UNIVERSITY OF ALBERTA

ECONOMIC ANALYSIS OF FOREST DEPENDENT COMMUNITIES IN THE PRAIRIE PROVINCES OF CANADA

BY

STEPHEN B. FLETCHER ©

A Thesis
submitted to the Faculty of Graduate Studies and Research in partial fulfillment of the requirements for the degree of Master of Science in Forest Economics.

Department of Rural Economy

Edmonton, Alberta

Fall, 1991

Canadian Theses Service   Service des thèses canadiennes

Ottawa, Canada
K1A 0N4

ISBN 0-315-70171-4

UNIVERSITY OF ALBERTA

RELEASE FORM

Name of Author: Stephen B. Fletcher

Title of Thesis: Economic Analysis of Forest Dependent Communities in the Prairie Provinces of Canada

Degree: Master of Science

Year This Degree Granted: 1991

Box 22, R.R. #2, Evergreen
Williams Lake, British Columbia
V2G 2P2

UNIVERSITY OF ALBERTA

FACULTY OF GRADUATE STUDIES AND RESEARCH

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research for acceptance, a thesis

Entitled: Economic Analysis of Forest Dependent Communities in the Prairie Provinces of Canada

Submitted by: Stephen B. Fletcher

In Partial fulfillment of the requirements for the degree of :

Master of Science in Forest Economics

W.A. White
co-supervisor

W.P. Phillips
co-supervisor

L.F. Constantino
examiner and chair

J.D. Heidt
committee member

Date: May 15, 1991

This thesis is dedicated to my wife, Lisa.

Abstract

The prairie provinces of Canada contain regional economies where forestry is the major economic activity, despite dominance at the provincial level by other sectors. These regions contain communities which are dependent primarily on the forest resource for their economic and social well-being. Resource dependent communities have unique problems which may not be present in more diverse economies. These potential problems include instability, risk of mass unemployment, limited job mobility and limited amenities. This study identifies forest dependent communities and investigates the welfare implications of dependency.

The paper includes three major components. The first outlines a methodology for identifying forest dependent communities. The methodology was formulated through an intensive review of past studies identifying dependence, as well as a review of pertinent theoretical literature. The second stage employs the methodology in identifying forestry dependent communities in the Canadian prairie provinces of Alberta, Saskatchewan and Manitoba. This analysis shows that there are few communities in these provinces which are totally dependent on the forest industry, but there are many communities to which the forest industry is a vital component of their economic base. The third stage of the analysis uses a three-sector general equilibrium model to estimate welfare impacts on a community from exogenous shocks such as a change in the world price of forest products or a change in timber supply. The results from this model give theoretical and empirical support to the hypothesis that welfare impacts on a community from these exogenous influences are directly related to the degree of forest dependency.

Acknowledgements

I would like to take this opportunity to acknowledge a number of individuals and organizations who contributed to the completion of this thesis.

I am truly grateful to my thesis committee; Dr. Bill White, Dr. Bill Phillips and Dr. Luis Constantino for their advice and encouragement, and Dr. Jack Heidt for serving on the committee on such short notice.

Thanks to Forestry Canada's Northern Forestry Centre for providing financial support for this research. Special thanks to the Regional Development staff who, led by Dr. White and also including Steve Price, Marjorie Stephen, Diana Boylen, Joe DeFranceschi and Tim Williamson, provided the support, advice and freedom necessary to complete this thesis. Thanks also to Andre Kruger for technical support.

Finally, I thank the staff of the department of Rural Economy, University of Alberta for their support.

Table of Contents

LIST OF TABLES

LIST OF FIGURES

Chapter I: Introduction to Forestry Dependent Communities

A. Background

In Canada economic development has historically been driven by natural resources, and this has been particularly prevalent in the prairie provinces of Alberta, Saskatchewan and Manitoba. Starting with the fur trade centuries ago, followed by agriculture, energy and forestry, life on the prairies has been shaped by the utilization of natural resources. These resources are often found in remote areas and communities are established on the strength of the resource industry. The forest resource, for reasons to be examined later, is particularly prone to the formation of single industry communities. This study contains an examination of these communities which depend strongly on the forest sector.

The prairie provinces have a long and rich tradition in forestry, despite the fact that the agriculture and energy sectors have dominated the provincial economies. If the scope is narrowed, however, to the regional or community level, small local economies are found in which the forest industry is the major economic force. These prairie communities are dependent on the forest industry for their economic and social livelihood.

The first step in understanding forestry dependent communities is to examine why these communities have developed. Many natural resources, especially forests, are found in widespread and remote locations across the country. Consequently, most natural resources are found far from cities where human and other resources could be employed readily in extraction and processing. In forestry, much local capital and labour is required for harvesting and transport of raw timber. This establishment of resource-based activity at the source, where forestry may be the only feasible industry, leads to the formation of single-industry communities.

Another factor which contributes to the formation of forestry dependent communities is the bulky nature of the raw forest product. The processes of lumber and pulp production are size and weight reducing; consequently processing plants tend to be built close to the timber source. Economies of scale influence plant location decisions in the opposite direction (ie. fewer, larger plants). A balance is reached, with sawmills and pulpmills being located closer to their raw material source than processing plants in other industries, such as energy and agriculture.

Timber processing plants employ many people and the large capital investments by forestry firms give the communities some long-term employment security. With this security comes more service related activities. These service activities increase the size of forestry communities, which are in some instances are totally dependent on the forest for their economic well-being.

The most obvious and perhaps most important problem faced by communities with a narrow economic base is their vulnerability to fluctuations in the resource industry. Demand for lumber, to a very large degree, mirrors cycles in construction, which in turn are the result of the business cycle. Much of Canada's forest product is exported, which means the Canadian forest industry is susceptible to foreign business cycles, particularly those in the United States. There are also supply driven shocks to the forest sector, such as short-run supply gaps or even long-run supply fall-downs.

When a key industry in a dependent community is lost, or significantly reduced, a large percentage of residents become unemployed and the income of the community is significantly reduced. Any fluctuations in forestry employment affect service activities which are supported by the base industry. These linkages will multiply the effects of changes in the base industry, possibly to an extent which is devastating to the community.

If industry downturns are cyclical, as in the business cycle, instability could be a chronic problem in the forest dependent community. If the decrease in forestry employment in a community is permanent, as with a supply fall-down there can be high adjustment costs. The limited availability of local employment opportunities in other fields may force workers and their families to move to other communities. If local employment opportunities are available in other fields, forestry workers may lack the requisite skills, and retraining may be required to allow them to remain in the work force. Governments may choose to provide aid in relocation and retraining.

There are other problems in single industry towns which are apparent even when the key industry is economically viable and stable. A community which relies on a single industry continually faces the risk of losing its major source of income. This risk may constrain the establishment of basic community infrastructure, services and amenities which are common in more diverse communities. These community aspects include medical facilities, recreational facilities, churches, educational institutions and public utilities. The inherent risk in a single industry community may discourage residents from owning their own homes, relying instead on company or other rental housing. These factors may detract from the quality of life in a single-industry community.

B. Objectives of the Study

The primary objectives of this study are to identify forest dependent communities in the prairie provinces of Canada, and to evaluate the effect that dependency has on a community's economic welfare. At present there is no fully accepted identification method readily available. Chapter 2 contains a review of theoretical literature as well as an examination of the methods used in the past to identify single industry communities. The chapter builds on past work to define a method for identifying forest dependent communities that is based on regional economic theory, and is practical for application to a large number of communities.

The next stage of the study, Chapter 3, focuses on the application of the method to communities in the three prairie provinces of Canada. The objective is to discover the degree and characteristics of forest sector dependence in prairie communities. A list of forest dependent communities is produced using employment data from the 1981 and 1986 census years.

Chapter 4 develops a general equilibrium model of a small economy and uses it to answer questions regarding forest dependence and community welfare. These questions include: Is there a relationship between forest dependence and community welfare changes from changes to the forest sector? How do cyclic demand and supply shifts affect community welfare? And, how do government policies like sustained yield, income transfers and capital subsidization affect community welfare?

The concluding chapter of the study contains a summary of findings and policy implications arising from the study. An examination of further research needs made apparent by this work and recommendations for future study are also included.

Chapter II. Towards a Method for Identifying Dependent Communities

A. Introduction

Studies conducted in Canada and the United States on forest sector dependence have used methods with varying degrees of sophistication. These studies have generally contained only brief presentations of their methods and proceeded with the empirical analysis, with little or no discussion of the underlying theory. There have been no comprehensive discussions of community dependence identification as it relates to economic theory and principles. The goal of this chapter is to fill that void and to provide a method for identifying forest dependent communities that meets both theoretical and practical requirements.

The first step is to establish the theoretical foundations of the community dependence issue. This includes a more explicit definition of the term "community dependence," which will provide direction to the relevant body of economic literature. A review of past studies that identify community dependence follows the review of theory. This review gives some insight into the practical nature of the problems and empirical difficulties that exist. Finally, after examination of theoretical and practical considerations, a method for identifying forestry dependent communities is presented.

B. What is "Community Dependence?"

The unit of analysis in the community dependence issue is a small, local economy, as opposed to a large provincial or national economy. This fact is critical. Due to resource limitations and economies of scale, a local economy cannot possibly supply itself with the goods and services to support anything more than a subsistence lifestyle unless it can import goods and services from other communities, provinces or nations. These imports must be paid for with credit earned through exports. A regional economy has a mercantilist flavour, with emphasis on exports. The same argument could be applied to larger economies, but the smaller the economy in question, the more pronounced the dependence on exports to drive the local economy.

The preceding argument supports the conclusion that a small, local economy is dependent on exports for its continued well-being. Most regional economists support this basic conclusion, including Tiebout (1956), Pleeter (1980) and Richardson (1985). It follows that if a community is to be classified as dependent on a particular industry then that industry must comprise some significant proportion of the export or economic base.

C. Economic Base Theory

Economic base theory was conceived in the 1930's when city planners required a method for estimating total impact on a community from expansion or introduction of a base industry (Weimer and Hoyt, 1939). Economic base theory is grounded in the notion that the basic sector, which is considered to include any activity that brings income into a regional economy, is the driving force of the economy. The non-basic sector in a community provides goods and services to the basic sector.

An important point to be made is that many industries contribute to both the basic and non-basic sectors. Restaurants, for example, may serve local residents as well as tourists. The income earned from the tourists comes from outside the community and is basic. Spending by locals is a recirculation of money within the community and is non-basic. The income of the non-basic sector and therefore of the entire economy is dependent on the basic sector, and can only grow if the basic sector grows (Tiebout, 1962).

This dual nature of many sectors causes problems in the measurement of the economic base of a region. It is necessary to determine what portion of each sector is basic, if one is to determine the size of the economic base as a whole. The issue of base measurement is a crucial one for this study and the theoretical and practical problems involved must be worked through.

1. Measuring the Economic Base

a) Units of Measurement

The first issue to be settled in measuring the economic base is the definition of the unit of measurement itself. Until now the vague term "activity" has been used to describe the economic base, but if the base is to be measured empirically, a more concrete unit is required. Tiebout (1962), in a paper summarizing the state of economic base literature at the time, lists four possible measurement units; sales, value added, income and employment. Though this paper is dated, the units in question and the arguments for and against them remain virtually intact. The units and their advantages and disadvantages are as follows:

i) sales - The dollar value of transactions is recorded and export sales considered to be a measure of base activity. There are at least three major problems with this approach. The first problem is data availability. Data of this kind is not readily available and requires interviews of individual firms to determine where their goods and services are being sold. The firms themselves may not have this information. The second problem is double counting of sales. This is a familiar problem when using total sales as measure of economic activity. The third problem is inclusion of non-local corporate profits. That is, some portion of income from export sales may leave the community as profits to external shareholders. These profits are of no use to the community and should not be included.

ii) value added - Value added is similar to sales but avoids the double counting problem by subtracting input costs from total sales. Data collection is more difficult than with sales since even more information is required. Also the problem of non-local corporate profits still exists with this measure.

iii) income to residents - This measure includes income accruing to residents including wages, dividends, interest, rental income and that from any other sources. Using income as a measure of economic activity eliminates the problem of non-local profits but may go too far and eliminate some income that should be included as part of the base. For example, local capital investment by firms would not appear as it should. Data collection is easier than for sales and value added but is probably still impractical for a study of wide scope.

iv) employment - The use of employment for measuring economic activity is without doubt a compromise between accuracy and data costs. Employment data is readily available and inexpensive. When employment is used as a substitute for income, a bold assumption is made that all jobs are of equal benefit to the community. This assumption is unlikely to be met considering the large differences in yearly income for different members of a community. Despite these disadvantages, employment has been by far the most widely used measure. The availability and low cost of employment data is an overwhelming consideration.

Richardson (1985) wrote a summary of economic base literature but does not discuss the relative merits of different units of measurement. He suggests employment as the unit to be used in large studies. This support, along with the fact that most economic base studies use employment, suggests that employment has been decided upon as the unit of choice. Tiebout (1962) pointed out a possible reason for neglect of the measurement issue. All of these measures probably tend to move together, that is, they are collinear. Studies which examine the validity of this assumption and the sensitivity of results to violations of it are absent.

b) Measurement Techniques

Literature on economic base theory contains two broad categories of techniques used to measure the economic base; direct methods, and indirect methods. Direct methods are so named because attributes of the economy are measured directly, with the collection of primary data. These techniques are usually considered more accurate but may be prohibitively expensive. Indirect methods use secondary data from censuses and other sources and are usually of relatively low cost.

i) Direct Methods of Measurement

- measuring commodity and money flows. This technique, described by Tiebout (1962), is conceptually the most straight forward. A tally of the goods leaving the community can be made and the value of these goods will be a measure of their contribution to the economy. The difficulty here is data collection. One approach that has been taken is to use transportation industry records. Unfortunately data from these sources are usually very difficult to obtain and often incomplete. Another problem is that records are usually kept only for volume or weights of shipments, not the value of them. Because of these problems this method has limited practical use.

- survey of the local economy. This is the most widely used direct method. The method involves surveying firms and individuals in a community. Firms are asked to indicate the proportion of their sales that are exported and individuals are asked to indicate the sector and location of their sources of income. This method is considered to be accurate and although data costs are high they may not be prohibitive for a study concentrating on a single community. This type of study is often carried out by municipal and regional governments when concentrating on their communities. For a study of many communities the data costs would be enormous.

ii) Indirect Methods of Measurement

- the assumption method. When using this method the researcher must make an assumption as to whether an industry is basic or non-basic. Commonly, primary manufacturing and construction industries are considered basic and the rest non-basic. Errors arising from such assumptions can be considerable. Many manufacturing industries serve local markets and many services such as restaurants serve non-locals. For some industries a valid assumption could be made in assigning them to one sector or the other. For example, it is probably safe to assume that agriculture or some forestry activities are basic activities. But for determining the total size of the economic base the error is considered too great (Richardson, 1985). Despite the drawbacks the technique is used because of its simplicity.

- the minimum requirements technique. This method involves ranking the communities in question by the percentage of the total labour force that an industry comprises. The minimum of these percentages is then assumed to be the size of industry a community needs to satisfy its own needs. If a community has more than the minimum then that portion above the minimum is considered basic activity. The glaring problem with this approach is the assumption that all communities are exporters and none are importers. Adjustments and improvements have been made to correct for this and other errors but the technique is still considered inferior to the one that follows.

- the location quotient. This technique is based on the underlying assumption that if a community is highly specialized in an industry relative to the national average, then that portion of the industry's activity above the average is considered to be export activity. Community j's location quotient for industry i is:

$$LQ_j^i=\frac{E_j^i/E_j^T}{E_N^i/E_N^T}$$

Where E is employment, T is the total for all sectors, and N is the national total. A location quotient of 5, for example, means that employment is five times more concentrated in the community than in the nation as a whole. Base employment is considered to be that above and beyond the national average because it is assumed the national average is what is required to serve local needs. Community j's base employment in industry i is:

$$X_j^i=(\frac{LQ_j^i-1}{LQ_j^i})E_j^i$$

Community j's total base employment is:

$$X_j^T=\sum_{i=1}^{n}X_j^i$$

The accuracy of this technique depends on four major assumptions. First, there are no net exports at the national or benchmark level. This assumption is required because the national production in an industry is assumed to meet domestic needs. If a community's labour force in an industry is the same percentage as that of the self-sufficient nation then the location quotient is one and the community is producing just enough for local needs and is a non-basic industry. If the nation is a net exporter in an industry then this technique will underestimate base employment. Conversely, if the nation is a net importer in an industry the location quotient will overestimate base employment. To deal with this problem an adjustment could be made to the benchmark employment in an industry. If the nation's consumption of a good equals half of its production then the benchmark employment in the industry should be halved as well.

Second, consumption patterns are assumed to be identical across the nation. The probability is high that per capita consumption differs across regions because of different preferences or incomes. The third fault with the location quotient is the assumption that labour productivity within an industry is identical across regions.

Schwartz (1982) suggests that error from consumption and productivity differences can be reduced if provincial rather than national benchmark employment is used. This adjustment will account, at least partially, for any regional biases which may exist. Or, if data on regional productivity were available an adjustment could be made. Isserman (1977) defined a modified location quotient which would adjust base employment for all three of the above problems:

$$X_j^i = [v_i \frac{E_j^i}{E_N^i} - c_i \frac{E_j^T}{E_N^T}(1-e_i)] \frac{E_N^i}{v_i}$$

where v_i is the regional/national labour productivity ratio, c_i is the corresponding consumption ratio and e_i is the national export/output ratio for industry i. The term $(1-e_i)$ represents the proportion of output which is consumed domestically. This modified equation adjusts for regional differences from national averages of productivity and consumption, as well as adjusting for exports.

The fourth problem is the degree of homogeneity of products within an industrial classification. If there is more than one product within a category then errors could be introduced. The following example illustrates the problem. Assume that within the category "meat products" there are actually two products, beef and pork. If a community specializes in producing beef (importing all their pork) and a location quotient is calculated for the meat industry then basic employment will be underestimated. Excess beef employment, which should be classified as basic, may be seen as producing pork for the local market.

The solution to this problem is to use data which are as highly disaggregated as possible. Location quotients have been heavily criticized for underestimating base employment by others who failed to recognize this problem. For example Gibson and Worden (1981) found that the location quotient yielded an underestimation of the economic base in comparison to survey methods. Their study used highly aggregated data, with the entire manufacturing sector in a single category. With such high aggregation their underestimation of the economic base is not surprising. As a rule more disaggregation means more accuracy.

D. A Review of Past Studies Identifying Community Dependence

Five studies have been found which define community dependence on the forest industry. These studies provide no theoretical justification for their methods. This section contains a description and critique of the criteria used.

The Department of Regional Economic Expansion (DREE, 1979) conducted a Canada-wide study to identify single-sector communities. Using 1971 census employment data, and other sources, the study employed a two-stage system to decide if a community was dependent on any one industry. In the first stage, employment in an industry was compared to total employment in the community. If employment in the industry was greater than a critical level then the community was deemed dependent on that industry. The critical levels were defined as follows:

- greater than 60% for population less than 2,500
- greater than 40% for population between 2,500 and 5,000
- greater than 30% for population between 5,000 and 10,000
- greater than 25% for population between 10,000 and 30,000
- greater than 20% for population over 30,000

There are a number of problems with this method. First, no explanation is provided regarding the selection of the critical values. Second, critical levels of sector employment are a function of total rather than base employment. This is a problem because, as has been shown, a community is dependent on its base employment and non-base employment is not relevant to the dependency issue. Using total employment would not be a serious problem if base employment were a linear function of total employment but it is not. Larger communities are able to provide a greater level of services locally, primarily due to economies of scale, and consequently have relatively larger non-basic sectors. This problem is important because a larger community would not require as high a percentage of total employment in a base activity to be considered dependent because a larger non-basic sector is supported by the base activity.

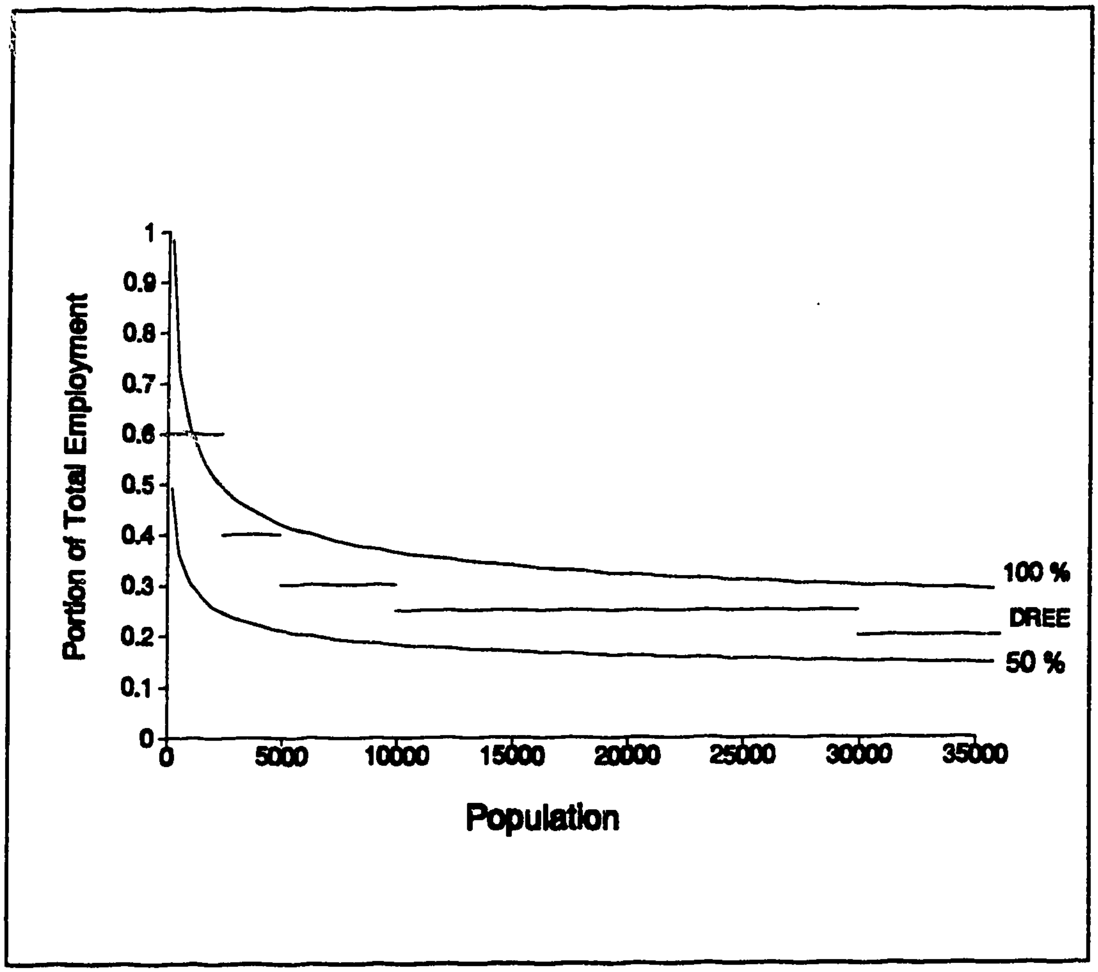
The authors have recognized this problem and attempted to correct it with the five different critical values which decrease with increasing population. There are two questions that arise from this procedure. The discontinuous "step" function for correcting for population would introduce considerable error if the relationship between the size of the non-basic sector and population is continuous. Secondly, how was the shape of the adjustment function determined, and is it appropriate?

The upper curve in Figure 2.1 relates the base/total employment ratio to the population of the community[1]. The curve represents complete dependence because it shows the basic portion of total employment. An industry would not be required to make up 100 percent of the base activity for the community to be considered dependent upon it. For the sake of demonstration assume that a community is dependent on a sector if it makes up more than 50 percent of the base activity. The lower curve in Figure 1 shows this 50 percent rule. The vertical position of this line is quite arbitrary due to the assumption made, but its shape is not.

---

[1] See Appendix 1 for derivation of this curve.

Figure 2.1: Base/total employment versus population.



A comparison of DREE's step-function to these curves raises two important points. First, if a step function is used, much finer increments are needed because in some places the step function is quite close to the derived dependence line and in other places it diverges widely. Second, the authors do not make enough adjustment for the higher base/total employment ratio in smaller communities. In fact at a population of 2,500 it would be impossible under DREE's criterion to find a dependent community. At this population an industry making up the maximum 100% of the base activity would only make up about 50% of total employment which is less than the 60% cut-off point. In other words a community with a basic sector of this size would generate such a large non-basic sector that it would be impossible to be described as dependent.

There is another factor besides population which could cause variation in the base/total employment ratio. According to the theory of central places, first discussed by Christaller (1966), there exists a hierarchy of communities in which the market area of each place is nested in the market area of the next highest order place. There is a flow of services and goods supplied down the hierarchy of communities. As a result of this flow a place high in the hierarchy will serve a larger external market than a place of comparable population that is lower in the hierarchy. These goods and services provided to lower order communities will be part of the economic base of the community. The larger total market and economies of scale will allow more services to be supplied to residents within the higher order community. This higher degree of service activity will cause a higher order community to have a lower base/total employment ratio which would make it less likely to be classified as a dependent community using DREE's criteria.

There are probably other factors, as well, causing variation in this ratio. All of these factors erode the accuracy of a dependence criterion, which relates industry employment to total employment rather than base employment.

The second stage of the DREE method uses a device called the Herfindahl index to find dependent communities which were missed in the first stage. This index was used to correct for dispersion of other economic activity. The form of the index used by the authors is as follows:

$$HI_j=\sqrt{\sum_{i=1}^{n}(E_j^i/E_j^T)^2}$$

where the definition of the employment variables is the same as that for the location quotient.

In this context the index is a measure of diversity of an economy. A maximum value of one indicates that all employment in a community is concentrated in a single industry. A minimum value of zero indicates infinite dispersion of employment. To account for the fact that communities with larger populations tend to have larger and more numerous service industries and therefore have more diverse economies, the index should be adjusted for population. Again this would not be necessary if base employment were used instead of total employment. The authors used the following cut-offs to define a specialized economy:

- greater than .3 for population less than 10,000
- greater than .2 for population between 10,000 and 30,000
- greater than .15 for population greater than 30,000

This step function undoubtedly has discontinuity problems similar to those described earlier, but there are more interesting problems with this measure. The authors provide no justification for the use of this index. They were probably operating under the assumption that a more specialized economy is a more dependent economy. This assumption seems reasonable at first but it can give rise to some interesting anomalies. Table 1.1 depicts two hypothetical communities to illustrate this problem. Even though

Table 1.1: The Herfindahl index.

sector	Community A	Community B
forestry	500 jobs	475 jobs
energy	100	325
agriculture	100	0
manufacturing	100	0
services	800	800
total	1600	1600
Herfindahl index	0.358	0.379

the communities have the same sized labour force, community B with a smaller forest sector has a higher Herfindahl index. Clearly community B has a more specialized economy than community A, but is it more dependent on forestry? The Herfindahl index as it is used here says it is.

White *et al* (1986) conducted a study identifying forest dependent communities in British Columbia. The authors used a method based on DREE (1979), but with some modifications. The most important modification was the inclusion of other categories for different degrees of dependency. These categories were, along with forestry dependent, dual communities (those dominated by the forest sector and one other), diversified communities (those with at least three dominant sectors, including forestry), specialized non-forest, (communities dependent on another sector but forestry employment still in the top five), and finally minor or no forest sector (forestry employment not in the top five).

The use of other categories by White *et al* alleviates some of the problems with the Herfindahl index. For example, community B in the illustration above would be classified as a dual community. This classification would recognize the fact that although forestry is the dominant employer, there is another very important industry in the community.

Pharand (1988) conducted a Canada-wide study describing the demographic characteristics of communities dependent on forestry. In this study a community was dependent on forestry if forest sector employment as a percentage of total employment exceeded a critical level. The critical levels were defined as follows:

- greater than 30% for population less than 10,000
- greater than 25% for population between 10,000 and 30,000
- greater than 20% for population greater than 30,000

The problems with this method are similar to that of the first stage of the DREE (1979) study. Forestry employment is compared to total employment and consequently, the critical level must be adjusted for population. The adjustments made for population are more crude than DREE's and the error introduced should be even greater.

Steele *et al* (1988) use the location quotient to define dependence on forestry. In their study, which looked at the forest industry in Saskatchewan, a community which had a location quotient for the forest industry of 10 or greater was considered to be dependent. In this study the authors used the provincial average as the benchmark with which to compare community forestry employment. Since the provincial average remained constant at about one percent, a location quotient of ten simply meant that ten percent of the community was employed in forestry. This method is reduced to a straight percentage of the total labour force, similar to that used by Pharand (1988) and has similar problems associated with it and more, because no attempt was made to adjust for population. The location quotient was intended as a means for finding out how much of an industry is basic activity. Its use in this case amounts to nothing more than an awkward method of calculating percentage employment.

In 1969 Schallau, Maki and Beuter published a study in which they projected economic impacts of alternative levels of timber production in the Northwestern United States. The authors classified economic areas as highly, moderately or slightly timber dependent. The method used was to compare forestry employment to economic base employment. The cutoff values they used were as follows, where the percentages shown are forestry employment over economic base employment:

- greater than 70% is highly timber dependent
- between 30% and 70% is moderately dependent
- between 0% and 30% is slightly dependent

Note that no adjustment was made for population of the region. As discussed earlier, this is not necessary when forestry employment is compared to base employment rather than total employment.

The authors estimated the economic base of communities using what they called "the method of excess employment" which is identical to the location quotient technique. The regional levels of employment were compared to the average for the entire U.S.A. The level of industrial disaggregation of the data was not indicated, nor was it indicated if adjustments were made to correct for the biases of the location quotient technique.

All of the dependency identification techniques described above have problems which could be corrected, or at least reduced, with little increase in cost of implementation. The following section outlines a method for identifying community dependence that is more consistent with economic theory, as well as practically feasible. The method draws on the strengths of past studies and improves on their weaknesses.

E. A Method for Identifying Community Dependence

In formulating a method for identifying community dependence there are issues to consider besides the conceptual problems outlined earlier. Consideration must be given to the intended application of the method, data availability and any other elements specific to the objectives of a particular study. In this case the objective is to find a method that can be used easily and at reasonable cost for a large number of communities. Such an approach is limited to secondary data sources, since surveys to collect primary data in a large number of communities across the prairies are prohibitively costly.

The only secondary source which yields industry specific data is the Canada Census. Data are collected every five years, with the last collected in 1986. Within the census, employment figures are the only one of the potential units described in Chapter 2 that are collected by industry and by census subdivision. For a study of broad scope, such as this one, the choices of data source and measurement unit are all but determined. This result is reflected by the fact that every community dependence study in the past has used census employment data.

The next item of concern is choosing a method of using census employment data to identify dependent communities. Previous discussion has established that, conceptually, a community is dependent on an industry if that industry makes up some "significant" portion of the economic base. There are two issues here; one is estimating the economic base, and the other is deciding how large the industry's portion of the economic base must be to be considered significant or critical.

In previous community dependence studies, discussed above, three different methods were used for estimating the economic base. The simplest, used by Steele *et al* (1988), implicitly assumed that the economic base was a constant portion of the total economic activity. The DREE (1979) study was more sophisticated, as were others based on it. An attempt was made to account for the change in the base/total employment relationship caused by population differences. Both of these methods failed to consider other factors which caused variation in the base/total employment ratio, most notably the community's position in the hierarchy of communities.

The study by Schallau, Maki and Beuter (1969) was the only one which actually tried to measure the economic base of communities. The authors used the location quotient to measure the economic base. Provided the base can be measured with reasonable accuracy, and at reasonable cost, this is clearly superior to the estimations using the other methods. The location quotient has the support of prominent authors such as Richardson (1985), Isserman (1977) and Schwartz (1982), as the best technique in its class, provided steps are taken to reduce errors caused by violation of its assumptions. In the case of forestry dependence[2] on the prairies the following measures are taken in this study to increase the accuracy of the location quotient:

1. The benchmark employment figures could be adjusted for net exports in an industry. Export data are available and the adjustment is a simple one.

[2] As discussed in section 3.C.

2. Data on regional productivity are probably not as readily available. However, as Schwartz (1982) suggests, if provincial rather than national figures are used as benchmarks the error from regional bias in consumption patterns and productivity is greatly reduced.

3. Census data on employment by industry are available in very highly disaggregated form. Its use here reduces the underestimation of the base caused by the product mix problem.

The final consideration is given to determination of the minimum percentage of base employment which places a community in the forestry dependent category. This point has received no discussion in the literature, perhaps because it is very difficult, if not impossible, to determine a cut-off point using anything other than arbitrary selections. Each author has had to make subjective decisions on the appropriate cut-off levels for their studies. In an effort to avoid this problem in this study, the following procedure is proposed:

1. Rank the communities by percentage forestry employment of economic base employment.

2. Use cut-off levels selected in the past as a rough guide and look for natural breaks in the rankings. If breaks exist they may indicate the structural differences in communities that are to be identified.

This method is not perfect for identifying forest dependent communities, but it is guided by a review of relevant economic literature as well as by the strengths of previous studies. Resource constraints require that some theoretical consistency be compromised, particularly in the use of secondary employment data, but overall the method addresses theoretical and empirical issues and is an improvement on past techniques.

Chapter III. Identifying Forest-sector Dependent Communities in the Prairie Provinces of Canada

A. Introduction

This chapter contains an identification of the degree of forest-sector dependence of all prairie communities where people are employed in forestry. This identification is made using the method outlined in the previous chapter. Efforts are also made to describe important aspects of community dependence on forestry, including changes in community dependence between 1981 and 1986, comparison of overall provincial levels of dependence between provinces and census years, and segregation of communities into categories by degree of forest dependence. The objective of this chapter is to discover the degree and characteristics of forest-sector dependence, and to present these findings in such a way as to answer certain questions regarding forest dependence.

B. The Communities in Question

The forested region makes up over two thirds of the prairie provinces. It contains over 300 communities, which represents one third of the total number of communities for the three provinces. These communities, with very few exceptions, are small (only four with population above 10,000, none above 40,000) and resource-based. Important sectors in this region, besides forestry, are oil and gas, agriculture, mining, and hydro-electric generation.

The fact that these communities are small is an important consideration to this project. Authors in economic base literature have indicated that the relative importance of economic base theory and its applications are inversely related to the size of the community or region in question (Pleeter,1980). Cities such as Edmonton or Regina are much more self-sufficient in goods and services provided than are small communities. This self-sufficiency means the export/import relationship crucial to economic base theory is diminished in importance in the large city economies.

C. The Data

The following analysis is based on data obtained from the Statistics Canada national censuses for 1981 and 1986. The data are comprised of employment figures for each census sub-division and are disaggregated into Standard Industrial Classifications (SICs), of which there are 257. In the forested region[1] of the prairie provinces there are 708 census sub-divisions, of which 333 are communities, 180 are rural districts[2], and 185 are Indian reservations.

The rural districts are not examined for forest dependency because they are agglomerations of wide-spread rural people and do not represent communities as such. Indian reservations are also not examined because their inherent cultural and governmental differences, such as treaty rights to federal government transfer payments, do not allow direct comparison. The study of rural districts and Indian reservations would be a worthy subject of future research but is beyond the scope of the present project.

As outlined in Chapter 2, the accuracy of the identification method can be

---

[1] The forested region includes the following census divisions for each province: Alberta divisions 3,6,9,12-19; Saskatchewan divisions 9,14-18, and Manitoba divisions 1,2,13,14,16-23.

[2] "Rural district" is a generic term used to describe counties, rural municipalities, local government districts, and improvement districts.

improved with some simple techniques. Provincial employment figures will be used as benchmark figures which will reduce any error due to regional bias in consumption and production patterns. Also benchmark employment figures are adjusted for net exports so that the benchmark represents the employment that would be required for the province to supply itself with the goods from a given sector[3].

D. Results

The first step in the analysis is calculation of the economic base of each community using the location quotient technique. The results from this stage of the analysis are of interest in their own right. The discussion in Chapter 2 hypothesized that the base/total employment ratio should decrease in size with increasing population. Another hypothesis put forward was that this ratio would be affected by the community's place in the hierarchy of communities. In Appendix 1 these issues are examined, with both hypotheses being supported by the data.

1. Degree of Dependency

Forest dependence is measured as the degree of employment that the forest sector contributes to the base divided by total base employment. This ratio is the forest dependence index (FDI) and can be interpreted as follows: a value of 0.3, for example, means that the forest sector makes up 30 percent of the economic base. Table 3.1 shows

[3] This adjusted benchmark employment replaces E^i_N in the location quotient equation. The adjustment, using data from national input-output tables (Stats Can, 1981 & 1986), is made as follows, where T_i is total output in sector i, X_i is total exports in sector i, M_i is total imports in sector i, and E_i is provincial employment in sector i.:

$$\textit{Benchmark employment} = \frac{(T_i - X_i + M_i)}{T_i} E_i$$

the top 40 prairie communities ranked by forest dependence in 1981 and 1986.

Appendix 2 contains a complete listing of all communities that have forest-sector employment. Appendix 2 also contains other important details of these communities. Included here are the actual size of the labour force, of the forest sector and of other important sectors in the community, as well as details regarding the location of the communities.

The most important feature in Table 3.1 is the fact that there are not many communities where forestry dominates the economic base. There are only six communities where forestry makes up over 50 percent of the base and four of these, Endeavour, Albertville, Smeaton, and Meath Park are extremely small communities[4]. Despite the lack of communities dominated by forestry, there are many where the forest sector is a significant component of base activity. This result is consistent with the perception of forestry on the prairies being a diversifying rather than a dominant agent.

The overall provincial levels of community dependence on forestry can also be represented in this analysis. The concept of overall dependency in a province as used here is meant to describe the aggregation of community dependence in a province, not the provincial forestry employment total. A quantitative estimate of overall dependence is the average of all communities' FDI in a province weighted by community size. Table 3.2 shows this sum for all three provinces in the two census years.

The most notable feature of Table 3.2 is the higher level of dependence in Alberta

[4] Endeavour and Albertville both have FDI rankings of 1.000. Closer examination of the data for these communities reveals that forestry makes up not only all of the basic employment, but all total employment as well. The fact that these communities are extremely small (total employment is 15 and 10 in Endeavor and Albertville, respectively) is undoubtedly responsible for the unusual results.

Table 3.1: Prairie communities ranked by forest dependence index (FDI).

1981				1986				
					1981			
Rank	Community	Province	FDI	Rank	Rank	Community	Province	FDI
1	Powerview	Man	0.797	1	-	Endeavour	Sask	1.000
2	Hudson Bay	Sask	0.637	2	new	Albertville	Sask	1.000
3	Smeaton	Sask	0.567	3	1	Powerview	Man	0.732
4	Meath Park	Sask	0.555	4	2	Hudson Bay	Sask	0.534
5	Big River	Sask	0.485	5	5	Big River	Sask	0.452
6	Hinton	Alb	0.425	6	-	Chitek Lake	Sask	0.409
7	Cowley	Alb	0.407	7	-	Togo	Sask	0.382
8	The Pas	Man	0.404	8	6	Hinton	Alb	0.379
9	Mayerthorpe	Alb	0.337	9	22	Hines Creek	Alb	0.352
10	Sangudo	Alb	0.298	10	8	The Pas	Man	0.331
11	Grande Prairie	Alb	0.288	11	13	High Level	Alb	0.323
12	Leoville	Sask	0.286	12	18	Paddockwood	Sask	0.301
13	High Level	Alb	0.278	13	35	Wembley	Alb	0.290
14	Glaslyn	Sask	0.215	14	11	Grande Prairie	Alb	0.275
15	Niverville	Man	0.214	15	62	Grande Cache	Alb	0.256
16	Boyle	Alb	0.211	16	9	Mayerthorpe	Alb	0.242
17	Whitecourt	Alb	0.200	17	17	Whitecourt	Alb	0.238
18	Paddockwood	Sask	0.200	18	27	Kinuso	Alb	0.195
19	Slave Lake	Alb	0.196	19	-	Donnelly	Alb	0.193
20	Steinbach	Man	0.192	20	26	High Prairie	Alb	0.189
21	Choiceland	Sask	0.190	21	20	Steinbach	Man	0.152
22	Hines Creek	Alb	0.190	22	34	Carrot River	Sask	0.148
23	Sundre	Alb	0.178	23	19	Slave Lake	Alb	0.142
24	Prince Albert	Sask	0.162	24	-	Debden	Sask	0.141
25	Wildwood	Alb	0.154	25	21	Choiceland	Sask	0.128
26	High Prairie	Alb	0.152	26	50	Edson	Alb	0.124
27	Kinuso	Alb	0.147	27	37	Roblin	Man	0.123
28	Delburne	Alb	0.139	28	-	Pelican Narrows	Sask	0.123
29	Spirit River	Alb	0.132	29	-	Mirror	Alb	0.116
30	Magrath	Alb	0.128	30	43	Meadow Lake	Sask	0.113
31	Edam	Sask	0.117	31	24	Prince Albert	Sask	0.110
32	Wabamun	Alb	0.115	32	16	Boyle	Alb	0.109
33	Maryfield	Sask	0.115	33	new	Denare Beach	Sask	0.103
34	Carrot River	Sask	0.111	34	23	Sundre	Alb	0.098
35	Wembley	Alb	0.106	35	38	Smoky Lake	Alb	0.092
36	Crowsnest Pass	Alb	0.099	36	new	Buffalo Narrows	Sask	0.090
37	Roblin	Man	0.093	37	new	Air Ronge	Sask	0.087
38	Smoky Lake	Alb	0.091	38	42	Cochrane	Alb	0.079
39	Swan River	Man	0.087	39	-	Sexsmith	Alb	0.078
40	Barrhead	Alb	0.085	40	36	Crowsnest Pass	Alb	0.078

Province abbreviations: Alb, Alberta; Sask, Saskatchewan; Man, Manitoba.

Table 3.2: Overall provincial dependence on forestry (sum of all FDI, weighted by population)

Province	1981	1986	Change
Alberta	0.0235	0.0202	-0.0033
Saskatchewan	0.0214	0.0169	-0.0045
Manitoba	0.0201	0.0164	-0.0037

than in either Saskatchewan or Manitoba. Two factors contribute to this result; Alberta has more communities with forestry employment, and Alberta has larger communities with forestry employment. Alberta communities such as Hinton and Grande Prairie are large communities with large absolute levels of forestry employment. They contribute heavily to overall provincial dependence even though, due to strength of other sectors, their FDI ranking is not as high as some communities in the other provinces.

The second notable feature in Table 3.2 is the decline in overall dependence in all three provinces between 1981 and 1986. This decline in overall dependence levels could be brought about by growth in other sectors, or by a decline in the forest sector itself. In fact, as is shown in Table 3.3, both of these factors played a part in the decline in overall dependence. Total forestry employment did fall in all three provinces while, at the same time, the other two important resource sectors, agriculture and energy, both showed increases in employment.

Despite the decline in forestry employment the sector remains an important diversifying agent in the prairie provinces. The decline in employment can be traced to improvements in technology, rather than downsizing of the industry. This technological change has produced a more competitive forest sector. Since 1986 new mills have been built on the prairies and others have been expanded. These developments may well have reversed the trend of decreasing employment in the forest sector. Also, particularly in Alberta, much of the new development has been in the pulp and paper side of the forest sector. This diversity within the forest sector means the forest sector as a whole will be less susceptible to any particular downturn, such as falling demand for lumber or a change in pulp prices.

Table 3.3: Provincial Employment in Resource Sectors in 1981 and 1986.

	Forestry		Agriculture		Energy	
Province	1981	1986	1981	1986	1981	1986
Alberta	14875	13725	92465	98810	62135	69165
Saskatchewan	4565	4030	89540	95805	4105	5360
Manitoba	7385	6740	48000	51580	715	860

2. Changes in Dependency

A feature of interest regarding forest dependence is how this dependence has changed for individual communities between 1981 and 1986. Table 3.4 shows the communities with the 20 largest increases and decreases in FDI between the census years[5].

There is an important point to be made regarding the communities with the more extreme changes in FDI. Endeavour, Chitek Lake, Togo, Smeaton, Meath Park, Cowley, Sangudo, and Leoville are all very small communities. There are three possible reasons for this pattern. First, with these very small communities, small absolute changes in the forest sector mean relatively larger changes in FDI. Second, the census data contain only a twenty percent sample of employment in a community. In smaller communities there is greater variability in the estimation of employment levels, leading to greater variability in FDI between census years. Third, the employment numbers are randomly rounded to multiples of five by Statistics Canada to protect confidential sources. In small communities this could introduce significant error.

Among communities with greater than 100 people employed, the four largest increases in FDI are to be found in Alberta. Grande Cache, Donnelly, Wembley and Hines Creek are all in northern Alberta where, since the mid-1980's, forestry has been undergoing tremendous growth, aided by the provincial government's diversification programs. Since 1985 major developments have been undertaken or announced in Grande Cache, Grande Prairie, Fox Creek, Whitecourt, Athabasca, Peace River, Hinton, Slave Lake and Drayton Valley. Most of the employment generated by these developments occurred subsequent to the 1986 census but the increase in forest dependence of some

---

[5] The communities of Albertville, Denare Beach, Buffalo Narrows, and Air Ronge are all new census sub-divisions to the 1986 census.

Table 3.4: Communities with the largest changes in FDI between 1981 and 1986.

Community	Province	Change in FDI
Endeavour	Sask	1.0000
Chitek Lake	Sask	0.4088
Togo	Sask	0.3821
Grande Cache	Alb	0.2344
Donnelly	Alb	0.1931
Wembley	Alb	0.1842
Hines Creek	Alb	0.1629
Debden	Sask	0.1414
Pelican Narrows	Sask	0.1229
Mirror	Alb	0.1160
Paddockwood	Sask	0.1012
Sexsmith	Alb	0.0781
Preeceville	Sask	0.0772
Edson	Alb	0.0752
Porcupine Plain	Sask	0.0555
Shellbrook	Sask	0.0536
Kinuso	Alb	0.0480
High Level	Alb	0.0446
Stonewall	Man	0.0386
Whitecourt	Alb	0.0383
Magrath	Alb	-0.0674
The Pas	Man	-0.0736
Sundre	Alb	-0.0796
Manitou	Man	-0.0832
Mayerthorpe	Alb	-0.0944
Boyle	Alb	-0.1020
Hudson Bay	Sask	-0.1022
Maryfield	Sask	-0.1149
Wabamun	Alb	-0.1153
Edam	Sask	-0.1166
Spirit River	Alb	-0.1322
Delburne	Alb	-0.1385
Glaslyn	Sask	-0.1393
Niverville	Man	-0.1393
Wildwood	Alb	-0.1543
Leoville	Sask	-0.2864
Sangudo	Alb	-0.2984
Cowley	Alb	-0.4069
Meath Park	Sask	-0.5547
Smeaton	Sask	-0.5667

communities in this region prior to 1986 is undoubtedly due to the early stages of the expansion.

Among the larger communities with the large decreases in FDI is Hudson Bay, Saskatchewan. During the 1980's Hudson Bay has suffered the phasing-out one of its three mills. Since the 1986 census that company's tenure has been terminated and no new mill has moved in to fill the void.

3. Categories of Dependency

For descriptive purposes it will be useful to segregate communities into categories of degree of dependence. The method as described in Chapter 2 calls for identification of natural breaks in the distribution of communities' forest dependence. If these breaks exist, they may indicate structural differences in the communities. Also, this technique will avoid separating communities which have very similar dependence rankings. Some subjective reasoning will be required to determine the number of categories and the general location of the cut-offs.

Figures 3.1 and 3.2 depict the distribution of FDI in all three provinces for 1981 and 1986. The vertical scale of the figures is the FDI ranking of the community and is primarily a visual aid. The figures show that there are breaks in the distribution. The vertical lines show the cut-offs for the following proposed categories:

- greater than 0.50 FDI, heavily forest dependent community (HFDC)
- between 0.23 and 0.50 FDI, moderately forest dependent community (MFDC)
- between 0.07 and 0.23 FDI, slightly forest dependent community (SFDC)

The placement of individual communities into these categories can be seen in Appendix 2. Table 3.5 shows the number of communities in each province which fall

Figure 3.1 Distribution of all communities' FDI in 1981.

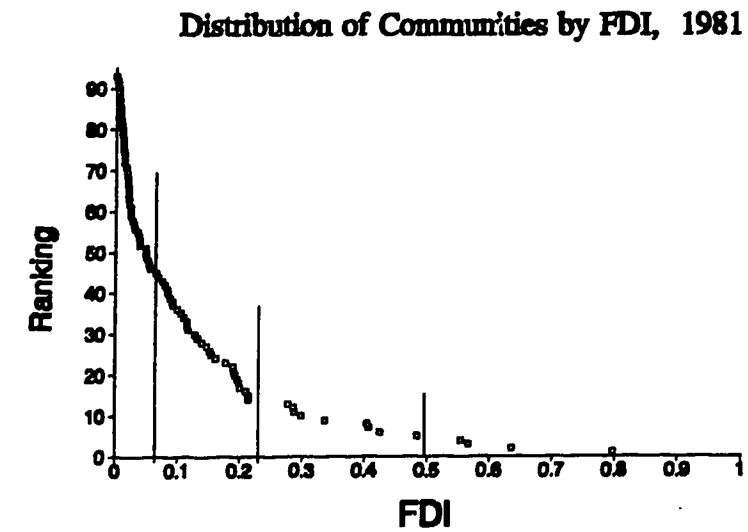


Figure 3.2 Distribution of all communities' FDI in 1986.

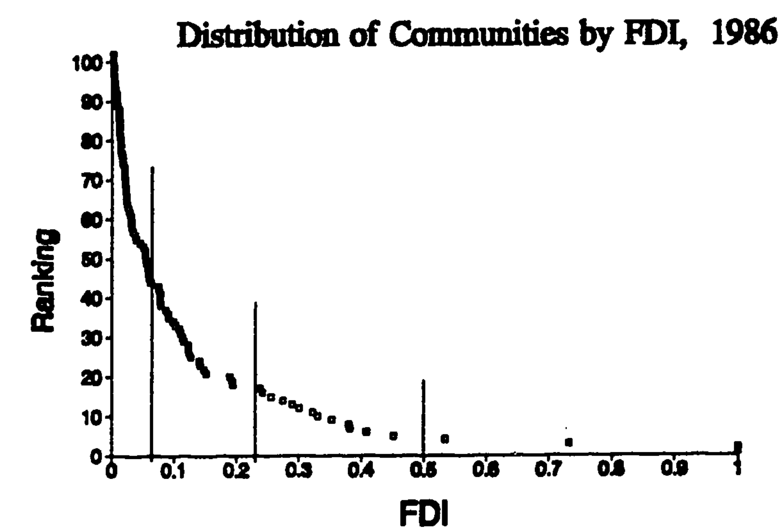


Table 3.5: Number of communities by dependence category and province.

Province	HFDC 1981	HFDC 1986	MFDC 1981	MFDC 1986	SFDC 1981	SFDC 1986
Alberta	0	0	6	8	17	12
Saskatchewan	3	3	2	4	8	11
Manitoba	1	1	1	1	5	3
Total	4	4	9	13	30	26

Abbreviations: HFDC, heavily forest dependent community
MFDC, moderately forest dependent community
SFDC, slightly forest dependent community

into these categories. A familiar trend is evident in Table 3.5. Alberta is different from the other two provinces. Alberta has less HFDCs than Saskatchewan and Manitoba but more MFDCs and SFDCs. The explanation for this difference is the presence of a strong energy sector in the forested region of Alberta. Appendix 2, Table A2.1 shows that in many Alberta communities, particularly Hinton and Whitecourt, a strong forest sector is accompanied by a strong energy sector. The dominance of the energy sector precludes the formation of heavily forest dependent communities in Alberta.

E. Summary and Policy Implications

The goal in this chapter was to present results from the application of an improved method for identifying community dependence on a single sector. The method was applied to the forest sector in the Canadian provinces of Alberta, Saskatchewan and Manitoba. In identifying community dependence on forestry there were no specific hypotheses being tested. The intent was, rather, to describe the nature of this dependence in the prairie provinces.

When communities were segregated into heavily forest dependent communities (HFDCs), moderately forest dependent communities (MFDCs) and slightly forest dependent communities (SFDCs) the results showed that there were only two communities, Hudson Bay, Saskatchewan and Powerview, Manitoba which were classified as HFDCs in both the 1981 and 1986 census years. There were however many cases where forestry, though not dominant, was an important component of the economic structure of the community.

These results, supporting a strong but not dominant forest sector, do not come as a surprise given the strength of other sectors in this region, especially energy and agriculture. In Alberta the forest sector is particularly strong from the provincial perspective, yet there are no HFDCs. One explanation for this result is the energy sector, which dominates the forested region of Alberta, reducing the relative importance of forestry. The high number of MFDCs and SFDCs in Alberta is also consistent with this explanation. The forest sector is a diversifying, rather than a dominant, economic force.

Another important result is the decline in overall forest dependence in all three provinces between 1981 and 1986. This decline was shown to be a result of decreasing forestry employment and increasing employment in other sectors. This increase in presence of the more dominant sectors means forestry's role as a diversifying agent is more important than ever. The decreasing employment trend could have been reversed by the recent expansion in the forest sector, particularly in Alberta. The answer to this question will require further research when the 1991 census data become available.

The results of this chapter are of potential interest to all levels of government, as well as research institutions. For example, further research may be directed toward examining relationships between forest dependence and various sociological and economic characteristics of communities. These results provide a database, upon which research of that nature could build. Governments would find these results useful for targeting policy toward forest dependent communities.

One example of how governments could target policy with this information is through regional development programs. Along similar lines, if policy changes regarding the forest sector were to be undertaken, this information would help to identify which, and to what degree, communities might be affected by shocks to the industry. Governments could also use this information to be more prepared to engage in counter-cyclical programs to alleviate short-run unemployment or other income reduction.

As well as short-run programs, governments may want to aid in long-term adjustments. These long-term adjustments may be necessary after more permanent industry changes such as a timber supply reduction. Knowledge of the economic structure of communities, such as is provided here, will assist policy makers with these problems and help them serve the people of the prairie region of Canada.

Chapter IV: Forest Dependency and Community Welfare

A. Introduction

The previous chapters focused on determination of the degree of community dependence on forestry. The next objective is to investigate the relationship between dependence on the forest industry and the economic well-being of the community. As discussed above, exogenous market shifts may have profound impacts on the community's welfare. It is these impacts which are to be examined here.

The basic hypothesis being tested in this chapter is as follows: As community dependence on the forest sector increases, so too do welfare impacts on the community from shocks to the forest sector. These shocks may be negative shocks, such as a decrease in timber supply, or they may be positive shocks, such as an increase in the price of forest products. If it can be shown that there exists a monotonic relationship between forest dependency, and measured by FDI, and welfare impacts, then a ranking of communities by FDI also represents a ranking of communities by welfare losses or gains from shocks to the forest sector.

The welfare impacts to communities become important when compared to the welfare impacts of these shocks to larger economic unions, particularly provincial and national economies. If, for example, a negative impact of a shock to the forest sector has negligible effects on the macroeconomy but significant welfare effects within a forestry community then the distribution of wealth will be altered. Governments may wish to compensate for such distributional changes through income transfers, industry "safety net" programs or other such measures.

Most of the relevant shocks to a community's economy are either demand shocks or supply shocks. One example of a demand shock which may affect the welfare of a forestry town is a change in world prices of forest products. Prices of forest products are set in international markets and the community faces perfectly elastic demand for its forestry output. A change in world demand will be seen by the community as a change in exogenous output prices. A dominant factor in the determination of forest product prices is fluctuation in demand caused by the business cycle. Volatility in demand causes volatility in prices. Three questions arise from this discussion: What is the welfare change from a price reduction? What is the welfare change from a price increase? If there is a cycle of equal but opposite price changes, do the welfare effects cancel out.

Another type of demand shock is a change in world prices of another of the community's exporting sectors. The prairie provinces depend highly on agriculture (and energy in Alberta) and growth in other sectors is desirable. The government of Alberta has stated publicly that they view the forest sector as a prime candidate for diversification of the provincial economy. If a larger forest sector reduces the welfare impacts to the community of a shock to another sector then the potential for benefits from diversification is supported.

An obvious example of a supply shock is a decrease in available raw timber. There are at least two reasons why a decrease in timber supply is a relevant issue. The first is the popular perception that our forests are being over-harvested and poorly regenerated and should be protected through reduced harvest. Second, following prudent and rational management of first-growth forests, harvest must be reduced as lower volume second-growth stands come on stream.

B. Estimating the Welfare Impacts

There are three aspects to consider in developing a process to estimate the welfare effects on a community of changes in output prices or changes in supply of a factor of production. First, the model must be well grounded in economic theory. Second, the modelling process should represent the actual conditions in the community as closely as possible. The third consideration is the limited availability of data, along with the limited time and financial resources of this project.

A crucial aspect of the entire project is the relationship of a community's forest sector to other sectors in the community. This fact requires that inter-sectoral linkages be represented in the modelling process. Percy *et al* (1989) provide an excellent discussion on the merits of competing modelling processes and they conclude that the best process for representing a multi-sector economy is the general equilibrium (GE) model. GE models are well supported by economic theory. Intersectoral and intrasectoral relationships are specified at the level of individual economic agents and aggregated from the "bottom up" (Percy *et al*, 1989). Also, key neo-classical economic concepts such as changes in relative prices and factor market relationships can be incorporated.

Data and computational requirements of a GE model depend on the modelling frameworks that is employed. If the model is specified in terms of the levels of the variables of interest (ie. their physical quantities) then data requirements can be excessive. Also, important economic relationships are likely to be non-linear and the solution of the model might require complicated computer algorithms and extensive computer time. An alternative is to differentiate relationships and specify the variables by their rate of change rather than by their absolute value. This framework demands less data and, because the relationships are made linear through differentiation, computation is easily done through simple matrix inversion.

C. A General Equilibrium Model of a Regional Economy

The following is a general equilibrium model of a small economy with three sectors and three primary factors of production. The model draws heavily on the work of Percy *et al* (1989), which is a model of a provincial economy. Some direction is also taken from a model by Boyd and Hyde (1989), which models the economy of a single community. There are three sectors in the model; forestry, other tradeable goods, and non-traded goods, including services and the government sector. The three factors of production are labour, capital, and timber.

In specifying the model many assumptions, which are explained at the appropriate time in the description of the specification, are made. These assumptions are of two general types. First, firms and consumers in the community are assumed to follow various behavioural assumptions which arise from economic theory. Important examples of such assumptions used in this model are profit maximization, perfect competition, and linearly homogeneous Cobb-Douglas production functions. Second, assumptions are made to simplify the process. An example of this is the grouping of all firms in the community into three sectors. These assumptions, though perhaps not totally realistic, are necessary if the model is to be practical under existing data and time constraints.

1. Production Functions[1]

The following is a Cobb-Douglas production function for the forest sector:

$$X = A_x L_X^{\theta_{LX}} K_X^{\theta_{KX}} T_X^{\theta_{TX}} Y_X^{\theta_{YX}} Z_X^{\theta_{ZX}}$$

Where X is the output of the forest sector, L_X, K_X, and T_X are labour, capital, and timber respectively used in the production of X. Y_X and Z_X are intermediate inputs of the other traded goods sector and the services and retail sector respectively. Under competition and constant returns to scale the exponents θ_{ix} represent shares of the i^{th} input in the cost of

[1] The following equations (i), (ii) and (iii) are not used in the final matrix because they are linear combinations of the cost functions and input demand functions. They are described here because they are important in understanding how the variables in the model are related.

producing X. A_X is the shift parameter.

Using total differentiation to convert to the rate of change format yields:

$$dX = A_X \theta_{LX} L_X^{\theta_{LX}} K_X^{\theta_{KX}} T_X^{\theta_{TX}} Y_X^{\theta_{YX}} Z_X^{\theta_{ZX}} [\theta_{LX} \frac{dL_X}{L_X} + \theta_{KX} \frac{dK_X}{K_X} + \theta_{TX} \frac{dT_X}{T_X} + \theta_{YX} \frac{dY_X}{Y_X} + \theta_{ZX} \frac{dZ_X}{Z_X}]$$

Substituting X for the term outside the brackets and using the circumflex to indicate proportional change[2] yields:

$$\hat{X} = \theta_{KX}\hat{K}_X + \theta_{LX}\hat{L}_X + \theta_{TX}\hat{T}_X + \theta_{YX}\hat{Y}_X + \theta_{ZX}\hat{Z}_X \qquad \text{(i)}$$

Intuitively, this equation sets the change in output of the sector equal to the average change in inputs, weighted by their shares in the cost of production. There are similar equations for the other traded goods sector, Y, and the service and retail sector, Z, which do not use timber in production:

$$\hat{Y} = \theta_{KY}\hat{K}_Y + \theta_{LY}\hat{L}_Y + \theta_{XY}X_Y + \theta_{ZY}Z_Y \qquad \text{(ii)}$$

$$\hat{Z} = \theta_{KZ}\hat{K}_Z + \theta_{LZ}\hat{L}_Z + \theta_{XZ}X_Z + \theta_{YZ}Y_Z + \theta_{MZ}M_Z \qquad \text{(iii)}$$

The variable M represents imports, which the service and retail sector uses as an input.

2. Cost Functions

Under the assumptions of linearly homogeneous production functions and perfect competition unit costs in a sector will equal the producer's output price. This result stems from the more basic economic relationship that, under the same assumptions, sales receipts equal production costs (Chiang, 1984). With Cobb-Douglas production

---

[2] for example:

$$\hat{X} = \frac{dX}{X}$$

technology, the cost function for the forest sector, X, can be defined as follows[3]:

$$C_X = P_X = \rho_X w^{\theta_{LX}} r_X^{\theta_{KX}} s^{\theta_{TX}} P_Y^{\theta_{YX}} P_Z^{\theta_{ZX}}$$

Where C_X and P_X are the unit cost and price of X, ρ_X is a collection of share parameters[4], w is the wage rate, r_X is the sector-specific capital rental rate, s is the stumpage price, P_Y and P_Z are the prices of intermediate inputs Y, the community's other exporting sector, and Z, the service and retail sector.

Using total differentiation to convert to the rate of change format:

$$dP_X = \rho_X w^{\theta_{LX}} r^{\theta_{KX}} s^{\theta_{TX}} P_Y^{\theta_{YX}} P_Z^{\theta_{ZX}} [\theta_{LX}\frac{dw}{w} + \theta_{KX}\frac{dr_X}{r_X} + \theta_{TX}\frac{ds}{s} + \theta_{YX}\frac{dP_Y}{P_Y} + \theta_{ZX}\frac{dP_Z}{P_Z}]$$

or:

$$\hat{P}_X = \theta_{LX}\hat{w} + \theta_{KX}\hat{r}_X + \theta_{TX}\hat{s} + \theta_{YX}\hat{P}_Y + \theta_{ZX}\hat{P}_Z \qquad (1)$$

This equation describes output and input price changes in the same way that equation (i) described outputs and inputs. Likewise for the other sectors:

$$\hat{P}_Y = \theta_{LY}\hat{w} + \theta_{KY}\hat{r}_Y + \theta_{XY}\hat{P}_X + \theta_{ZY}\hat{P}_Z \qquad (2)$$

$$\hat{P}_Z = \theta_{LZ}\hat{w} + \theta_{KZ}\hat{r}_Z + \theta_{XZ}\hat{P}_X + \theta_{YZ}\hat{P}_Y + \theta_{MZ}P_M \qquad (3)$$

[3] This result is obtained by assuming profit maximization under the constraint of a Cobb-Douglas production function. Using the Lagrangian method, unit cost is solved for as a function of input prices (Baumol, 1977).

[4] See Appendix 3 for description of ρ.

3. Product Markets

The constraint is imposed that product markets must clear. In other words, production in a sector is equal to demand. Total product demand is equal to domestic consumer demand plus intermediate demand by other local sectors plus exports. It is assumed that there is product homogeneity which means that consumers will purchase local products, which in turn means that there are no imports in the two exporting sectors. The relationship is a straightforward adding-up equation:

$$X = X_D + X_Y + X_Z + X_E$$

Assuming that consumer behaviour can be represented by a Cobb-Douglas utility function local demand is as follows:

$$X_D = \alpha_X \frac{I}{P_X}$$

Where α is the product's budget share and I is consumer income. Assuming exporting firms face perfectly elastic external demand for their product, exports are determined residually as the difference between production and local demand. Inserting local demand into the total demand equation and differentiating gives:

$$dX = \frac{\alpha_X}{P_X}dI - \frac{\alpha_X I}{P_x^2}dP_x + dX_Y + dX_Z + dX_E$$

or, in rate of change format:

$$\hat{X} = \gamma_{DX}\hat{I} - \gamma_{DX}\hat{P}_X + \gamma_{YX}\hat{X}_Y + \gamma_{ZX}\hat{X}_Z + \gamma_{EX}\hat{X}_E \qquad (4)$$

Where γ_{ij} is the share of sector j's output going to i. This equation is not of the straightforward weighted average format. Change in consumer demand for forest products is represented by income (a positive income effect) and price (a negative substitution effect). Similarly, the other traded goods sector can be represented as follows:

$$\hat{Y} = \gamma_{DY}\hat{I} - \gamma_{DY}\hat{P}_Y + \gamma_{XY}\hat{Y}_X + \gamma_{ZY}\hat{Y}_Z + \gamma_{EY}\hat{Y}_E \tag{5}$$

In the service sector there are no exports) demand is:

$$\hat{Z} = \gamma_{DZ}\hat{I} - \gamma_{DZ}\hat{P}_Z + \gamma_{XZ}\hat{Z}_X + \gamma_{YZ}\hat{Z}_Y \tag{6}$$

4. Factor Markets

As in any market, the market for factors of production is characterized by demand and supply. A sector's demand for a factor can be derived from the sector's cost function through Shephard's lemma (Henderson and Quandt, 1980). Shephard's lemma describes the unit demand for a factor as the derivative of the cost function with respect to the price of that factor.

a) Labour

The forest sector's demand for labour is the unit demand (found through Shephard's lemma) times the level of production, as follows:

$$\frac{\partial C_X}{\partial w}X = L_X = X\rho_X\theta_{LX}w^{\theta_{LX}-1}r^{\theta_{KX}}s^{\theta_{TX}}P_X^{\theta_{YX}}P_Z^{\theta_{ZX}}$$

Differentiation yields:

$$dL_X = X\rho_X\theta_{LX}w^{\theta_{LX}-1}r^{\theta_{KX}}s^{\theta_{TX}}P_Y^{\theta_{YX}}P_Z^{\theta_{ZX}}[\frac{dX}{X}+(\theta_{LX}-1)\frac{dw}{w}+\theta_{KX}\frac{dr_X}{r_X}+\theta_{TX}\frac{ds}{s}+\theta_{YX}\frac{dP_Y}{P_Y}+\theta_{ZX}\frac{dP_Z}{P_Z}]$$

Substituting L_X for the term outside the brackets gives the final form of the equation:

$$\hat{L}_X = \hat{X} + (\theta_{LX}-1)\hat{w} + \theta_{KX}\hat{r}_X + \theta_{TX}\hat{s} + \theta_{YX}\hat{P}_Y + + \theta_{ZX}\hat{P}_Z \qquad (7)$$

The first part of the right-hand side, X, describes the output effect. As output increases so does demand for an input. The remainder of the equation describes substitution effects. As the price of another input increases then there will be substitution away from that input, resulting in an increase in labour demand. The own-price substitution effect is of the opposite sign. Labour demanded by sectors Y and Z is as follows:

$$\hat{L}_Y = \hat{Y} + (\theta_{LY}-1)\hat{w} + \theta_{KY}\hat{r}_Y + \theta_{XY}P_{\hat{X}} + \theta_{ZY}\hat{P}_Z \qquad (8)$$

$$\hat{L}_Z = \hat{Z} + (\theta_{LZ}-1)\hat{w} + \theta_{KZ}\hat{r}_Z + \theta_{XZ}P_{\hat{X}} + \theta_{YZ}\hat{P}_Y + \theta_{MZ}P_M \qquad (9)$$

The supply of labour in the community is characterized, given the short-run scenario, by a fixed stock of labour. This fixed stock of labour, which includes a natural level of unemployment, is mobile between sectors. The employed labour (L_E) in the three sectors plus the natural level of unemployment (L_U) will equal the fixed labour stock (L_F):

$$L_F = L_E + L_U$$

or, in rate of change format:

$$\theta_{EL}\hat{L}_E + \theta_{UL}\hat{L}_U = 0 \qquad (10)$$

and employed labour is tallied as follows:

$$\hat{L}_E = \theta_{XL}\hat{L}_X + \theta_{YL}\hat{L}_Y + \theta_{ZL}\hat{L}_Z \tag{11}$$

The previous two equations are merely adding up equations. Still required is an equation specifying the relationship between the amount of labour supplied and the wage rate. Assuming labour responds to real wages, labour supply is as follows:

$$L_E = \sigma_L\left(\frac{w}{\alpha_X P_X + \alpha_Y P_Y + \alpha_Z P_Z}\right)$$

where σ_L is the elasticity of supply of labour and α_i is the budget share of the i[th] good. The rate of change format of the equation is:

$$\hat{L}_E = \sigma_L(\hat{w} - \alpha_X\hat{P}_X - \alpha_Y\hat{P}_Y - \alpha_Z\hat{P}_Z) \tag{12}$$

As wages go up, so too does labour supplied. An increase in prices, which is the same as a fall in real wages results in a decrease in labour supplied.

b) Capital

The supply of capital is fixed, immobile between sectors, and fully utilized in the short-run. Since the change in K_X is zero, the demand and supply of capital for a sector can be represented by a single equation:

$$\hat{K}_X = \hat{X} + \theta_{LX}\hat{w} + (\theta_{KX}-1)\hat{P}_X + \theta_{TX}\hat{s} + \theta_{YX}\hat{P}_Y + \theta_{ZX}\hat{P}_Z = 0 \tag{13}$$

and the other sectors:

$$\hat{Y} + \theta_{LY}\hat{w} + (\theta_{KY}-1)\hat{P}_Y + \theta_{XY}P_{\hat{X}} + \theta_{ZY}\hat{P}_Z = 0 \tag{14}$$

$$\hat{Z} + \theta_{LZ}\hat{w} + (\theta_{KZ}-1)\hat{P}_Z + \theta_{XZ}P_{\hat{X}} + \theta_{YZ}\hat{P}_Z = 0 \tag{15}$$

c) Timber

The demand for timber by the forest industry is given as:

$$\hat{T}_X = \hat{X} + \theta_{LX}\hat{w} + \theta_{KX}\hat{r}_X + (\theta_T - 1)\hat{s} + \theta_{YX}\hat{P}_Y + \theta_{ZX}\hat{P}_Z \qquad (16)$$

Supply of timber is:

$$\hat{T}_X = \sigma_T \hat{s} \qquad (17)$$

Where σ_T is the elasticity of supply of timber. This equation, like the labour supply equation, comes from the theoretical definition of elasticity of supply (Henderson and Quandt, 1980). If companies are under strict AAC regulations then σ_T is equal to zero.

d) Imports

The demand for imports by the service and retail sector is of the familiar type. Since P_M is determined outside the community, supply of imports is perfectly elastic and only one equation is required:

$$\hat{M} = \hat{Z} + \theta_{LZ}\hat{w} + \theta_{KZ}\hat{r}_Z + \theta_{XZ}\hat{P}_X + \theta_{YZ}\hat{P}_Y + (\theta_{MZ} - 1)\hat{P}_M \qquad (18)$$

e) Intermediate Inputs

There are demand equations for the six intermediate inputs as follows:

$$\hat{Y}_X = \hat{X} + \theta_{LX}\hat{w} + \theta_{KX}\hat{r}_X + \theta_{TX}\hat{s} + (\theta_{YX} - 1)\hat{P}_Y + \theta_{ZX}\hat{P}_Z \qquad (19)$$

$$\hat{Z}_X = \hat{X} + \theta_{LX}\hat{w} + \theta_{KX}\hat{r}_X + \theta_{TX}\hat{s} + \theta_{YX}\hat{P}_Y + (\theta_{ZX} - 1)\hat{P}_Z \qquad (20)$$

Supply of these intermediate inputs is represented in the product market equations.

$$\hat{X}_Y = \hat{Y} + \theta_{LY}\hat{w} + \theta_{KY}\hat{r}_Y + (\theta_{XY}-1)\hat{P}_X + \theta_{ZY}\hat{P}_Z \qquad (21)$$

$$\hat{Z}_Y = \hat{Y} + \theta_{LY}\hat{w} + \theta_{KY}\hat{r}_Y + \theta_{XY}\hat{P}_X + (\theta_{ZY}-1)\hat{P}_Z \qquad (22)$$

$$\hat{X}_Z = \hat{Z} + \theta_{LZ}\hat{w} + \theta_{KZ}\hat{r}_Z + (\theta_{XZ}-1)\hat{P}_X + \theta_{YZ}\hat{P}_Y + \theta_{MZ}\hat{P}_Z \qquad (23)$$

$$\hat{Y}_Z = \hat{Z} + \theta_{LZ}\hat{w} + \theta_{KZ}\hat{r}_Z + \theta_{XZ}\hat{P}_X + (\theta_{YZ}-1)\hat{P}_Y + \theta_{MZ}\hat{P}_M \qquad (24)$$

5. Consumer Income

Income to the community is the sum of all wages earned by labour plus some returns to capital. The assumption can be made that the capital equity in the exporting industries is held outside the community, while the service sector is owned locally. This assumption is based on the fact that service industries tend to be small, locally owned businesses, while the exporting firms, particularly in forestry, tend to be large companies with their owners residing outside the community. Under this assumption returns to capital in the service industry contribute to community income:

$$\hat{I} = \theta_{EI}\hat{w} + \theta_{EI}\hat{L}_E + \theta_{K_Z I}\hat{r}_Z \qquad (25)$$

6. Other Assumptions

The prices of exported goods are exogenous, while the output price in the non-traded sector is endogenous. A price shock is introduced to the system wherever that price appears in the equations. A supply shock is introduced in equation (17). The change in timber used technically remains an endogenous variable in the model, but the equation is used to fix it at the predetermined level. In this case the change in exogenous prices is zero.

7. Measures of Welfare

A measure of welfare must be specified before this model can be used to make statements about changes in community welfare. Common welfare measures in economic theory are consumer's surplus and producer's surplus (Just *et al*, 1982). These measures are difficult to estimate in a GE model such as the one developed in this chapter. In order to calculate consumer's and producer's surplus demand and supply functions for all goods must be specified. The demand and supply functions used in the model are in differentiated form and only the slope of the functions, not their shapes, are known from the initial equilibrium conditions[5].

A measure of welfare commonly used in GE models is the income earned by factors of production (Boyd and Hyde, 1989). In order to contribute to community welfare the income earned must stay in the community. Wages earned by labour clearly contribute in a direct fashion to community welfare, as these returns constitute income of residents in the community. Returns to capital are not as straightforward. A portion of capital returns would stay in the community. The amount that stays in the community depends on how much equity in the capital is held locally. As stated earlier, an assumption can be made that the service industries are operated by small business owners, and that the exporting industries are owned by larger corporations outside the community. Under this assumption only the capital wealth from the service sector contributes to community welfare. Therefore, community income, as specified in equation (25) is a measure of community welfare.

---

[5] For example, the shape of the forest product supply function must be known to determine what portion of total receipts is producer's surplus and what portion is opportunity cost.

8. Data Requirements

To use this GE model, data are required for the initial sectoral distribution of employment, factor shares in production and budget shares in consumption. The three-sector specification of the model is well suited to using employment data from Chapter 3. Forestry employment is counted directly. Employment in the other traded sector can be determined residually as the remainder of the economic base after forestry. The service and retail sector is taken to be total employment minus economic base employment.

Provincial averages can be used for the factor and budget shares, given the specification of the model. The Cobb-Douglas production and consumption functions imply constant returns to scale and constant shares, *ceteris paribus*, at any level of production. Data regarding averages of budget and consumption shares for the province of Alberta can be found in Percy *et al* (1989). The economic and physical similarities between Alberta and the other two prairie provinces allow the Percy *et al* numbers to be used for all three provinces. The details of these shares are found in Appendix 3.

9. How Shocks are Transmitted Through the Model

Following the chain of events from the initial shock to the end result will provide insight into how the model works as well as changes to other aspects of the community's economy. The following discussion uses a hypothetical community to show how two different shocks, change in output price and change in supply of an input, have similar effects on the local economy, as predicted by this GE model. The changes to endogenous variables are found by inverting the matrix of 25 linear equations described above, then multiplying the inverted matrix by the vector of exogenous impacts.

The change in the price of forest products appears many times in the model. Most times it appears in input demand functions of the other two sectors and is of little consequence, since forestry output is a minor input for these sectors. The equation that matters in introducing the price shock is the forest sector's cost function, equation (1). The decrease in output price causes contraction of the industry leading to reduced demand for inputs, which in turn leads to downward pressure on input prices. This sequence is implicit in the cost function. The most important input in terms of effecting change in the other sectors is labour because it has a large share of input cost and is used by all three sectors. The downward pressure on wages causes sector Y to expand because of the cheaper labour (equation 8). The transfer of labour is not complete, however. With positive, finite elasticity of labour supply some labour will become unemployed (equation 12). Sector Z contracts, despite lower wages, because the decrease in community income caused by the combined effects o[illegible]es and less employment reduce product demand (equation 6). These change[illegible]wn in Table 4.1.

The decrease in timber supply has almost identical effects, in terms of direction of movement, on the economic variables (Table 4.2). The shock is introduced by fixing stumpage supply (equation 17). This change puts downward pressure on output and prices of other forest sector input prices through the stumpage demand relationship (equation 16). The key element is downward pressure on wages which causes changes to the other sectors in much the same fashion as with the price shock.

Table 4.1: Percentage change in endogenous economic variables from a 1% decrease in P_X in a community with 0.400 FDI and 4000 initially employed.

variable	% change	variable	% change
X (forestry output)	-1.486	Z_X (sector Z output used by forestry)	-2.113
Y (other exported output)	0.626	Z_Y (sector Z output used by sector Y)	0.999
Z (service and retail output)	-0.246	M (imports used by sector Z)	-0.619
L_X (labour in forestry)	-2.025	X_B (forestry exports)	-1.921
L_Y (labour in sector Y)	1.089	Y_B (exports by sector Y)	1.406
L_Z (labour in sector Z)	-0.158	w (wages)	-0.461
L_B (employed labour)	-0.158	r_X (capital rental rate in forestry)	-2.486
L_U (unemployed labour)	2.994	r_Y (capital rental rate in sector Y)	0.626
T_X (timber used in forestry)	-1.243	r_z (capital rental rate in sector Z)	-0.619
X_Y (forestry output used by sector Y)	1.626	s (stumpage fees)	-1.243
X_Z (forestry output used by sector Z)	0.381	P_Z (price of sector Z output)	-0.373
Y_X (sector Y output used by forestry)	-2.456	I (community income)	-0.619
Y_Z (sector Y output used by sector Z)	-0.619		

Table 4.2: Percentage change in endogenous economic variables from a 1% decrease in T_X in a community with 0.400 FDI and 4000 initially employed.

variable	% change	variable	% change
X (forestry output)	-0.322	Z_X (sector Z output used by forestry)	-0.273
Y (other exported output)	0.078	Z_Y (sector Z output used by sector Y)	0.127
Z (service and retail output)	-0.033	M (imports used by sector Z)	-0.082
L_X (labour in forestry)	-0.262	X_B (forestry exports)	-0.378
L_Y (labour in sector Y)	0.138	Y_B (exports by sector Y)	0.202
L_Z (labour in sector Z)	-0.020	w (wages)	-0.061
L_B (employed labour)	-0.020	r_X (capital rental rate in forestry)	-0.322
L_U (unemployed labour)	0.413	r_Y (capital rental rate in sector Y)	0.078
T_X (timber used in forestry)	-1.000	r_z (capital rental rate in sector Z)	-0.082
X_Y (forestry output used by sector Y)	0.078	s (stumpage fees)	-0.678
X_Z (forestry output used by sector Z)	0.082	P_Z (price of sector Z output)	-0.049
Y_X (sector Y output used by forestry)	-0.322	I (community income)	-0.082
Y_Z (sector Y output used by sector Z)	-0.082		

D. The Relationship Between FDI and Welfare Impacts

This section uses the GE model to test the hypothesis that there is a positive, monotonic relationship between FDI and the magnitude of welfare impacts from shocks to the forest industry. This test will involve inserting different sectoral employment shares into the model. There are two aspects of a community's economy, FDI and the size of the community (more specifically base/total employment ratio), which influence the sectoral employment shares. In order to understand the importance of each of these factors their welfare impacts are examined in isolation using hypothetical communities.

The shocks simulated here are price and supply shocks. The price shock is a one percent decrease[6] in the world price of forest products. The supply shock is a one percent decrease in available timber. In using this GE model it is important to remember that all relationships have been made linear by the rate of change format. This means that the predictions of the model are more reliable for small changes in exogenous variables. The effects of shocks larger than one percent can be extrapolated linearly, but with decreasing reliability.

Table 4.3 and Figure 4.1 show welfare effects, measured as percentage change in community income, of price and supply shocks. The model predicts that (with constant community size), for both price and supply shocks, there is a nearly linear relationship between FDI and income changes[7]. This relationship supports, but does not confirm, the

---

[6] The model is linear and therefore symmetric. This symmetry means that equal positive shocks will have precisely opposite effects on endogenous variables.

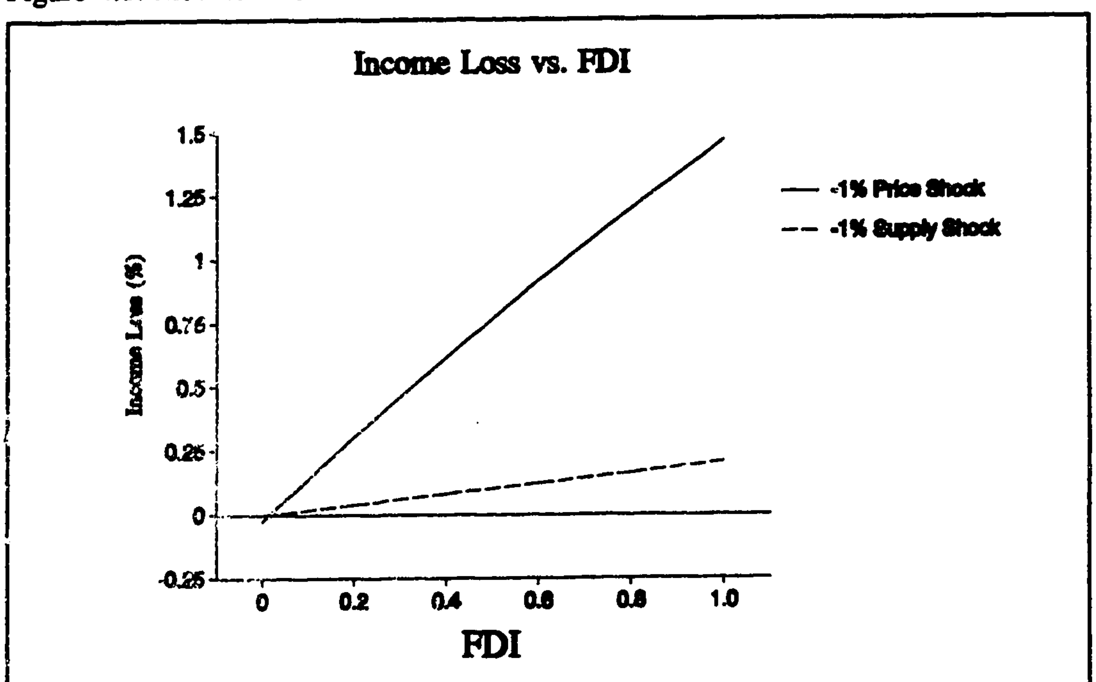
[7] There are two other interesting points about these curves. First, very small FDI results in an income gain (P_X only) because the negative effects to sector X are outweighed by the positive effects (decrease in an input price) to sector Y. Second, they are concave, probably due to the fact that as FDI increases linearly from zero to one, the ratio of the size of sector X to that of sector Y (therefore the ratio of negative effects to positive effects of the price decrease) increases non-linearly from zero to infinity. If the much larger harmful effects increase linearly and the beneficial effects decrease at a decreasing rate, the overall effect is increasing income loss, but at a decreasing rate.

Table 4.3: Income effects of price and supply shocks in a community with 4000 initially employed.

	proportional loss in income (%)	
FDI	P_X = -1%	T_X = -1%
0.0	-0.023	0.000
0.2	0.306	0.041
0.4	0.619	0.082
0.6	0.917	0.124
0.8	1.201	0.165
1.0	1.472	0.206

Where FDI is forest dependence index, P_X is the percentage change in the price of forest products, and T_X is percentage change in timber supply.

Figure 4.1: Income losses vs. FDI.



previously stated hypothesis. It remains to be shown if this monotonicity holds over varying community size. Table 4.4 shows the effects of price and supply shocks for varying levels of community size[8] and fixed FDI. The model predicts that changing community size has no effect on percentage change in income.

If the partial effect of community size on income changes is zero, then welfare impacts from forest sector shocks predicted by this model are strictly monotonic with FDI. This result is important because it means a ranking of communities by FDI (such as the one derived in Chapter 3 and shown in Tables A2.1 and A2.2), also represents a ranking of communities by welfare impacts from forest sector shocks. The further conclusion can be drawn that, in the event of policy changes or external shocks, a ranking of communities by FDI, *ceterus paribus*, also represents a priority ranking for any government intervention which may be undertaken.

---

[8] Total employment is used as a proxy for community size.

Table 4.4: Income effects of price and supply shocks in a community with 0.400 FDI.

Total Employment	proportional change in income (%) P_X = -1%	T_X = -1%
1000	0.619	0.082
2000	0.619	0.082
4000	0.619	0.082
8000	0.619	0.082
16000	0.619	0.082
32000	0.619	0.082

Where FDI is forest dependence index, P_X is the percentage change in the price of forest products and T_X is the percentage change in timber supply.

E. Welfare Impacts of Specific Shocks

This section examines in more detail the welfare impacts of specific shocks which may affect forestry communities. These shocks are: cyclic forest product prices, a price shock to the community's other exporting sector and a decrease in timber supply. These issues are brought into a more realistic context by using real communities as examples and by measuring welfare impacts in dollars rather than in proportional change.

The model predicts proportional changes but, for community income (the current measure of welfare), monetary change can be calculated indirectly. This is done by assuming an initial wage rate[9], and then finding the initial service sector capital returns from their share of community income[10]. Once initial community income is known, the post-shock income is easily found from the changes in the wage rate, employment and the capital rental rate. To enable comparisons between communities of different sizes change in income is given in units of dollars per initial employee per month.

1. Cyclic Forest Product Prices

The first set of simulations (Table 4.5) show the effects that equal but opposite shocks in the price of forest products, such as might occur from the business-cycle, have on the income of communities with different degrees of forest dependence[11]. The price shocks are one percent, positive and negative. Table 4.5 shows the resulting changes in income, as well as the net change.

---

[9] The wage used is $1945.62/month, the 1986 industrial average for Alberta (Alberta Bureau of Statistics, 1990)

[10] For example, if wage income is $1000, θ_{K2I} is 0.3 and service sector capital returns are x, then:

$$x = 0.3(1000 + x); \qquad x = \$428.57$$

[11] Two communities from each forest dependence category (Chapter 3) are shown.

Table 4.5: Welfare effects of symmetric price shocks.

		income change ($/employee/month)		
Community	FDI	P_X = -1	P_X = 1	net
Powerview	0.732	-21.95	21.95	0
Hudson Bay	0.534	-17.26	17.26	0
Hinton	0.379	-12.64	12.64	0
The Pas	0.331	-11.34	11.34	0
Slave Lake	0.142	-4.74	4.74	0
Prince Albert	0.110	-4.04	4.04	0

Where FDI is the forest dependence index and P_X is the percentage change in the price of forest products.

The important result in Table 4.5 is the symmetry of the changes in welfare, suggesting that the effects of cyclic prices cancel out with no net change. This result could have been easily predicted given the symmetric structure of the model. The question of the net welfare effects of cyclic prices is not so easily answered, however, because of the possibility that the elasticity of supply of labour is not symmetric.

The concept of asymmetry in labour supply is well supported in economic literature (McConnell *et al*, 1990; Branson, 1972). The underlying notion is that wages are more flexible upward than downward. If a sector's demand for labour increases, it is easy to increase wages to lure workers away from other sectors. Likewise, it is easy to offer workers a wage increase to keep them. If demand for labour decreases then, in order to maintain previous employment levels, wages would have to fall. This decrease may be less likely to occur than an increase due to labour unions or other barriers.

Table 4.6 shows the welfare impacts of the same symmetric shocks, but using a kinked labour supply curve[12]. There is now a net loss from symmetric price shocks. This result indicates that, under asymmetric labour supply, cyclic instability causes a welfare loss to the community as measured against stable forest product prices[13].

Under continuing cyclic prices, the short-run nature of the model would predict cyclic wages, mirroring the price cycles, but with an increasing trend. The increasing trend is due to a ratchet effect caused by the asymmetric wage flexibility. Conversely,

---

[12] The labour supply curve is steeper for the positive shock ($\sigma_L = 0.2$) than for the negative shock ($\sigma_L = 5$).

[13] Neo-classical economic theory suggests that a consideration in this issue is the degree to which these income changes are anticipated. See Appendix 4 for a brief discussion.

Table 4.6: Welfare effects of symmetric price shocks (P_X) with asymmetric labour supply (σ_L).

		income change ($/employee/month)		
		$\sigma_L = 5$	$\sigma_L = 0.2$	
Community	FDI	$P_X = -1$	$P_X = 1$	net
Powerview	0.732	-30.07	16.42	-13.65
Hudson Bay	0.534	-23.15	13.10	-10.05
Hinton	0.379	-16.68	9.70	-6.98
The Pas	0.331	-14.89	8.74	-6.15
Slave Lake	0.142	-6.11	3.69	-2.42
Prince Albert	0.110	-5.21	3.15	-2.06

Where FDI is forest dependence index, σ_L is elasticity of labour supply and P_X is the percentage change in the price of forest products.

employment would ratchet downward. Over the time period of multiple business cycles (longer than short-run) labour migration would act to keep wage and employment trends level. The important result remains intact: Over any one price cycle there is a net income loss compared to stable prices.

The size of the income loss is directly related to the community's degree of forest dependence. As Table 4.5 shows the average monthly income loss in Powerview, Manitoba (FDI, 0.73) is $13.65[14] compared to $2.06 for Prince Albert, Saskatchewan (FDI, 0.11). Powerview was classed as a heavily dependent community and its income loss is more than six times that of Prince Albert, a slightly dependent community.

These income losses, even in heavily dependent Powerview ($13.65 per employee per month), may seem small but it should be remembered that they are the result of small, one percent, shocks. In reality the shocks may be much larger. In fact, Boyd and Hyde (1989) use an 18 percent price shock[15] to drive their general equilibrium model. If the above result is extrapolated using 18 percent shocks, the result is an income loss of $247.70. This represents over twelve percent of their total income, certainly a significant loss.

2. A Price Shock to the Community's Other Exporting Sector

The prairie provinces are all dependent, at the macroeconomic level, on sectors other than forestry. Alberta is dependent on energy and agriculture, and Saskatchewan and Manitoba both depend on agriculture. Due to instability in these sectors the Alberta

[14] Even though community income was chosen as the measure of welfare, the true welfare loss is probably greater than the dollar figure indicates. Workers who are laid off during the downswing suffer a much greater income loss than those who suffer a small wage decrease. If there is diminishing marginal utility of money then the welfare loss to laid-off workers is greater than the income loss would suggest.

[15] The largest price deviations from the mean over their 14 year study period.

government intends to diversify the provincial economy and has stated that the forest sector is a prime candidate to contribute to this diversification. The model can be modified to show the effect of a stronger forest sector on welfare impacts from cyclic prices in the dominant sector[16].

Crowsnest Pass, Alberta is heavily dependent on the Energy sector (EDI[17], 0.55). Grande Cache, Alberta is moderately dependent on the energy sector (EDI, 0.32) as well as being moderately dependent on the forest sector (FDI, 0.26). Table 4.7 shows the income losses to these communities of cyclic prices in the energy sector[18]. The income loss in Crowsnest Pass is more than double that in Grande Cache, supporting the idea that diversification reduces instability.

3. A Decrease in Timber Supply

The next type of shock to be simulated is a decrease in the supply of timber. As was shown in section IV.D, as FDI increases so too does the loss of welfare to the community. Table 4.8 demonstrates this relationship again, this time with real communities and monetary change in income.

Hudson Bay, Saskatchewan, is a particularly interesting case. In recent years timber supply problems have forced one of Hudson Bay's three processing plants to be shut down. The size of the supply decrease can be estimated (in an admittedly *ad hoc* fashion) by reducing capital by one-third. The model predicts that a 25.32 percent decrease in timber supply would cause a one-third decrease in capital use. Such a

---

[16] Technically speaking this analysis is identical to that in section 4.B.1 but the different context makes it a worthwhile exercise.

[17] Energy Dependence Index. EDI = energy employment / base employment

[18] For the purposes of this analysis FDI and EDI of these communities are adjusted so that they sum to one.

Table 4.7: Welfare effects of symmetric price shocks in the other exporting sector.

	income change ($/employee/month)		
	$\sigma_L = 5$	$\sigma_L = 0.2$	
Community	$P_Y = -1$	$P_Y = 1$	net
Crowsnest Pass	-29.37	16.43	-12.94
Grande Cache	-11.75	5.61	-6.14

Where FDI is forest dependence index, σ_L is elasticity of labour supply and P_Y is the percentage change in the output price of sector Y.

Table 4.8: Welfare effects of a decrease in timber supply.

		income change ($/employee/month)
Community	FDI	$T_x = -1$
Powerview	0.732	-2.99
Hudson Bay	0.534	-2.31
Hinton	0.379	-1.68
The Pas	0.331	-1.51
Slave Lake	0.142	-0.65
Prince Albert	0.110	-0.57

Where FDI is forest dependence index and T_x is the percentage change in timber supply.

decrease in timber supply would, in the short-run, decrease average community income by $227.44/month (10.8%) and put 68 (8.4%) people out of work.

F. Evaluation of Policy

The preceding section outlined various instances where the welfare of certain communities may be adversely affected by shocks to the forest sector. The decision regarding whether or not government intervention is appropriate is a political one. The role of economists in this case is to point out the need for policy and to suggest alternative courses of action.

There are many alternatives governments could undertake in aiding forest dependent communities. Schemes with various tax incentives, subsidies and regulations are innumerable. Three alternatives which stand out as likely candidates are even flow harvest, government funding of forest management, and direct income transfers.

1. Even Flow Harvest

Even flow harvest, or sustained yield, is a concept which has been around almost as long as forestry itself. There are two quite different objectives which advocates of a sustained yield program might hope to achieve. One objective of sustained yield is to ensure a long-run timber supply. The other objective is to promote community stability in the short to medium term. It is the latter objective which is relevant here.

Sustained yield can be simulated by setting the elasticity of timber supply in equation 17 to zero. This will cause the supply of timber, T_X, to remain fixed. Table 4.9 shows the change to community income from constant harvest, using the scenario in Table 4.6 (cyclic prices under asymmetric labour supply) as a base for comparison.

Table 4.9: The effect of constant harvest on cyclic welfare impacts.

		income change ($/employee/month)					
		$\sigma_T = 1$			$\sigma_T = 0$		
		$\sigma_L = 5$	$\sigma_L = 0.2$		$\sigma_L = 5$	$\sigma_L = 0.2$	
Community	FDI	$P_X = -1$	$P_X = 1$	net	$P_X = -1$	$P_X = 1$	net
Powerview	0.732	-30.07	16.42	-13.65	-25.37	14.62	-10.75
Hudson Bay	0.534	-23.15	13.10	-10.05	-19.21	11.33	-7.88
Hinton	0.379	-16.68	9.70	-6.98	-14.21	8.18	-6.03
The Pas	0.331	-14.89	8.74	-6.15	-12.11	7.30	-4.81
Slave Lake	0.142	-6.11	3.69	-2.42	-4.84	2.93	-1.91
Prince Albert	0.110	-5.21	3.15	-2.06	-4.07	2.48	-1.59

Where FDI is forest dependence index, σ_L is elasticity of labour supply, σ_T is the elasticity of timber supply and P_X is the percentage change in the price of forest products.

The results in Table 4.9 demonstrate the model's prediction that constant harvest reduces the magnitude of the income change from both the positive and negative shocks, stabilizing community income. This stabilization has the effect of reducing net income loss from the price cycle. In The Pas, Manitoba, for example, average income loss is reduced by $1.34/month, or 22 percent of the original loss. The model supports the idea that stabilizing timber harvest will, in the short-run, stabilize community income, and in doing so, increase community income under cyclic output prices.

The literature on sustained yield suggests that despite the above result, sustained yield may still be an economically unsound policy. Pearse (1990) expresses a common lament of economists regarding sustained yield:

> "...there is little evidence to support the proposition that an even flow of timber over long periods will promote regional stability ... it is likely instead to retard growth, adaptation to change, and reallocation of resources."

The suggestion is that, though it may have short-run benefits, a constant harvest policy may be a disruptive force over a longer time period. An alternative policy of a regulated flow that is allowed to adjust to economic forces more permanent than the business cycle may be a viable option.

2. Income Transfers

Economic theory suggests that any intervention in market forces, such as imposing sustained yield, results in a decrease in efficiency. Boyd and Hyde (1989) show that constant harvest results in a short-run gain to the community, but an even larger loss outside the community. Losses outside the community in the present model would be a result of decreasing returns to capital in the exporting industries as well as a possible decrease in stumpage returns.

The Boyd and Hyde result suggests that constant harvest is, in effect, an inefficient method of tranferring income from the macroeconomy to the community economy. A more efficient method of income transfer might be direct transfer payments to the community. This type of policy currently exists, not only in forest dependent communities but across Canada, in the form of unemployment insurance (UI).

The effect of an income transfer such as UI can be simulated in the GE model. Using the same base scenario (Table 4.6), the effect of UI can be modelled as payments of 60% of their original wages to workers who become unemployed in the down side of the cycle. Table 4.10 shows the results. As expected, the income loss from instability is substantially reduced over the base scenario. The more important result is that, although UI reduces income loss from instability, it does not totally compensate for it.

This result has implications for policy. If governments intended to compensate communities for economic instabilty then additional aid is required over and above unemployment insurance. The model can be used determine the percentage of income compensation (as opposed to 60 % for UI) that would result in no income loss from instability. The prediction of the model is that compensating laid off workers for 74.5 percent of their original wages results in no income loss from instability. In Hinton, Alberta, for example transfer payments would have to be increased by 19 percent, from a total of $24,603 to $30,503.

3. Subsidizing Investment

Another popular method of supporting the forest industry is government subsidization of forest industry investments. This support may take the form of silvicultural investments such as reforestation, or it may consist of capital investment. The present GE model can simulate this type of support as a capital infusion. The benefits to the forest company may not accrue for many years, but the benefits to the community will be felt immediately through the increased labour supported by the

Table 4.10: The effect of Unemployment Insurance on cyclic welfare impacts.

		income change ($/employee/month)					
		without UI			with UI		
		$\sigma_L = 5$	$\sigma_L = 0.2$		$\sigma_L = 5$	$\sigma_L = 0.2$	
Community	FDI	$P_X = -1$	$P_X = 1$	net	$P_X = -1$	$P_X = 1$	net
Powerview	0.732	-30.07	16.42	-13.65	-19.07	16.42	-2.65
Hudson Bay	0.534	-23.15	13.10	-10.05	-15.18	13.10	-2.08
Hinton	0.379	-16.68	9.70	-6.98	-11.05	9.70	-1.35
The Pas	0.331	-14.89	8.74	-6.15	-10.01	8.74	-1.27
Slave Lake	0.142	-6.11	3.69	-2.42	-4.13	3.69	-0.44
Prince Albert	0.110	-5.21	3.15	-2.06	-3.73	3.15	-0.58

Where FDI is forest dependence index, σ_L is elasticity of labour supply and P_X is the percentage change in the price of forest products.

increase in the capital stock. The following simulation (Table 4.11) again uses the cycle scenario in Table 4.6 as a base for comparison. Also, in order to allow comparison of the effectiveness of money directed to transfer payments and money spent on capital infusion, the dollar value of the capital infusion is equivilant to the UI payments[19] in Table 4.10. The effect of the capital infusion (undertaken during downswings only) is to reduce the income loss from instability. Another interesting result is that this loss reduction is only about 21 percent as that acheived by spending the money on direct transfer payments.

There are other benefits of an increase in capital which do not appear in this analysis. These other benefits include the likelihood that the new capital will not depreciate over one business cycle, and therefore contribute to future community income. Also, increased capital will increase income to those who own it, and in this model owners of forestry capital are outside the community. However, if short-run community income stabilization is the policy goal, these factors do not affect the above result, which is: Money directed toward transfer payments is more effective at reducing income loss from instability than subsidizing capital investment.

---

[19] The dollar value of initial K_X is found as follows:

$$K_X = (w\ L_X\ \theta_{KX})/(r_X\ \theta_{LX})$$

Table 4.11: The effect of a capital infusion on cyclic welfare impacts.

		income change ($/employee/month)					
		without capital infusion			with capital infusion		
		$\sigma_L = 5$	$\sigma_L = 0.2$		$\sigma_L = 5$	$\sigma_L = 0.2$	
Community	FDI	$P_X = -1$	$P_X = 1$	net	$P_X = -1$	$P_X = 1$	net
Powerview	0.732	-30.07	16.42	-13.65	-28.59	16.42	-12.17
Hudson Bay	0.534	-23.15	13.10	-10.05	-21.50	13.10	-8.40
Hinton	0.379	-16.68	9.70	-6.98	-14.90	9.70	-5.20
The Pas	0.331	-14.89	8.74	-6.15	-13.53	8.74	-4.79
Slave Lake	0.142	-6.11	3.69	-2.42	-5.54	3.69	-1.85
Prince Albert	0.110	-5.21	3.15	-2.06	-4.44	3.15	-1.29

Where FDI is forest dependence index, σ_L is elasticity of labour supply and P_X is the percentage change in the price of forest products.

G. Summary

In this chapter a three-sector general equilibrium model was used to investigate how a community's dependence on the forest industry is related to welfare impacts from shocks to the forest sector. The model was used in three ways. First, the model is used to test the hypothesis that there is a positive, monotonic relationship between FDI and welfare impacts under shocks to the forest sector; second, the welfare effects of specific economic scenarios were examined; and third, the relative merits of three policy options, regarding compensation for welfare losses, were examined.

The analysis in section IV.D confirmed the hypothesis of monotonicity between forest dependence (measured by FDI) and welfare changes (measured by community income) from forest sector shocks. This result allows the useful conclusion that a ranking of communities by FDI also represents a ranking of communities by welfare changes from shocks to the forest industry. If governments decide to intervene and reduce welfare losses then, a list of communities ranked by FDI can be used in directing aid to where it is most needed.

Section IV.E investigated welfare implications of specific shocks. One result of this analysis was the conclusion that under asymmetric labour supply and/or diminishing marginal utility of money, cyclic price changes, such as might occur during the business cycle, result in a net welfare loss. In other words under cyclic forest product prices the benefits the upswing do not compensate for the costs of the downswing. Community residents are worse off than under stable prices. The size of the net welfare loss to the community increases with dependence on the forest industry.

In similar analysis, it was demonstrated that welfare losses from cyclic prices in another basic sector are reduced with increasing size of the forest sector in a community.

This result illustrates that decreasing dependence on any industry decreases the community's vulnerability to external shocks.

Another specific shock examined was a decrease in timber supply. An exogenous decrease in timber available to the forest sector was found to negatively impact a community's welfare. The welfare effect is positively related to the community's FDI.

The ultimate goal of this entire project is to help policy makers make better decisions regarding forest dependent communities. This chapter discussed three types of programs which governments may pursue in aiding these communities. They are summarized as follows:

> 1. Even flow harvest may be used to reduce instability from cyclic output prices. The GE model shows that under strict sustained yield there is a reduction in short-run welfare losses resulting from cyclic prices.
>
> 2. Direct income transfers, such as UI, may be used to compensate residents. The model shows that UI does not fully compensate for welfare losses under cyclic prices. For full compensation additional transfers would be required.
>
> 3. Subsidized investment could be used to support the forest industry. The model shows that a capital infusion equal to UI payments has a smaller positive impact on short-run community income. If short-run income stabilization is the policy goal, then dollars spent on income transfers are more effective.

Chapter V. Summary and Recommendations

This research project has three components which are distinct studies and, at the same time, intimately related. First, there is the development of a method for identifying forest dependent communities, followed by implementation of the method on prairie communities. The final component examines the implications of forest dependency to these communities, as well as implications of policy.

In the first component a method for identifying forest dependent communities has been derived. The method is founded in economic base theory and can be implemented at reasonable cost for a large number of communities. The first step is to estimate the economic base of the community, which can be done using the location quotient technique. Next, the forest dependence index (FDI) is calculated as the ratio of forest sector employment to economic base employment. Communities can be ranked by forest sector dependence with this measure.

The following component contains an outline of the method used to identify the degree of forest dependency in all communities of the prairie provinces of Canada. The results showed that there are only two communities, Powerview, Manitoba and Hudson Bay, Saskatchewan, which showed continuing heavy dependence on the forest sector. There are, however, many communities which show moderate or slight forest dependence. Forestry on the prairies does not dominate the economic picture but it is an important diversifying agent.

The final component of the research used a general equilibrium model to estimate the effect that varying degrees of forest dependency have on communities' welfare.

Sectoral distribution of employment was used to predict the welfare effects that forest sector shocks have on communities. The model predicts that welfare changes from forest sector shocks are directly related to (FDI).

The general equilibrium model is also used in policy evaluation. Important results of this evaluation are: sustained yield decreases short-run income losses from output price instability; income transfers decrease losses from instability but unemployment insurance, the standard income transfer method, is insufficient in compensating for losses; capital subsidization decreases income losses from instability but the short-run effect is much less than if the dollars were spent on direct income transfers.

These policy recommendations are based on a general equilibrium model built from economic theory. The author acknowledges that the model has not been confirmed empirically. The model has been provided as a framework for analysis. Future research aimed [illegible]rmation and calibration of this model could result in this framework bec[illegible]al and effective policy tool.

This research could also be extended by expanding the range of policy options examined. The policy options which were modeled in this study are only a few of many available. There are many tax regimes, industry subsidies and regulations which might also benefit forest dependent communities. The framework provided here could be built upon and modified to model virtually any scenario that policy makers may wish to test.

A final recommendation for further research is modification of the somewhat restricting short-run nature of the general equilibrium model. This would allow insight into the effects on forest dependent communities of more permanent forest sector shocks. For example, the long-run effects of the mill closure in Hudson Bay would be an interesting study.

References

Alberta Bureau of Statistics. Alberta Statistical Review: Fourth Quarter 1989. 1990.

Baumol, W.J. Economic Theory and Operations Analysis. Fourth Edition. Prentice-Hall. 1977.

Boyd, R.G. and W.F. Hyde. Forestry Sector Intervention: The Impacts of Public Regulation on Social Welfare. Iowa State University Press. 1989.

Branson, W.H. Macroeconomic Theory and Policy. Harper and Row. 1972.

Canada, Department of Regional Economic Expansion. Single Sector Communities. Canada, Ministry of Supply and Services. 1979.

Chiang, A.C. Fundamental Methods of Mathematical Economics. Third Ed. McGraw-Hill Book Company. 1984.

Christaller, Walter. Central Places in Southern Germany. (C. Baskin, trans.) Englewood Cliffs, N.J.; Prentice Hall. 1966.

Gibson, L.J. and M.A. Worden. "Estimating the Economic-Base Multiplier: A Test of Alternative Procedures," Economic Geography, 57 (1981), 146-159.

Henderson, J.M. and R.E. Quandt. Microeconomic Theory: A Mathematical Approach. Third Edition. McGraw-Hill. 1980.

Isserman, A.M. "The Location Quotient Approach to estimating Regional Economic Impacts," American Institute of Planners Journal. 43 (1977) 33-41.

Just, R.E., D.L. Hueth and A. Schmitz. Applied Welfare Economics and Public Policy. Englewood Cliffs, N.J., Prentice-Hall Inc. 1982.

McConnell, C.R., S.L. Brue and W.H. Pope. Macroeconomics. 5th Canadian Edition. McGraw-Hill Ryerson Limited. 1990.

Pearse, Peter H. Introduction to Forestry Economics. University of British Columbia Press. 1990.

Percy, M., L. Constantino, B. Gellner, S. Jennings, and W. Phillips. ALTIM 1.0: The Specification of a General Equilibrium Model of the Alberta Forest Sector. Department of Rural Economy (University of Alberta) Staff Paper 89-5. FEPA Working Paper 123. 1989.

Pharand, Nicole L. Forest Sector Dependent Communities in Canada: A Demographic Profile. Labour Market Development Branch, Canadian Forestry Service, DPC-X-23. 1988.

Pleeter, Saul. "Methodologies of Economic Impact Analysis: An Overview," Economic Impact Analysis: Methodology and Applications. Martinus Nijhoff Publishing. 1980.

Richardson, Harry W. "Input-Output and Economic-Base Multipliers: Looking Backward and Forward," Journal of Regional Science, 25 (1985), 607-658.

Schallau, C.H., W. Maki and J.H. Beuter. "Economic Impact Projections for Alternative Levels of Timber Production in the Douglas Fir Region". The Annals of Regional Science. 3 (1), 1969, 96-106.

Schwartz, H. A Guide to Regional Multiplier Estimation. Canada, Department of Regional Economic Expansion. 1982.

Steele, T.W., D.M. Boylen, and A. Baumgartner. Saskatchewan's Forest Industry, 1985. Canadian Forestry Service, NOR-X-295. 1988.

Tiebout, C.M. The Community Economic Base Study. Suppl. Paper 16, Community Economic Development, New York. 1962.

Weimer, Arthur M. and Homer Hoyt. "Economic Base Analysis," Principles of Real Estate. Ch. 18, 3rd Ed. 1954.

White, W., B. Netzel, S. Carr and G.A. Fraser. Forest Sector Dependence in Rural British Columbia, 1971-1981. Pacific Forestry Centre, Canadian Forestry Service, BC-X-278. 1986.

Appendix 1. The Location Quotient's Ability to Measure the Size of the Economic Base

Figure A1.1 plots the base/total employment ratio (measured by the location quotient) versus total employment in the community. As expected from the discussion in Chapter 2, there is an inverse relationship. Using logarithmic transformations of both variables a regression line is fitted. For regression purposes the base/total ratio was adjusted downwards so that the fitted line could converge to a positive minimum value instead of converging to zero[1].

A relationship between residuals from this regression and the characteristics of the communities would indicate that using the economic base measured by the LQ would be preferred to using the predicted value from the regression. If there is no relationship or pattern of any kind to the residuals then the size of the economic base predicted by the regression would be preferred to the individual economic base measured by the LQ. Table A1.1 shows all residuals plus or minus two standard deviations from zero.

Examination of these results requires some subjective and qualitative interpretation. An argument was put forth in Chapter 2 that was based on central place theory. This argument stated that a community with a high place in the hierarchy of communities would have a lower base/total ratio than would be expected from its population, and vice-versa for communities low in the hierarchy. Many of the communities with the large

---

[1] The regression line converges to 0.15. This was determined by iteration, maximizing R^2. The regression equation is:

$$\ln(\text{ratio} - 0.15) = 1.284 - 0.3669\ln(\text{total employment}); \quad R^2 = 0.857$$

Figure A1.1: Base/total employment ratio vs. total employment.

Table A1.1: Communities with high *employment ratio vs. population* residuals.

Community	Residual
Fort MacMurray	.5710
Hinton	.5410
Leaf Rapids	.5258
Thompson	.4619
Grande Cache	.4584
Flin Flon	.4396
Swan Hills	.4297
Snow Lake	.4228
Fox Creek	.4109
Cold Lake	.3460
Grand Centre	.3305
Crowsnest Pass	.3103
Spruce Grove	-.3053
Innisfail	-.3056
Swift Current	-.3098
Tisdale	-.3556
Brandon	-.4463
Airdrie	-.5164
Grande Prairie	-.5430
St. Albert	-.6642
Medicine Hat	-.6767

negative residuals, particularly Medicine Hat, Grande Prairie, Brandon, and Swift Current are regional service centres with a large outlying population below them on the hierarchy. Many of the communities with the large positive residuals, particularly Fort MacMurray, Leaf Rapids, Thompson, Flin Flon, Snow Lake, Swan Hills, and Fox Creek, are isolated communities with very sparse population in outlying areas.

These results are entirely consistent with the hierarchy of communities hypothesis. The location quotient technique is sensitive to such differences in communities, and its use in this instance is supported.

Appendix 2. A List of All Prairie Communities With Some Forestry Employment

Abbreviations used in this appendix are as follows:

prov	Province
A	Alberta
S	Saskatchewan
M	Manitoba
CD	Census subdivision
Tot Emp	Total employment
Base	Total base employment
For	Basic employment in forestry. SIC #'s 031, 039,251-259,271-274
SIC	Standard Industrial Classification
FDI	Forest dependence index
Ag	Basic agriculture employment SIC #'s 001-021,101,103,104,105,106
Min	Basic mining employment SIC #'s 051-052,057-059,071-073,099
En	Basic energy employment SIC #'s 061,064,096,365,369
FH&T	Basic employment in fishing, hunting and trapping. SIC #'s 041,045,047

The forest dependency category cutoffs described in Chapter 3 are indicated by the horizontal lines in Tables A2.1 and A2.2.

Table A2.1: A list of all prairie communities with some forestry employment. 1981.

COMMUNITY	PROV	CD	TOT EMP	BASE	FOR	AG	EN	MIN	FH&T	HYDRO	FDI
POWERVIEW	M	1	250	219.3	174.9	0.0	0.0	0.0	0.0	0.0	0.7974
HUDSON BAY	S	14	900	575.4	366.3	9.1	0.0	0.0	0.0	0.0	0.6365
SMEATON	S	14	40	35.1	19.9	6.0	0.0	0.0	0.0	0.0	0.5667
MEATH PARK	S	15	20	18.0	10.0	8.0	0.0	0.0	0.0	0.0	0.5547
BIG RIVER	S	16	220	183.9	89.1	0.0	0.0	0.0	9.9	0.0	0.4846
HINTON	A	14	4040	1951.9	829.0	10.6	582.7	0.0	0.0	0.0	0.4247
COWLEY	A	3	85	73.6	29.9	0.0	0.0	0.0	0.0	0.0	0.4069
THE PAS	M	21	2875	1332.5	538.5	0.0	0.0	0.0	0.0	0.0	0.4041
MAYERTHORPE	A	13	440	308.4	103.9	0.0	0.0	24.7	0.0	0.0	0.3358
SANGUDO	A	13	75	66.8	19.9	0.0	0.0	0.0	0.0	0.0	0.2984
GRANDE PRAIRIE	A	15	13160	3805.7	1094.2	8.7	0.0	402.5	0.0	76.7	0.2875
LEOVILLE	S	16	85	69.2	19.8	21.5	0.0	0.0	0.0	0.0	0.2864
HIGH LEVEL	A	15	1055	590.7	164.1	0.0	0.0	47.4	0.0	9.9	0.2779
GLASLYN	S	17	160	115.8	24.9	4.0	0.0	0.0	0.0	0.0	0.2146
NIVERVILLE	M	2	390	274.5	58.7	9.6	0.0	0.0	0.0	0.0	0.2139
BOYLE	A	13	185	141.8	29.8	3.5	0.0	0.0	0.0	0.0	0.2106
WHITECOURT	A	13	2735	1269.1	253.9	12.0	133.4	247.3	0.0	6.8	0.2001
PADDOCKWOOD	S	15	55	50.0	10.0	0.0	0.0	0.0	0.0	0.0	0.1996
SLAVE LAKE	A	15	2045	970.2	190.2	0.0	44.2	210.5	0.0	30.2	0.1960
STEINBACH	M	2	2845	1331.5	256.0	96.3	0.0	0.0	0.0	0.0	0.1923
CHOICELAND	S	14	125	103.7	19.7	37.5	0.0	0.0	0.0	0.0	0.1904
HINES CREEK	A	15	150	131.3	24.9	0.0	0.0	23.2	0.0	0.0	0.1895
SUNDRE	A	6	610	384.5	68.5	0.0	63.4	0.0	0.0	7.1	0.1780
PRINCE ALBERT	S	15	14505	4280.4	693.0	8.3	0.0	0.0	0.0	0.0	0.1619
WILDWOOD	A	14	70	64.0	9.9	0.0	0.0	0.0	0.0	0.0	0.1543
HIGH PRAIRIE	A	15	1070	553.6	84.1	0.0	14.7	0.0	0.0	0.0	0.1520
KINUSO	A	15	115	101.7	14.9	16.0	23.9	0.0	0.0	0.0	0.1466
DELBURNE	A	8	140	105.5	14.6	0.0	0.0	13.3	0.0	0.0	0.1385
SPIRIT RIVER	A	15	445	291.6	38.6	29.5	10.7	0.0	0.0	0.0	0.1322
MAGRATH	A	3	385	266.1	33.9	31.6	0.0	0.0	0.0	0.0	0.1276
EDAM	S	17	100	84.0	9.8	35.0	0.0	0.0	0.0	0.0	0.1166
WABAMUN	A	11	200	173.2	20.0	0.0	29.1	0.0	0.0	79.0	0.1153
MARYFIELD	S	1	105	85.1	9.8	24.5	0.0	0.0	0.0	0.0	0.1149
CARROT RIVER	S	14	365	224.1	24.8	13.4	0.0	20.0	0.0	0.0	0.1106
WEMBLEY	A	15	320	229.1	24.2	3.8	11.9	31.2	0.0	0.0	0.1056
CROWSNEST PASS	A	9	2955	1521.7	151.3	0.0	792.4	0.0	0.0	0.0	0.0994
ROBLIN	M	16	550	321.7	29.8	11.5	0.0	0.0	0.0	5.0	0.0925
SMOKY LAKE	A	12	295	214.8	19.5	19.7	2.6	0.0	0.0	0.0	0.0910
SWAN RIVER	M	20	1285	599.4	52.1	0.0	0.0	0.0	0.0	0.0	0.0869
BARRHEAD	A	13	1420	694.5	58.8	60.7	26.4	0.0	0.0	8.2	0.0847
MANITOU	M	4	245	179.3	14.9	44.2	0.0	0.0	0.0	0.0	0.0832
COCHRANE	A	6	1595	632.7	50.5	18.3	107.7	0.0	0.0	12.3	0.0798
MEADOW LAKE	S	17	1460	681.3	51.1	0.0	0.0	0.0	0.0	0.0	0.0751
LLOYDMINSTER (PART)	A	10	4805	1621.9	110.4	26.7	212.0	317.5	0.0	26.9	0.0681
ROCKY MT. HOUSE	A	8	2215	965.5	63.7	0.0	304.0	33.5	0.0	4.3	0.0660
HYTHE	A	15	215	161.9	10.0	12.5	0.0	0.0	0.0	0.0	0.0615
LA RONGE	S	18	1255	747.7	40.8	0.0	0.0	34.3	0.0	6.7	0.0545
CLARESHOLM	A	3	1310	688.5	36.4	42.5	2.4	0.0	0.0	3.7	0.0528
FAIRVIEW	A	15	1225	576.9	29.0	7.2	23.3	10.3	0.0	0.0	0.0503
EDSON	A	14	2820	1290.7	63.0	0.0	387.8	91.3	14.8	0.0	0.0488
STE. ANNE	M	2	420	281.5	13.7	0.0	0.0	0.0	0.0	0.0	0.0486

COMMUNITY	PROV	CD	TOT EMP	BASE	FOR	AG	EN	MIN	FH&T	HYDRO	FDI
BEAVERLODGE	A	15	795	422.3	16.4	27.2	0.0	10.5	0.0	0.0	0.0389
LAC LA BICHE	A	12	880	485.0	18.6	0.0	2.9	19.5	0.0	0.0	0.0384
FORT MACLEOD	A	3	1920	921.1	34.5	30.0	0.0	0.0	0.0	0.0	0.0375
RIVERS	M	7	340	248.9	8.9	15.5	0.0	0.0	0.0	0.0	0.0359
VALLEYVIEW	A	15	805	447.9	13.8	0.0	53.3	45.4	0.0	0.0	0.0307
LLOYDMINSTER (PART)	S	17	2895	1423.4	41.2	0.0	270.4	248.1	0.0	0.0	0.0290
OKOTOKS	A	6	1705	697.0	18.5	25.8	18.1	0.0	0.0	0.0	0.0265
SPRUCE GROVE	A	11	4730	1417.0	34.6	20.0	21.1	3.4	0.0	57.2	0.0244
CREIGHTON	S	18	775	559.9	13.4	0.0	0.0	309.0	0.0	0.0	0.0239
PEACE RIVER	A	15	2710	1099.2	25.8	0.0	0.0	7.6	0.0	27.0	0.0235
GRANDE CACHE	A	15	2115	1392.4	29.7	0.0	1036.0	15.0	0.0	54.8	0.0213
CALGARY	A	6	341105	50465.1	1069.0	125.3	10430.5	21.2	0.0	0.0	0.0212
NIPAWIN	S	14	1715	686.5	14.0	71.3	0.0	0.0	0.0	13.7	0.0204
MORINVILLE	A	11	1855	735.4	14.9	17.5	6.9	0.0	0.0	6.1	0.0202
YORKTON	S	9	7015	2311.6	45.8	51.2	0.0	0.0	0.0	0.0	0.0198
CARMAN	M	3	740	409.5	7.7	58.4	0.0	0.0	0.0	0.0	0.0187
AIRDRIE	A	6	3980	1269.4	23.6	20.3	50.7	0.0	0.0	35.9	0.0186
MOOSE JAW	S	7	15470	4892.5	89.8	72.7	34.6	0.0	0.0	0.0	0.0184
TISDALE	S	14	1105	578.7	9.6	13.9	0.0	0.0	0.0	22.7	0.0166
FLIN FLON (PART)	M	21	3610	2044.3	33.4	21.1	18.8	1176.0	0.0	0.0	0.0163
WINNIPEG	M	11	296075	35412.1	481.0	595.9	67.6	6.8	33.6	0.0	0.0136
REDCLIFF	A	1	1640	787.6	10.5	27.7	0.0	35.4	0.0	0.0	0.0133
BONNYVILLE	A	12	1770	705.7	9.2	12.0	38.4	3.8	0.0	0.0	0.0130
HIGH RIVER	A	6	1905	770.6	9.1	42.6	11.7	0.0	0.0	0.8	0.0118
PINCHER CREEK	A	3	1715	755.1	8.6	13.1	221.3	49.5	0.0	1.7	0.0114
WESTLOCK	A	13	1755	780.5	8.6	0.0	33.2	4.0	0.0	6.6	0.0110
SELKIRK	M	13	4325	1901.2	20.6	0.0	0.0	0.0	22.6	55.5	0.0108
CANMORE	A	9	2270	1139.0	11.5	0.0	0.0	0.0	0.0	14.1	0.0101
CAMROSE	A	10	5760	1767.8	17.3	61.3	19.8	0.0	0.0	42.3	0.0098
WINKLER	M	3	1990	954.3	8.7	98.2	0.0	0.0	0.0	0.0	0.0091
FORT MCMURRAY	A	12	16385	6544.2	54.7	2.2	4591.9	6.1	0.0	0.0	0.0084
SWIFT CURRENT	S	8	7130	2054.6	15.7	29.6	45.5	35.8	0.0	22.9	0.0076
DRAYTON VALLEY	A	11	2305	1126.5	8.1	0.0	300.7	182.4	0.0	3.9	0.0072
EDMONTON	A	11	305455	43285.9	303.5	1472.3	176.4	64.7	0.0	0.0	0.0070
ST. ALBERT	A	11	16785	3421.7	18.4	24.0	0.0	0.0	0.0	0.0	0.0054
SASKATOON	S	11	79050	20155.1	105.7	882.1	5.5	92.6	10.3	0.0	0.0052
MORDEN	M	3	1885	802.0	4.0	56.1	0.0	0.0	0.0	0.0	0.0050
REGINA	S	6	84840	21945.2	101.2	259.8	225.8	0.0	0.0	389.0	0.0046
LETHBRIDGE	A	2	27615	6893.0	28.6	732.5	0.0	0.0	0.0	0.0	0.0042
NORTH BATTLEFORD	S	16	6400	1990.8	6.6	9.8	0.0	0.0	0.0	0.0	0.0033
LEDUC	A	11	5930	1836.7	3.6	23.6	101.1	114.0	0.0	0.0	0.0020
MEDICINE HAT	A	1	19600	5037.8	0.8	145.9	197.1	135.5	0.0	0.0	0.0002

Table A2.2: A list of all prairie communities with some forestry employment. 1986.

COMMUNITY	PROV	CD	TOT EMP	BASE	FOR	AG	EN	MIN	FH&T	HYDRO	FDI
ENDEAVOUR	S	9	15	15.0	15.0	0.0	0.0	0.0	0.0	0.0	1.0000
ALBERTVILLE	S	15	10	10.0	10.0	0.0	0.0	0.0	0.0	0.0	1.0000
POWERVIEW	M	1	200	170.6	124.9	0.0	0.0	0.0	0.0	0.0	0.7322
HUDSON BAY	S	14	815	481.5	257.3	8.7	0.0	0.0	0.0	0.0	0.5343
BIG RIVER	S	16	265	208.9	94.3	0.0	0.0	0.0	0.0	0.0	0.4515
CHITEK LAKE	S	16	25	24.3	9.9	0.0	0.0	0.0	0.0	0.0	0.4088
TOGO	S	9	30	26.1	10.0	7.1	0.0	0.0	0.0	0.0	0.3821
HINTON	A	14	4370	2286.9	867.1	4.8	769.1	0.0	0.0	0.0	0.3792
HINES CREEK	A	17	185	154.7	54.5	8.5	0.0	23.1	0.0	0.0	0.3524
THE PAS	M	21	3005	1389.0	459.1	0.0	0.0	0.0	0.0	0.0	0.3305
HIGH LEVEL	A	17	1500	787.9	254.1	0.0	51.0	94.5	0.0	0.0	0.3225
PADDOCKWOOD	S	15	60	49.6	14.9	9.2	0.0	0.0	0.0	0.0	0.3008
WEMBLEY	A	19	355	221.2	64.1	7.5	0.0	16.3	0.0	0.0	0.2898
GRANDE PRAIRIE	A	19	14235	3358.3	923.1	0.7	72.5	448.0	8.9	6.1	0.2749
GRANDE CACHE	A	18	1615	1011.2	258.6	0.0	324.1	0.0	0.0	37.2	0.2557
MAYERTHORPE	A	13	375	246.1	59.6	1.8	0.0	6.1	0.0	0.0	0.2424
WHITECOURT	A	13	2845	1357.7	323.7	0.0	242.6	135.6	0.0	0.0	0.2384
KINUSO	A	17	85	76.7	14.9	0.0	0.0	0.0	0.0	0.0	0.1946
DONNELLY	A	19	155	128.7	24.9	0.0	0.0	0.0	0.0	0.0	0.1931
HIGH PRAIRIE	A	17	1180	590.3	111.8	0.0	0.0	0.0	0.0	0.0	0.1894
STEINBACH	M	2	3480	1492.6	226.5	88.0	0.0	0.0	0.0	1.0	0.1518
CARROT RIVER	S	14	330	232.9	34.4	43.0	0.0	0.0	0.0	0.0	0.1478
SLAVE LAKE	A	17	2660	1187.0	168.2	0.0	157.5	172.5	0.0	32.1	0.1417
DEBDEN	S	16	80	69.6	9.8	0.0	0.0	0.0	0.0	0.0	0.1414
CHOICELAND	S	14	95	76.9	9.8	0.8	14.5	0.0	0.0	0.0	0.1275
EDSON	A	14	3530	1446.3	179.3	10.8	371.3	53.5	0.0	0.0	0.1240
ROBLIN	M	16	700	435.5	53.7	59.3	14.6	0.0	0.0	0.0	0.1233
PELICAN NARROWS	S	18	90	80.5	9.9	0.0	0.0	0.0	0.0	0.0	0.1229
MIRROR	A	8	95	85.8	10.0	16.5	9.1	0.0	0.0	0.0	0.1160
MEADOW LAKE	S	17	1495	670.3	75.7	6.9	0.0	8.1	0.0	0.0	0.1129
PRINCE ALBERT	S	15	15755	4463.3	491.3	36.3	0.0	60.5	0.0	0.0	0.1101
BOYLE	A	13	180	136.6	14.8	13.7	0.0	0.0	0.0	0.0	0.1086
DENARE BEACH	S	18	110	96.3	9.9	0.0	0.0	25.0	0.0	0.0	0.1025
SUNDRE	A	6	685	399.9	39.4	0.0	49.7	17.9	0.0	6.7	0.0984
SMOKY LAKE	A	12	280	212.1	19.5	14.7	0.0	0.0	0.0	0.0	0.0920
BUFFALO NARROWS	S	18	400	271.3	24.5	0.0	0.0	9.1	9.9	0.0	0.0904
AIR RONGE	S	18	200	170.1	14.8	0.0	0.0	0.0	0.0	0.0	0.0867
COCHRANE	A	6	1970	850.3	67.2	12.7	33.3	0.0	0.0	30.5	0.0790
SEXSMITH	A	19	465	314.6	24.6	0.0	10.7	0.0	0.0	0.0	0.0781
CROWSNEST PASS	A	15	2945	1434.2	111.9	24.6	774.3	0.0	0.0	0.0	0.0780
PREECEVILLE	S	9	370	249.5	19.3	14.1	0.0	0.0	0.0	0.0	0.0772
GLASLYN	S	17	170	131.9	9.9	18.5	0.0	0.0	0.0	0.0	0.0753
NIVERVILLE	M	2	550	376.0	28.0	100.9	0.0	0.0	0.0	0.0	0.0746
SWAN RIVER	M	20	1495	676.2	42.2	21.2	0.0	0.0	0.0	0.0	0.0625
ROCKY MT. HOUSE	A	9	2480	1018.3	62.1	0.0	348.0	74.4	0.0	0.0	0.0610
MAGRATH	A	3	480	319.0	19.2	65.2	0.0	0.0	0.0	0.0	0.0602
VALLEYVIEW	A	18	825	487.0	28.5	0.0	40.8	66.5	0.0	16.0	0.0586
FORT MACLEOD	A	3	1255	597.6	34.6	9.8	0.0	0.0	0.0	0.0	0.0580
PORCUPINE PLAIN	S	14	265	174.2	9.7	24.3	0.0	0.0	0.0	0.0	0.0555
LA LOCHE	S	18	335	264.8	14.6	0.0	0.0	0.0	14.9	0.0	0.0551
CLARESHOLM	A	3	1350	704.2	37.8	2.4	22.4	0.0	0.0	0.0	0.0536

COMMUNITY	PROV	CD	TOT EMP	BASE	FOR	AG	EN	MIN	FH&T	HYDRO	FDI
SHELLBROOK	S	16	300	179.9	9.6	15.9	0.0	0.0	0.0	0.0	0.0536
BARRHEAD	A	13	1555	763.7	38.5	60.6	5.5	0.0	0.0	7.5	0.0505
ILE-A-LA-CROSSE	S	18	275	208.5	9.7	0.0	0.0	14.4	14.9	0.0	0.0463
STONEWALL	M	14	855	439.6	17.0	0.0	0.0	0.0	0.0	0.0	0.0386
FALHER	A	19	370	247.8	9.4	46.6	0.0	0.0	0.0	0.0	0.0379
ATHABASCA	A	13	785	419.7	14.3	0.0	32.7	0.0	0.0	16.2	0.0340
LLOYDMINSTER (PART)	A	10	5270	1730.8	55.4	13.7	383.2	210.6	0.0	4.5	0.0320
AIRDRIE	A	6	5010	1310.3	40.6	34.9	53.1	13.2	0.0	15.8	0.0310
MARTENSVILLE	S	11	840	461.6	14.1	18.7	0.0	0.0	0.0	0.0	0.0306
MORDEN	M	3	2150	897.8	27.4	66.0	0.0	0.0	0.0	7.1	0.0305
DRUMHELLER	A	5	2735	1001.1	27.9	21.7	9.5	0.0	0.0	21.8	0.0279
PEACE RIVER	A	19	3215	1136.0	29.3	0.0	0.0	26.8	0.0	39.4	0.0258
DRAYTON VALLEY	A	11	2625	1207.6	29.2	0.0	354.7	272.9	0.0	7.3	0.0242
CANORA	S	9	845	398.1	9.1	66.2	0.0	0.0	0.0	5.2	0.0229
INNISFAIL	A	8	2535	867.2	19.7	51.0	47.1	0.0	0.0	0.0	0.0227
LAC LA BICHE	A	16	1110	586.0	13.0	0.0	0.0	28.5	0.0	0.0	0.0223
LA RONGE	S	18	1120	617.0	13.6	10.7	0.0	27.2	9.8	13.6	0.0221
BOISSEVAIN	M	5	600	375.3	7.9	83.7	0.0	0.0	0.0	0.0	0.0210
BONNYVILLE	A	12	2425	997.4	20.7	0.0	120.1	100.0	0.0	8.3	0.0208
FAIRVIEW	A	19	1355	669.0	13.7	97.3	47.4	1.0	0.0	3.4	0.0205
CREIGHTON	S	18	660	423.0	8.7	0.0	0.0	0.0	0.0	0.0	0.0205
GRIMSHAW	A	19	995	493.5	9.8	0.0	0.0	4.7	0.0	0.0	0.0199
WINKLER	M	3	2370	1070.8	19.7	99.9	0.0	0.0	0.0	0.0	0.0184
KILLARNEY	M	5	745	417.0	7.3	73.2	0.0	0.0	0.0	8.8	0.0176
THREE HILLS	A	5	915	496.0	8.4	57.8	0.0	0.5	0.0	0.0	0.0169
SPRUCE GROVE	A	11	5775	1705.7	25.5	17.6	0.0	0.0	0.0	77.1	0.0149
LLOYDMINSTER (PART)	S	17	3535	1512.5	22.0	0.0	297.8	178.6	0.0	0.0	0.0145
ALTONA	M	3	1070	576.3	8.1	51.3	0.0	0.0	0.0	0.0	0.0140
STONY PLAIN	A	11	2355	922.9	12.8	8.8	61.4	5.7	0.0	63.6	0.0138
HIGH RIVER	A	6	2155	883.2	11.4	46.6	0.0	0.0	0.0	4.6	0.0130
REDCLIFF	A	1	1545	787.9	9.7	55.6	30.6	39.0	0.0	0.0	0.0124
CALGARY	A	6	365470	53166.2	652.6	184.8	11395.5	7.4	18.7	0.0	0.0123
DAUPHIN	M	17	3640	1223.2	14.7	64.8	0.0	0.0	0.0	0.0	0.0120
CANMORE	A	15	2185	1062.8	12.5	0.0	0.0	0.0	0.0	4.4	0.0118
MOOSE JAW	S	7	15880	4399.7	48.3	91.2	57.3	0.0	0.0	0.0	0.0110
THOMPSON	M	22	7350	3238.4	35.7	0.0	0.0	1463.4	0.0	18.6	0.0110
WINNIPEG	M	11	313710	37704.8	411.8	585.2	38.8	0.0	10.5	0.0	0.0109
FLIN FLON (PART)	M	21	3160	1659.9	14.3	0.0	0.0	161.7	0.0	0.0	0.0086
REGINA	S	6	93070	24027.8	181.8	97.5	104.4	0.0	0.0	376.1	0.0076
COALDALE	A	2	2075	887.5	6.6	104.5	0.0	0.0	0.0	5.0	0.0074
EDMONTON	A	11	320495	49431.5	357.5	1021.7	2.0	99.8	0.0	0.0	0.0072
FORT SASKATCHEWAN	A	11	5760	2015.3	9.8	0.0	163.4	0.0	0.0	0.0	0.0049
FORT MCMURRAY	A	16	19135	7157.7	29.1	0.0	5137.8	0.0	0.0	0.0	0.0041
WETASKIWIN	A	11	4455	1500.4	5.8	57.1	33.5	0.0	0.0	3.4	0.0039
NORTH BATTLEFORD	S	16	7030	2056.2	8.1	16.0	3.0	0.0	0.0	0.0	0.0039
LETHBRIDGE	A	2	30025	6477.8	24.9	513.5	0.0	0.0	13.2	0.0	0.0038
WEYBURN	S	2	4430	1507.0	5.3	13.0	164.6	34.5	0.0	49.8	0.0035
ST. ALBERT	A	11	20350	4407.5	14.9	38.7	0.0	6.0	0.0	66.5	0.0034
SASKATOON	S	11	92640	21688.7	61.8	1258.9	9.2	164.9	9.2	0.0	0.0028
CAMROSE	A	10	6000	1808.9	4.4	90.9	19.1	0.0	0.0	1.0	0.0024
LEDUC	A	11	6580	2003.2	4.1	15.2	178.7	99.1	0.0	8.2	0.0021

Appendix 3: Technical Details Regarding the General Equilibrium Model

A. Cost Functions

The value of the composite parameter ρ_X is defined as follows:

$$\rho_X = A^{-1}[(\frac{\theta_{LX}}{\theta_{KX}})^{\theta_{KX}}(\frac{\theta_{LX}}{\theta_{TX}})^{\theta_{TX}}(\frac{\theta_{LX}}{\theta_{YX}})(\frac{\theta_{LX}}{\theta_{ZX}})^{\theta_{ZX}} + (\frac{\theta_{KX}}{\theta_{LX}})^{\theta_{LX}}(\frac{\theta_{KX}}{\theta_{TX}})^{\theta_{TX}}(\frac{\theta_{KX}}{\theta_{YX}})^{\theta_{YX}}(\frac{\theta_{KX}}{\theta_{ZX}})^{\theta_{ZX}}$$

$$+ (\frac{\theta_{TX}}{\theta_{LX}})^{\theta_{LX}}(\frac{\theta_{TX}}{\theta_{KX}})^{\theta_{KX}}(\frac{\theta_{TX}}{\theta_{YX}})^{\theta_{YX}}(\frac{\theta_{TX}}{\theta_{ZX}})^{\theta_{ZX}} + (\frac{\theta_{YX}}{\theta_{LX}})^{\theta_{LX}}(\frac{\theta_{YX}}{\theta_{KX}})^{\theta_{KX}}(\frac{\theta_{YX}}{\theta_{TX}})^{\theta_{TX}}(\frac{\theta_{YX}}{\theta_{ZX}})^{\theta_{ZX}}$$

$$+ (\frac{\theta_{ZX}}{\theta_{LX}})^{\theta_{LX}}(\frac{\theta_{ZX}}{\theta_{KX}})^{\theta_{KX}}(\frac{\theta_{ZX}}{\theta_{TX}})^{\theta_{TX}}(\frac{\theta_{ZX}}{\theta_{YX}})^{\theta_{YX}}]$$

Where A is the shift parameter in the original Cobb-Douglas production function.

B. Share Parameters

The data used to define the share parameters of the GE model draw heavily on the ALTIM model of Percy *et al*, (1989). ALTIM modelled the province of Alberta's economy, but the constant returns to scale assumption allows the use of ALTIM's share parameters in this model of a community economy. ALTIM divided Alberta's economy into 13 sectors. For the purposes of this model these sectors will be combined as follows:

- The forest sector will include ALTIM's forestry, wood products, and pulp and paper sectors.

- The other exporting sector will include ALTIM's agriculture, energy, mining, food and beverage, secondary manufacturing, non-metal mineral, primary manufacturing, and construction sectors.

- The service sector will include ALTIM's service and government sectors.

The shares derived from ALTIM are as follows:

$\theta_{LX} = 0.2887$	$\gamma_{DX} = 0.0507$
$\theta_{KX} = 0.2322$	$\gamma_{YX} = 0.0508$
$\theta_{TX} = 0.1552$	$\gamma_{ZX} = 0.0599$
$\theta_{YX} = 0.0649$	$\gamma_{EX} = 0.8386$
$\theta_{ZX} = 0.2590$	
	$\gamma_{DY} = 0.1137$
$\theta_{LY} = 0.1542$	$\gamma_{XY} = 0.0389$
$\theta_{KY} = 0.3967$	$\gamma_{ZY} = 0.2528$
$\theta_{XY} = 0.0158$	$\gamma_{EY} = 0.5946$
$\theta_{ZY} = 0.4333$	
	$\gamma_{DZ} = 0.5625$
$\theta_{LZ} = 0.3542$	$\gamma_{XZ} = 0.0156$[1]
$\theta_{KZ} = 0.3388$	$\gamma_{YZ} = 0.4219$
$\theta_{XZ} = 0.0000$	
$\theta_{YZ} = 0.0616$	$\alpha_X = 0.0094$
$\theta_{MZ} = 0.2455$	$\alpha_Y = 0.2019$
	$\alpha_Z = 0.7888$

---

[1] For the province of Alberta. A community's shares (γ_{XZ} and γ_{YZ}) are adjusted, making the ratio of shares equal to the ratio of employment shares (θ_{XL} and θ_{YL}) for the two exporting sectors.

$\theta_{EL} = 0.95$

$\theta_{UL} = 0.05$[2]

$\theta_{EI} = 0.5991$[3]

$\theta_{KzI} = 0.4009$

$\sigma_L = 1$ [4]

$\sigma_T = 1$ [5]

---

[2] Assume natural unemployment rate is 5%.

[3] For Alberta. Assume Alberta is at the horizontal asymptote of the base/total ratio vs. community size relationship in Appendix 1 (ratio = 0.15). Sector Z's capital income share is adjusted down according to community size based on that relationship as follows (let r = community's ratio):

$$let\ \ x = \frac{(\frac{1}{r} - 1)}{(\frac{1}{.15} - 1)} .4009$$

$$\theta_{KzI} = \frac{x}{.5991 + x}$$

[4] Unless otherwise stated in Chapter 4.

[5] Unless otherwise stated in Chapter 4.

Appendix 4: Anticipated Welfare Losses From Cyclic Prices

A consideration in the issue of welfare losses from cyclic output prices is the degree to which these price swings are anticipated. Neo-classical economic theory suggests that to the extent that the business cycle price changes can be predicted, and to the extent that labour markets are working, workers will insulate themselves against income losses (if any) by demanding higher wages than might be found in a more stable community.

If, however, there were market failures present which prevent markets from reaching an acceptable solution then the welfare loss from instability would also be present. An example of such a market failure is incomplete information available to workers with would not allow them to make optimal decisions. The attention given to cyclic instability by policy makers and researchers suggests that welfare loss from instability is indeed a problem.