \( u_t \) is an \( n \times 1 \) vector of disturbances which are assumed to be orthogonal, and have variance covariance matrix \( \Omega \). This means that the variables can be represented as an infinite sequence of independent current and past structural disturbances which come from a well defined distribution. In other words, the value of the elements of \( y_t \) are determined by some combination of the orthogonal innovations. In order to characterize the process, we would like to estimate the matrix \( \Phi(L) \). This is not possible since the shocks themselves cannot be observed. Instead a VAR is estimated, exploiting the fact that a stationary infinite MA process will converge to a finite AR process. Unfortunately we cannot recover the parameters of the impact matrix, \( \Phi_0 \), through the estimation of the companion VAR obtained by inverting Equation 4.8. What is actually estimated is a reduced form representation of Equation 4.8:

\[
y_t = C(L)e_t
\]

where \( C_0 \) is the identity matrix and \( e_t \) are error terms with variance covariance matrix \( \Sigma \).

\(^{38}\)The exposition in this section draws on a number of sources including, but not limited to, Davidson and MacKinnon [55], pp. 684-686; Hamilton [84], pp. 257-261, 291-349; and Keating [103].
The difficulty at this point is that in general it is not possible to uniquely identify the structural model through the estimation of the reduced form without imposing further restrictions. The disturbances in 4.9 are linear combinations of the elements of $\mathbf{u}_t$. Multiple representations of $\mathbf{y}_t$, obtained, for example, by changing the order of the variables, can be represented as combinations of orthogonal disturbances by using mechanical techniques to decompose $\mathbf{e}_t$. These orthogonalized disturbances are not necessarily linked to the structural innovations, $\mathbf{u}_t$. Some identifying assumptions are required to make this link.

In fact the 'mechanical' identification technique of Choleski decomposition suggested by Sims [154] contains such assumptions implicitly. Cooley and LeRoy [48] pointed out that the Choleski identification technique implicitly imposes a recursive contemporaneous structure on the variables. In other words, the current structural innovation to the first variable in the ordering could influence variables later in the ordering, but not vice versa. If such an ordering is intuitively and theoretically plausible, then the model identified using Choleski decomposition is structural. If the matrix of coefficients for the contemporaneous effects in the VAR representation of Equation 4.9 is lower triangular, then the model will be just identified.\(^{39}\)

In the case of B.C.'s G.D.P. and forest exports, such a recursive structure is intuitively plausible. Much of the literature discussed earlier contains such an ordering implicitly. The idea that growth is export led suggests this structure. It is B.C.'s forest export performance which is driving G.D.P. If B.C.'s forest exports affect G.D.P. through market size externalities or linkage effects, then it seems implausible the process could instantaneously influence the level of forest exports. Since B.C. is a relatively small player in world markets for primary products over the sample as a whole, the degree of contemporaneous ex-

\(^{39}\)The difficulty is in finding intuitively plausible reasons why the variables should have a recursive relationship. If they do not, then the orthogonalized disturbances are linear combinations of the structural disturbances. This makes it difficult to interpret the VAR results.
The technical presentation of both the impulse response functions and variance decompositions draws from Hamilton [84], pp. 318-324, to which the reader is referred for more detail.
forecast error variance is then defined as in Equation 4.11.

\[
E[(y_{t+s} - \hat{y}_{t+s|t})(y_{t+s} - \hat{y}_{t+s|t})'] = \Sigma + C_1\Sigma C_1' + C_2\Sigma C_2' + \cdots + C_{s-1}\Sigma C_{s-1}'
\]  (4.11)

Equation 4.11 gives the forecast error variance in terms of \(e_t\). This error term is a linear combination of the structural disturbances, \(e_t = A\mu_t\). Using the identifying restrictions, in this case a recursive structure combined with orthogonality and independence of the structural disturbances, the elements of \(A\) can be identified and \(\Sigma\) can be written in terms of the variance of the structural disturbances:

\[
E[(y_{t+s} - \hat{y}_{t+s|t})(y_{t+s} - \hat{y}_{t+s|t})'] = \sum_{j=1}^{n} \text{Var}(u_{jt} \cdot [a_j a_j' + C_1 a_j a_j' C_1' + \cdots + C_{s-1} a_j a_j' C_{s-1}']
\]  (4.12)

where there are \(n\) structural disturbances and \(a_j\) is the \(j\)'th column of the matrix \(A\).

Decomposing the forecast error variance this way allows us to determine how much of the forecast error for each variable is attributable to the individual shocks. For example, if we attempt to predict B.C.'s G.D.P. based on what we know today there will be some error in our forecast. The variance decomposition allows us to identify how much of the variance in our estimate of future GDP growth is due to unanticipated movements in the growth of forest exports. This gives an idea of the relative importance of shocks to each variable.

### 4.5.2 Results

I estimate a bivariate VAR in the growth rates of B.C.'s G.D.P. and forest exports.\(^4\) I select the lag length for the VAR on the basis of sequential \(\chi^2\)
tests which restrict the order of the VAR, in combination with Kolmogorov-Smirnov tests for white noise residuals and asymptotically valid tests for first order autocorrelation of the residuals. Based on these tests I employ a first order VAR.\footnote{Results generated by VARs with additional lags are similar to those reported. The conclusions do not appear to be very sensitive to the lag structure of the VAR.} I first estimate the VAR for the full sample for which growth rates are available, 1920-1992. In addition, I estimate VARs for two subsample periods, 1920-1945 and 1946-1992.\footnote{Lag length for these VARs are determined by the tests discussed above. Reported results again refer to a first order VAR, but results are insensitive to lag length.} The results from the subsample estimations may shed some light on the changing nature of the dynamic interaction between the growth of B.C.’s forest exports and its overall economic growth.

First consider the impulse responses generated by the three VARs, focusing on the response of G.D.P. growth to forest export growth shocks. These are shown in Figure 4.4.\footnote{The initial impulse is a one standard deviation shock to forest export growth.} The difference between the responses over the three samples is striking. The greatest response is generated during the early subsample, 1920-45. During this period the response is greatest initially and declines in every subsequent period. The decline is gradual, however, with almost no drop from the first period to the second. The 1920-45 response shows a great deal more persistence than either the full or later sample. The 1946-92 response is qualitatively very different. The response in the first period is significantly smaller (0.12 standard deviations compared with 0.48) but, unlike the early sample response which falls after the initial period, the 1946-92 response is amplified. In the second period it is almost the same as that for the earlier sample. In the subsequent periods, the response oscillates toward zero. By the fourth year it is essentially gone. Unsurprisingly the response for the full sample is a hybrid of the two discussed. While it dampens more continuously and gradually than the later sample response, there is still virtually no effect by the fourth year. The response in the first two periods is moderate (0.29 and 0.42 standard deviations}
respectively), but after this there is little effect.

The changes in the response over time are consistent with the view that B.C.'s forest exports may have been 'more important' during the earlier period. Unanticipated changes in forest export growth stimulated a greater response in G.D.P. growth during these years, and the effects were persistent. This offers some evidence that links between the forest industry and the rest of the economy were important at this point.

The economy appears to respond to shocks in forest export growth in a qualitatively different way in the post-W.W. II period. While a positive shock to export growth stimulates G.D.P. growth in the next period, it appears to slow output growth in the third year. This is consistent with the predictions of Dutch disease models for primary exporters, although the effect is small. The economy adjusts relatively rapidly and the effects of unanticipated movements in forest export growth are not persistent. This is consistent with an economy which has grown beyond direct links to its resource endowments.

A similar picture emerges from the variance decompositions, given in Table 4.5. Shocks to forest export growth account for approximately 22% of the forecast error variance for G.D.P. growth over the full sample. During the early period the figure is roughly 35%, compared with 18% for the period from 1946-92. This decline of almost 50% indicates that disturbances to forest export growth exert less influence on the variation in G.D.P. growth around its expected value in the post-W.W. II era. Again, the difference between the results for the two sub samples seems to support the idea that forest exports may have led growth in the province's early history, but play a less influential role over time. The effect in the later sample is far from trivial, but not as high as might be expected if forest exports were the driving force behind the provincial economy. While forest export growth makes a significant contribution to overall provincial growth and its variability, the two are not equivalent.
Table 4.5: Forecast Error Variance of Growth in B.C.'s G.D.P. Attributable to Forest Export Growth Shocks

The VAR analysis provides a way of summarizing the dynamic links between B.C.'s forest exports and its G.D.P. The underlying premise in the export led growth view of B.C.'s development is that forest export growth drives provincial G.D.P. growth. The VAR analysis suggests that forest exports do stimulate significant responses in B.C.'s G.D.P. There is, however, a more substantial share of variation in provincial growth performance which must be explained by other factors. The evidence for a changing pattern of responses over time lends some support to the idea that B.C.'s forest exports may have served as a trigger for sustained economic growth. The idea that B.C.'s forest exports promoted provincial growth through attracting factors of production, increasing market size and other ‘linkage’ effects is consistent with the stronger connection between forest export growth and overall economic performance identified in the 1920-45 sample. The finding that forest export growth is less closely linked to provincial G.D.P. growth in the post-W.W. II period is also not entirely unexpected. During this period resource rent and the relative importance of the sector declined, in terms of value of output, employment, and exports themselves.
4.6 Conclusion

The importance of B.C.'s forest industry, particularly its exports, for the provincial economy is virtually unquestioned. Both academic work and popular media reserve a central role for forest export growth in determining overall economic growth in B.C. This chapter examines data spanning most of the 20th century to investigate this view empirically. The results are of not only regional interest, but also bear on theoretical debate over the potential role for primary exports in economic development.

Generally the results do not support the standard view. There is no convincing evidence of a stable deterministic link between the level of B.C.'s forest exports and provincial G.D.P. This is the conclusion which follows from the failure to establish a cointegrating relationship between the variables over the sample period. As these two variables are trending stochastically upward independently of one another, it is not possible to tell a simple story in which the level of forest exports and provincial G.D.P. are linked in a stable way in the long run.

There is some evidence that B.C.'s forest resources may have acted as an initial catalyst for growth. The VAR results for the early period indicate that a higher than anticipated growth in forest exports had a significant positive effect on G.D.P. growth. This effect was strong initially and persistent. The pre-W.W. II B.C. economy appears to conform to a model in which forest exports could have acted as a leading sector.

Conversely, there is little convincing evidence that this was true in the post-W.W. II economy. The VAR evidence indicates that the response of G.D.P. growth to export shocks was smaller and dampened rapidly. There was also some indication that unexpectedly positive forest export growth, while raising G.D.P. growth initially, could lower G.D.P. growth later. This is more consistent
with the negative effects of primary exports suggested by models in the spirit of ‘Dutch disease’. In addition, relatively little of the unanticipated volatility of G.D.P. growth could be attributed to shocks to forest exports. This is not a finding one would expect if the province’s vulnerability in forest export markets was really responsible for the volatility of its overall economic performance.

The results of this chapter demonstrate that the relationship between primary exports and economic development is not easily understood and may not be stable over time. The evidence for B.C. suggests that during the province’s early history its forest exports had an important effect on growth. The data appear to support the idea that historically it was possible to stimulate growth through primary exports. More recent data indicate the perils of applying the ‘lessons of history’ too liberally. There is little convincing evidence that forest exports determined provincial growth in the post-W.W. II period. The exact role of the province’s forest exports in its economic development is impossible to trace with the data at hand. What is clear is that the evidence does not support a story in which the level of forest exports and provincial G.D.P are linked in a stable deterministic way in the long run. It seems unlikely that forest exports continue to play the same role in the provincial economy over time. The simple view that B.C.’s growth is export led, driven by the forest industry, is inconsistent with the evidence.

The results for B.C. are problematic for theoretical models which predict the consequences of primary exports for economic growth unambiguously. The evidence for B.C. indicates a more complex interaction between primary export and G.D.P. growth. Perhaps the difficulty arises from comparing periods and situations in which the sources of growth are likely different. In the first case, the attraction of mobile factors plays a role in generating growth, perhaps through

---

45 See Sachs and Warner [151] for example.
46 The absence of data for the period before 1920 is unfortunate, since the effects would likely have been stronger.
the influence of market size effects. In the second case, the sources of growth are more likely efficiency gains in the use of factors.\textsuperscript{47} The ability of primary exports to stimulate overall regional growth likely depends on the context and the degree to which each of these factors is relevant. The models of export led development which address the role of primary exports tend to focus on one or the other of the possible influences and arrive at different conclusions as a result. As the evidence for B.C. illustrates, the ‘truth’ may lie somewhere in between.

\textsuperscript{47}In most models these are assumed to be generated most successfully in the manufacturing sector of the economy.
Figure 4.1: Forest Exports and G.D.P. of British Columbia, 1919-92
Figure 4.2: Ratio of Forest Exports to G.D.P. for British Columbia, 1919-92
Figure 4.3: Level of Forest Exports and G.D.P. of British Columbia, 1919-92
Figure 4.4: Responses of B.C. G.D.P. Growth to Forest Export Growth Shocks
Chapter 5
Conclusion

The same physical features that have restricted outside contact determined that natural resources would be the basis of British Columbia’s economy...Providing a decent living for generations of British Columbians, the plenitude of natural resources also ensured dependence on external markets and capital. The structure of the economy has remained relatively unchanged from the arrival of the first Europeans. All that alters are the names of the particular staples being exploited.

J. Barman

The view that British Columbia’s natural resources are at the heart of the provincial economy is almost universally held. This thesis provides empirical evidence for the forest industry to assess the historical accuracy of this view. The results are surprising.

The first substantive chapter constructed estimates of resource rent which the forest industry generated over the period 1918-92. Resource rent measures the direct contribution of the province’s forest resources (through industrial exploitation) to provincial income and growth. The estimates indicated that forest rent accounted for a relatively small share of provincial income measures over the sample period. Rather than driving provincial growth, rent declined over the second half of the century. While there were periods during which the contribution of rent to provincial income measures was nontrivial, the same cannot be said for the sample period as a whole. If it is the case that rent

1See Barman [6], pp. 341.
measures the full long term effect of the resource on provincial income per capita (as authors such as Percy [140] suggest), then B.C.'s forest resource endowment accounted for virtually none of the growth in provincial income per capita over most of the 20th century.

The results above were partly driven by the secular decline in rent which began from mid-century. Forest industry rent was also extremely volatile. This caused the effect of the forest industry on measures of provincial income and growth to appear larger at shorter horizons. In the second substantive chapter I investigated the forces which were driving the evolution and variability of forest rent.

Changes in the rent per unit of B.C. timber were found to be responsible for the broad trends in aggregate rent. The measure of average rent per unit was decomposed into the components which define it; the (exogenous) price for forest products and average harvesting costs. A sharp rise in price appears to have been responsible for the rapid rise in rent during the period from 1940-51. The long term decline resulted from the combination of a falling output price and rising costs. Price changes were largely outside the influence of B.C. forest industry firms, however, there is some evidence that a decline in timber quality may have played a role. Real costs were estimated as a function of industry output, depletion and the state of technology. The influence of these variables on the increase in costs was identified. Technological change was found to have lowered harvesting costs. Depletion, as measured by cumulative harvest, was found to contribute significantly to rising costs. The variability of rent was investigated by regressing the observed (percentage) change in the average rent per unit of B.C. timber on a set of variables suggested by a model of forest rent. The results suggested that factors which represented market risk were responsible for the variation in rent in the B.C. forest industry.

In the third substantive chapter I returned to the central objective of as-
sessing the historical role of the forest industry in the provincial economy. In this chapter I investigated the possibility the industry influenced the regional economy through indirect effects. Specifically, I considered the possibility that the forest industry acted as a leading export sector. Such a contribution may not have been reflected in resource rent. I tested for a stable long term link between forest exports and provincial G.D.P. using both single equation and systems approaches to cointegration testing. The results indicated that forest exports and provincial income did not share a common trend. The levels were not deterministically linked in the long run. VARs were used to investigate the short run interaction of growth in the two variables. Shocks to forest export growth were found to influence provincial growth, but the effects were not as strong, nor persistent as might have been expected. There was some evidence that the influence of the forest industry played a more substantive role in explaining variations in provincial growth during the years before the end of W.W. II. Overall, while forest exports did influence provincial G.D.P. growth, the effects were short term in nature. In addition, the strength and nature of the forest industry's influence appears to have varied over time.

The main finding of this thesis is that empirical evidence does not appear to sustain the overwhelming emphasis on resource endowments as the basis of the B.C. economy, at least not if the evidence for the forest industry is representative. Other authors have discovered that the staples framework may provide too limiting a view of the factors responsible for Canadian economic development. The evidence which this thesis generates for the B.C. forest industry suggests that this may also be true when considering regional development. The B.C. economy appears to be narrowly based on resource exploitation, concentrated mainly on the province's forest resources. However, attributing this industry with the central role in the determination of provincial income and growth (a view that alters little throughout the province's history) is inconsistent with the
evidence. While the province's forest resources made a contribution to provincial income and its growth over the period from 1919-92, by itself this was not nearly large enough to 'explain' the development of the provincial economy. The evidence in this thesis suggests that the virtually exclusive emphasis on the role of resources in analysis of the B.C. economy may be misleading. In spite of its intuitive appeal, the staples framework provides an incomplete view of the provincial economy and the factors which influence it.
Bibliography


215


[134] Pacific Lumber Inspection Bureau (various years): Annual Report, Pacific Lumber Inspection Bureau: Bellvue, WA.


218


Appendices
A Forest Industry Data

A.1 Industry Data Sources

The B.C. Forest Industry is broadly defined in this thesis to include activity in the primary Logging Industry and associated primary manufacturing industries, the Wood Industry and the Paper and Allied Industry. Most of the industry level data are readily available from published sources, which I note below for the three component industries. I discuss data which are not available in these sources in Section A.2.


Wood Industries: Principal Statistics The Wood Industries include: Saw, Shingle, and Planing Mills, Veneer and Plywood Mills; Sash and Door and Other Millwork Plants; Wooden Box Factories; the Coffin and Casket Industry; and Miscellaneous Wood Industries. Data for the period from 1919-52 are

---

\(^1\)References for B.C. Statistical Publications are listed under ‘B.C.’ in the Bibliography.

\(^2\)References for Statistics Canada and D.B.S. publications are listed under ‘Canada’ in the Bibliography.

A.2 Forest Industry Capital Stock Construction

The principle statistics data do not include information on the value of the forest industry capital stock. This is necessary to calculate the cost of capital required in the forest industry rent estimation. I therefore generate capital stock estimates for the Logging, Wood, and Paper and Allied Industries. The Wood and Logging Industry capital stocks are constructed in a similar fashion, while the approach is somewhat different for the Paper and Allied Industries. I describe the two construction techniques in turn. The capital series which I construct are gross, historic cost estimates of the industry capital stocks.

Provincial industry capital stock data exist from 1955. These are available in the Statistics Canada special publication *Fixed Capital Flows and Stocks, British Columbia, 1955-86* [27]. Data for Gross Fixed Capital Formation are available from CANSIM, as series D840085, D840113, and D840121 for the Logging, Wood, and Paper and Allied industries respectively. I employ these figures to extend the gross capital stock estimates.

**Paper and Allied Industry Capital Stock** The estimated capital stock for the paper and allied industries is derived using three sources. From 1.91.9 to 1939 data on industry capital stocks by province are reported in the D.B.S. Census of Manufactures publication, *The Pulp and Paper Industry*. There is some concern that these figures are not accurate for a number of reasons. However, in the absence of other data these figures are accepted as rough estimates of the capital stock in the Pulp and Paper Industry in B.C. These data do not reflect capital employed in the other components of the Paper and Allied industries. However, the number of employees outside the Pulp and Paper Industry during this early period was extremely small. The degree of understatement which results from using the pre 1940 Pulp and Paper capital stock figures to represent

---

3Essentially these include incomplete industry coverage and inaccurate reporting. See Hood and Scott [91], pp. 232.
the capital of the Paper and Allied Industries should be slight.

Estimates for the period 1940-55 are based on the firm level information. Data from the B.C. Pulp and Paper Company and the Powell River Company are used to obtain the gross current dollar value of capital per employee. A weighted average is constructed of the two firms' capital-labour ratios, with the weights based on each firm's relative employment share. This capital-labour ratio is then multiplied by the figure for total provincial industry employees, given in the Census of Manufactures, to get an industry capital stock figure. This method of capital stock construction is based on the assumption that the two firms are a representative sample of the provincial industry. This seems like a heroic assumption for a sample of two firms, however, they represent a significant share of the industry due to the degree of concentration during this period.

From 1955 on annual Gross Fixed Capital Formation figures are added to the firm-based capital stock estimate to continue construction of the capital stock series up to 1992.

It is possible to construct the Paper and Allied Industry capital stock in different ways. Industry capital stock data are available at a national level from 1936 in Fixed Capital Flows and Stocks [28], Catalog No. 13-568. I use this data to construct an alternate measure of the capital stock for the B.C. industry from 1936-92. I allocate the B.C. industry a share of the national capital stock based on its share of the national industry labour force in each year. This estimate of the B.C. Paper and Allied Industry capital stock is based on the assumption that the capital-labour ratio is fixed in each year. These estimates of the capital stock are similar to the firm-based estimates, but slightly lower. The use of the alternative capital stock measure does not change the estimates of industry

---

4The labour figures used to derive the 1940-55 capital stock estimates reflect all industries in the Paper and Allied Industries aggregate.
resource rent substantively. I use the capital stock estimate as initially described in the measure of industry rent for which results are reported.

Logging and Wood Industry: Capital Stocks The capital stocks for both the Logging and Wood Industries are constructed using a combination of two index number series and available capital stock data.

The first series is an index of productive capacity in the wood industry, which takes a value of 1 in 1955. The capacity figures which I use are taken from the tables “Saw and Shingle Mills of the Province” in the *Ministry of Forests Annual Report* [13]. The figures are for eight hour daily capacity, converted to Mbdft for both saw and shingle mills. I include data on the capacity of both operating and closed mills, since this may reflect temporary changes in the degree of capacity utilization rather than changes in the stock. Mills often close temporarily and re-open during this period. Capital costs cannot be constructed over the full sample in a way which allows for changes in rates of capacity utilization.

The second index reflects changes in the current dollar value of (gross historic cost) capital per unit of capacity. This index also takes a value of 1 in 1955. I construct this index using data from the firm level sample. I use data from the Victoria Lumber Company, Columbia River Company, Canadian Western Lumber Company and Bloedel, Stewart and Welch. I use the data for each firm to obtain a figure for nominal capital per unit of capacity. I use the firm level panel to construct a weighted average estimate of an industry capital-capacity ratio, where the weights are based on relative output shares of the firms. This index reflects changes in the capital required per unit of capacity over the sample, produced for example by changes in technology.

I multiply the two indices above to obtain an index representative of the level of the current dollar value of capital. Since saw and shingle mills represent a significant share of the Wood Industry, it is likely that the index reflects the development of the capital stock in this industry fairly well. The match with the
Logging Industry is not likely to be as close. Since the Logging industry produces the major input for the Wood Industry, it is not unreasonable to suppose that the general trends in the two industries' development are similar. I use the index to construct capital stock estimates for both the Logging and Wood Industries. I take the 1955 current dollar value of the capital stock for the Logging and Wood industries respectively, available in the Statistics Canada special publication *Fixed Capital Flows and Stocks, B.C. 1955-86* [27], and project them backward using the constructed index. This yields series for the nominal value of the capital stocks of the Logging and Wood Industries in B.C.

Both capital stock series are extended forward from 1955 by the addition of annual Gross Fixed Capital Formation figures to the stock in the previous year.
B A Depletable Resource Model with Stochastic Uncertainty

In this section I discuss the model which Slade and Thille [155] develop for a nonrenewable resource, incorporating stochastic uncertainty in demand and the evolution of technology. I modify this model slightly so that it is applicable to a depletable natural resource by the resource grows naturally, a harvest rate which leads to a declining stock causes harvesting costs to increase.

Slade and Thille’s model incorporates uncertainty in both the evolution of technology and demand (through exogenously given prices). Prices are assumed to be characterized by generalized Brownian motion:

\[
\frac{dP}{P} = \mu_P dt + \sigma_P dz_P
\]  

(B.1)

where \( \mu_P \) is the instantaneous rate of change of prices; and \( \sigma_P^2 \) is the instantaneous variance per unit time.\(^5\) The use of generalized Brownian motion to represent prices in this application implies that firms in the forest industry know the current rate of change of prices, but are uncertain about future prices, and their uncertainty increases with the time horizon.\(^6\) Slade and Thille note that this specification of prices is sufficiently general that it can approximate any continuous price path. I assume that this specification could represent the evolution of the price of forest products faced by firms in the B.C. industry.

Slade and Thille incorporate uncertainty related to technological change on the supply side. They model a firm’s total cost of extraction as a function of

\(^5\)The increment in the Weiner process, \( dz = \sqrt{\varepsilon} d\varepsilon \), where \( \varepsilon \sim iid\, \mathcal{N}(0, \sigma^2) \), is such that the variance of the random variable increases linearly with the time horizon.

\(^6\)For a good introduction to stochastic processes see Dixit and Pindyck [58], pp. 59-92.
current output and extraction, cumulative extraction and the state of technology. The state of technology, \( \Theta \), is a random variable. Its evolution is represented as generalized Brownian motion:

\[
\frac{d\Theta}{\Theta} = \mu_{\Theta} dt + \sigma_{\Theta} dz_{\Theta}
\]  

(B.2)

This introduces an element of stochastic uncertainty in the cost function:

\[
C = C(q, S, \Theta)
\]  

(B.3)

where \( \Theta \) is a random variable representing the state of technology and all other variables are as defined previously. Firms know the current rate at which technology is evolving, but are uncertain about technological change in the future and this uncertainty increases with the time horizon. This uncertainty about the evolution of technology generates uncertainty about future costs. This specification also seems applicable to firms in the B.C. forest industry. Technological change profoundly altered production methods over the 20th century. Advances in genetic research and silvicultural practices also affect the industry's future costs. Technological change is uneven over the sample period. A representation in which agents uncertainty about the rate of technological improvements increases over time seems plausible.

Following the approach in Slade and Thille [155], I derive an expression for the evolution of the shadow value of timber by focusing on a firm's decision problem. I also begin by deriving the risk neutral rate of return on timber when forest assets are risky assets. The risk adjusted rate of return, \( \rho \), will then equal this risk neutral rate plus a risk premium. Following Slade and Thille, I assume that the risk premium is given by \( \beta(r^m - r) \). In other words assets are priced according to the ICAPM.8

---

7 The derivatives of the cost function are signed as in the depletable resource model of Section 3.3.

8 The expression for the risk premium above is based on the ICAPM, but as noted by Slade
The firm chooses a harvest sequence \( q_t, 0 < t < \infty \), which maximizes the present value of its expected profits. Future profits are discounted by a risk adjusted discount factor, \( \rho \). This is a stochastic control problem, which can be represented by the following value function:

\[
V(S, P, \Theta) = \max_{q_t} E_t \left\{ \int_t^\infty e^{-\rho(t-s)} [P_{r} q_r - C(q_r, S_r, \Theta_r)] ds \right\} \quad (B.4)
\]

subject to

\[
\dot{S}_r = f(S_r) - q_r \quad S_r \geq 0 \quad q_r \geq 0 \quad (B.5)
\]

and Equation B.1 and Equation B.2.\(^9\)

The specification above differs only slightly from that in Slade and Thille [155] in that the evolution of the stock contains a deterministic growth term in addition to the depletion resulting from current harvests.

Suppose that the firm is risk neutral and let \( r \) equal the risk neutral rate of return. In this case the stochastic Bellman equation which corresponds to Equation B.4 is given by:

\[
rV(S, P, \Theta) = \max_q \left\{ \pi + V_S [f(S) - q] + V_P \mu P + V_{\Theta} \mu \Theta + \frac{1}{2} V_{PP} \sigma_P^2 P^2 + \frac{1}{2} V_{\Theta \Theta} \sigma_{\Theta}^2 \Theta^2 + V_{\Theta P} \Theta P \sigma_{\Theta P} \right\} \quad (B.6)
\]

I partially differentiate Equation B.6 with respect to the stock, \( S \), at the optimal \( q \) to get the following:

\[
rV_S = -C_S + V_S f'(S) + V_{SS} [f(S) - q] + V_{SP} \mu P + V_{S\Theta} \mu \Theta + \frac{1}{2} V_{SPP} \sigma_P^2 P^2 + \frac{1}{2} V_{S\Theta \Theta} \sigma_{\Theta}^2 \Theta^2 + V_{S \Theta P} \Theta P \sigma_{\Theta P} \quad (B.7)
\]

\(^9\)For an introduction to the techniques of stochastic control see Kamien and Schwartz [102], pp. 241-249.
Equation B.7 can be simplified by applying Ito's lemma to the right hand side. This yields:

\[ rV_S = -C_S + V_S f'(S) + \frac{1}{dt} E_t dV_S \]  

(B.8)

Rearranging Equation B.8 leads to the following:

\[ \frac{\frac{1}{dt} E_t dV_S}{V_S} = r + \frac{C_S}{V_S} - f'(S) \]  

(B.9)

The shadow value of the resource, \( \lambda \), is defined as the change in the objective with respect to the constraint, or \( V_S \).

This means that Equation B.9 governs the expected evolution of the shadow value as shown below:

\[ \frac{\lambda}{\lambda} = r + \frac{C_S(\cdot)}{\lambda} - f'(S) \]  

(B.10)

where

\[ \frac{\frac{1}{dt} E_t d\lambda}{\lambda} \equiv \frac{\lambda}{\lambda} \]

Equation B.10 gives the rate of return on forest resources for risk neutral investors. It states that the average expected rate of change in the shadow value of these assets should equal the risk neutral rate of return, which accounts for appreciation of the asset through natural growth, as well as any potential increase (or decrease) in future costs of harvesting due to stock effects. The expected rate of return required for risk neutral investors is the same as that earned in the certainty case.

If agents are risk averse, then in addition to the risk neutral rate, they require a risk premium in order to be indifferent between forest resource assets and other potential assets. Assuming that the ICAPM model of asset pricing is applicable, then this risk premium should be captured by the addition of the term \( \beta(r^m - r) \), where \( \beta \) is specific to the forest industry and reflects the degree of correlation between volatility in returns in the forest sector and market returns. The size

\[ \text{From the maximization problem, } V_S = P - C_q, \text{ so the level of the shadow value is determined by the same condition as it was in all previous models.} \]
of the risk premium depends on the degree to which volatility in the industry is correlated with the market. If much of the volatility in the value of forest assets is not correlated with the market return, then this risk could be diversified away and the risk premium would be small.\textsuperscript{11} The higher the correlation between the volatility in the shadow value of forest assets and market fluctuations, the larger is the required risk premium. In other words, the risk premium reflects undiversifiable risk and its influence on returns in the forest industry. The risk adjusted rate of return on forest assets evolves as follows:

$$\frac{\dot{\lambda}}{\lambda} = r + \frac{C_{S}(\cdot)}{\lambda} - f'(S) + \beta(r^{m} - r)$$  \hspace{1cm} (B.11)

This is the analog of Slade and Thilles' [155] result for a depletable, rather than strictly exhaustible resource. I use the expression above as the basis for selecting variables to explain the evolution in the average shadow value of B.C. timber.

\textsuperscript{11}If it were the case that the volatility of forest assets was negatively correlated with the market, then individuals would be willing to earn a lower return on this asset in order to protect themselves against market fluctuations. Forest assets in this case would be a hedging asset.
C Forest Product Price Index

In Chapter 4 I analyze the relationship between real forest exports and provincial income measures. Data for real provincial G.D.P. and forest exports are obtained by deflating the current dollar series. Unfortunately suitable provincial deflators which span the period from 1926-92 are unavailable. The provincial income measure is deflated using the Canadian GNE deflator. This general deflator could also be used to deflate the export series. This is not an uncommon approach in the literature. In cases where the composition of exports is broad, the use of a general deflator is more appropriate and avoids the substantial effort involved in constructing a more precise deflator. In the case of B.C. forest exports, the export category considered is sufficiently narrow that the use of a broadly based deflator would probably be inappropriate.

Selling price indices for the Wood and Paper and Allied Industries are available at a national level from Statistics Canada for the period from 1956-92. The data are taken from *Industry Selling Price Indexes*, Catalog No. 62-011. Data are annual from 1956-85 and are the series 'Industry Selling Prices' for the Wood and Paper and Allied Industries. In 1985 these series were replaced with the monthly series 'Industrial Product Price Indexes' for the respective industries. The annual figures I employ from 1986-92 are the average of the monthly data. The forest export series includes a small log export component, for which a price index is not available. I use the Wood Industry selling price index as a proxy.

\[^{12}\text{See, for example, Henriques and Sadorsky [89], Ghatak, Milner and Utkulu [72], Thornton [161].}\]
I construct price indices for the Wood and Paper and Allied Industries for the period from 1919-56 to adjoin to the existing Statistics Canada series. I use data on the total quantity and value of production in the Lumber Industry to derive an implicit price for lumber; these data are available for the period from 1919-56 in *The Statistical Record of the Lumber Industry in British Columbia* [15] and *The Statistical Record of the Lumber Industry in British Columbia: 1950-65* [16]. I use this implicit price series as the basis for a price index for the Wood Industry for the period from 1919-56. I also employ this as the proxy for the log price index for the period from 1919-56. I use data on the total quantity and value of pulp production to derive an implicit price of pulp for the period from 1919-56. These data are taken from *The Statistical Record of the Pulp and Paper Industry in British Columbia* [17] and *The Statistical Record of the Pulp and Paper Industry in British Columbia: 1950-65* [18]. Data on the quantity and value of paper production are incomplete, so the price index for the Pulp and Paper Industry is based on the price series for pulp. Available data indicate that pulp and paper prices generally move together during the period from 1919-56. I assume that this price index captures the movement in prices for the Paper and Allied Industries.

An overall forest export price index is derived as follows:

\[
P_{FOR} = (P_{WD})^{s_{WD}}(P_{PA})^{s_{PA}}
\]

(C.1)

where \(P_i\) is the price index for the Wood and Paper and Allied Industries for the period 1919-92, with 1991 as the base year, and \(s_i\) is the share of the Wood and Paper and Allied Industries in the current dollar value of exports in each year. Log exports are included with Wood Industry exports in calculating the shares.