OPTIMAL ALLOCATION OF ECONOMIC ACTIVITIES OVER SPACE:

THE CANADIAN CASE

OPTIMAL ALLOCATION OF ECONOMIC ACTIVITIES OVER SPACE: THE CANADIAN CASE

by

Pierre Abou-Ezze, B.A. (Hons.), M.A.

A thesis

submitted to the School of Graduate Studies

in partial fulfilment of the requirements

for the degree

Doctor of Philosophy

McMaster University

1987

DOCTOR OF PHILOSOPHY (1987)
(ECONOMICS)

MCMASTER UNIVERSITY
HAMILTON, ONTARIO
CANADA

TITLE: OPTIMAL ALLOCATION OF ECONOMIC ACTIVITIES OVER SPACE:

THE CANADIAN CASE

AUTHOR: PIERRE ABOU-EZZE, B.A. (HONS.), University of Ottawa, Ottawa
M.A., McMaster University, Hamilton, Ontario

SUPERVISORY COMMITTEE: Professors A.A. Kubursi (Chairman)
D.W. Butterfield
J.R. Williams

NUMBER OF PAGES: xiv, 214

TO SAMIA

With Love

ABSTRACT

Canadian regions have not shared equally in the general prosperity of the Canadian economy. There are now a plethora of regional economic policies dealing with regional disparities and unbalanced growth. Two contending principles, however, dominate the choice open to the policy maker -- moving people to jobs, or moving jobs to people -- and there is not yet a satisfactory resolution as to which policy is more effective.

In this study an attempt is made to compare the effects of these two policies on the aggregate efficiency of the economy. The question of how to increase the income of the slow growing regions in such a way that it does not interfere with overall economic efficiency is addressed.

A linear programming approach is used, where the objective is to maximize the total gross national product of the ten Canadian provinces. To capture all the side effects and to take into account all the bottlenecks that may hamper the growth process, the analysis is conducted within a general equilibrium framework.

The trade-off between aggregate efficiency and inter-regional equity is analyzed within the same framework. The consequences, in terms of efficiency, of equalizing per capita income across provinces are quantified.

The major conclusions drawn from this study are that the mobility of factors of production across regions improves considerably the aggregate efficiency of the Canadian economy. In addition, the cross-regional mobility of factors allows interregional equity to be achieved at a relatively low efficiency cost.

ACKNOWLEDGEMENTS

My deep appreciation is extended to the members of the dissertation commiteee for their guidance and assistance in all stages of this thesis. In particular, I am greatly indebted to Professor Atif A. Kubursi who guided the development of this work with dedication. I am also indebted to Professor David W. Butterfield for his valuable time and interest that made the completion of this work possible. I thank Professor J.R. Williams for his valuable comments.

I am especially thankful to my wife Samia and daughter Rheam for their patience, continuous support and encouragement during the many years of studies.

A special word of thanks is due to Mrs. A. Munian for her excellent typing.

The financial support I have received from McMaster University and the Government of Ontario is gratefully acknowledged.

Finally, I alone assume responsibility for any errors or omissions in this study.

TABLE OF CONTENTS

LIST OF TABLES

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTORY REMARKS

Traditional economic theory has neglected the spatial aspects of economic behaviour. The classical models of production and distribution were formulated for a "spaceless" economy where no frictions existed. It was not until after World War II that economists and policymakers paid attention to interregional growth imbalances. It was then that regional policy began to develop.

Regional economic policies imply different treatment of the economic regions of the country. It calls for measures that favour the lagging regions and discriminate against the prosperous ones in order to reduce regional disparities. While regional policy is based on equity, national policy is based on efficiency. That is to say that while regional policy aims at an equal distribution of economic activities among the different regions of a nation, the national policy calls for an efficient allocation of resources so as to improve the national economy regardless of the distributional aspects of economic activities.

The introduction of spatial elements in economic analysis and policy creates the possibility of conflict between aggregate

efficiency and interregional equity. The policy maker then, has to decide how to reconcile these two objectives. In other words, he has to take into consideration both the equity consequences of a national policy and the efficiency consequences of a regional policy.

Before reviewing the literature on equity and efficiency and possible trade-offs between them, it is necessary that we define these two concepts. Efficiency is usually defined as the maximization of national output subject to given resource constraints[1]. That implies the allocation of scarce factors of production to the activities that are most productive. Whereas the definition of efficiency is widely accepted among economists, the definition of equity is not. Hudson (1974) argued that equity has three faces: equality of income, equal opportunities and distributional aspects of the supply of public services.

In an interregional context the most commonly used approximation for equity is the average per capita income. The lack of interregional equity (regional disparities) is usually measured by a dispersion coefficient among regional per capita incomes. Unfortunately, this measure is very sensitive to the size of the regions considered. The larger the size of the regions, the smaller the dispersion is likely to be, because some (or most) of the interregional variations could be averaged out.

O.J. Firestone (1974), among others, argued that regional disparities are much broader than can be reflected in income measures. He used economic and social and demographic indicators in studying the trend of economic disparities in Canada; he found that while regional per capita income tends to diverge among Canadian provinces, most of the other indicators tend to converge.

It may be argued, however, that equalizing interregional per capita incomes does not violate the equity concept, irrespective of the definition used. Rather, it brings us closer to achieving equity on all definitions.

In this study, efficiency is defined as the maximization of national output, and equity is defined (unless otherwise specified), as interregional equality of per capita income.

The remainder of this chapter is devoted to exploring the relationships between equity and efficiency. Section 1.2 reviews the implications of regional economic theory for equity and efficiency and their relationship. Section 1.3 reviews the treatment of factor mobility and its consequences for equity and efficiency in existing multiregional economic models , and finally, Section 1.4 describes the methodology followed in this study, and the organization of the various chapters.

1.2 EQUITY AND EFFICIENCY: TRADE-OFF OR COMPATIBILITY?

While there is a wide agreement among economists that regional policy is equity oriented and national policy is efficiency oriented, the relationship between equity and efficiency does not enjoy such wide agreement.

Neoclassical economists reject regional policy considerations on the ground that they constitute a distortion of the market mechanism. They believe that market forces by themselves will promote equity among regions through migration of factors of production and/or through the movement of commodities between regions. The basic assumptions of the neoclassical theory are:

a. perfect competition among regions in all markets;

b. free mobility of the two main factors of production, namely, labour and capital;

c. all regions have identical production functions, and

d. factors are paid the value of their marginal product.

Under these assumptions, neoclassical theory predicts that homogeneous factors will move between regions until their marginal products are equalized and, thus, satisfy the efficiency criterion. Equity, defined as the equality of per capita income across regions, cannot be addressed in a neoclassical framework, because the neoclassical model focuses on individuals and not on regions, and individuals are generally treated as mobile. Equity, however,

can be promoted by the outcome of the market mechanism through the equalization of returns to homogeneous factors of production. According to the neoclassicals, wages and returns to capital are inversely related so that high-wage regions import labour and export capital while low-wage regions offer better returns to capital, and thus, attract it, while labour emigrates. The final result of this process will be the equality of returns to the homogeneous factors employed in different regions[2].

An alternative version of the neoclassical model was offered by Heckscher and Ohlin. They kept all of the neoclassical assumptions but one. They replaced the factor mobility assumption with interregional free trade. Their main conclusion was that in equilibrium factor prices will be identical and per capita income differentials will be lessened.[3]

The mechanism that may lead to the promotion of equity in the neoclassical theory is the free movement of factors and/or of commodities across regions. A number of economists, such as Myrdal, Perroux, and Lefeber were not ready to accept the neoclassical predictions about interregional factor movements. They argued that in reality the neoclassical mechanism outlined above does not work. Labour and capital do not fully respond to interregional differentials in returns. Moreover, regions do not have identical production functions and that the spatial transmission of technical

progress may be an essential element in the equalization of productivity of factors of production among regions.

Several alternative theories were developed to incorporate these non-neoclassical perspectives. Three of these theories are singled out here. These include: cumulative causation theory, growth pole theory, and location theory. Let us consider each in turn.

1.2.1 Cumulative Causation Theory

Cumulative causation theory, which was advanced by G. Myrdal (1957), predicts increased inequality among regions over time. Perhaps more importantly, Myrdal argues that this inequality is the natural outcome of the market forces. He stated that, "the play of the forces in the market tends to increase rather than to decrease the inequalities between regions"[4]. According to Myrdal, economic expansion in one region generates backwash (negative) effects and spread (positive) effects on other regions. The backwash effects are the results of two phenomena: First, the migration of labour and capital from other regions to the expanding region, and second, the competitive advantage of the expanding region.

The expanding region attracts labour (especially the skilled and most active) from other regions causing the demand for goods and services in the receiving region to grow and that in the sending regions to contract. Income in the sending regions will decline and this leads to less employment. The consequences for

regions of this outmigration could be very severe as they lose the most talented and vigorous group of their labour force. Investment capital migrates to the expanding region due to favourable demand and that increases income which in turn, increases demand even further, and calls for new investment. The outmigration of capital from other regions implies less investment which causes income to decline, which in turn, causes demand to decline, and that leads to less investment and so on.

A competitive advantage for the expanding region will result due to the widening of the market where industries usually operate under conditions of increasing returns. There will be some spread effects, however, that have positive impacts on other regions, especially for the primary sector (agriculture and raw materials). Myrdal's conclusion was that the backwash effects outweigh the spread effects so that market forces by themselves may increase interregional disparities over time.

Myrdal's analysis implies that economic activities will be concentrated in the prosperous and economically efficient regions; efficiency stems from the fact that production functions in the expanding regions exhibit increasing returns. Since the resources that remain in the disadvantaged regions will be idle or under-utilized, their mobilization towards the growing regions entails a zero or very low opportunity cost. In consequence, any policy directed towards an equal distribution of economic activities over

regions will be associated with a loss in aggregate efficiency since the opportunity cost of transferring resources employed in the prosperous regions towards the lagging regions is relatively high. A trade-off between efficiency and equity will necessarily follow.

M. Polese (1981), in extending Myrdal's conclusions, has argued that migrants out of lagging regions embody not only labour but other sources of growth as well, such as capital, education, and advances in knowledge, as well as their possible effect on scale economies. He also suspects that migrants embody these sources of growth at a proportionately higher level than the population of the receiving regions. Thus, over time, immigrants will raise the per capita income of the receiving regions and increase the disparity gap relative to the sending regions.

In an argument similar to Myrdal's, A. Hirschman (1958) talks about two opposing forces: trickling down effects and polarization effects. Trickling down effects stem from the complementarity of less developed and more developed regions. While the prosperous regions are basically industrial, agriculture is the dominant sector in the lagging regions. As the more developed regions increase their production, they increase their purchases from, and their investment in, the less developed regions. The industrial regions absorb the unutilized factors of production in the agricultural regions through migration. The polarization effects result from the migration of factors of production to the expanding regions and also from the deterioriation of terms of trade of the lagging regions. Capital will

move to the industrial regions due to lack of investment opportunities in the agricultural regions and a selective migration process, including skilled labour and managers, takes place in the same direction. Terms of trade for the lagging regions will deterioriate because of increasing imports and decreasing exports as a result of more efficient production in the expanding regions.

Hirschman's results are different from Myrdal's, however, in the sense that the income disparities between regions could be lessened given that the complementarity of regions prevails.

1.2.2 Growth Pole Theory

Growth pole theory, along similar arguments to cumulative causation theory, rejects the long term equilibrating process of the spatial distribution of economic activities. F. Perroux (1955) argued that growth does not happen everywhere at the same time. Instead, it occurs at certain points with different intensities. Myrdal's backwash effects are portrayed in Perroux's theory by the outmigration of factors and trade from other parts of the country. Like Myrdal, Perroux emphasizes the importance of internal and external economies in promoting the growth of centers. He stresses the role which "growth firms" and "growth sectors" play in the dynamic promotion of the polarization process.

According to the growth pole theory, market forces will lead eventually to the concentration of economic activities in some

areas at the expense of others. In order to offset this tendency towards polarization of economic activities, Perroux urges the establishment of "counter-poles" in the less prosperous regions. Once again, as in cumulative causation theory, a more equitable distribution of economic activities over space has to be made at the expense of aggregate efficiency.

1.2.3 Location Theory

This theory is based on the locational decisions of firms. The choice of location rests solely upon the minimization of total transport cost of both input and final product. Although the emphasis is on market boundaries instead of regional boundaries, locational theory is helpful in explaining interregional disparities.

Building on earlier work by Weber, a general theory of location was advanced by Losch (1954), Greenhut (1956), and by Isard (1956). It was based, however, on the very restrictive and unrealistic assumptions of identical production cost for all firms and of spatial uniformity of transport cost. Lefeber (1958) developed a general theory of location in which he removed these restrictive assumptions. The objective of Lefeber's model is to determine the optimal location of firms and the maximization of production of final goods simultaneously. The equilibrium solution gives the optimal allocation of mobile factors that correspond to different combinations of goods to be produced. The rates of return

of homogeneous factors may differ between locations. The difference is equal to the marginal cost of transportation.

Location theory tells us that the efficient allocation of factors leads to inevitable disparities between locations (or regions). The disparities stem from the concentration of activities in certain locations that enjoy some advantages over others. In the earlier version of location theory these advantages were represented by transportation and communication costs, while later versions also stressed the importance of socio-cultural location conditions, such as educational facilities, medical care, etc.

1.2.4 Other Theories

It has been pointed out, however, that in some circumstances the equity-efficiency trade-off can be avoided. One example is provided by Williamson (1965). He argues that interregional inequalities increase during the early stages of development due to agglomeration forces, but that the process reverses itself as disequilibrating tendencies -- such as the movement of factors from poor to rich regions -- diminish. Thereby countries can expect achievement of both aggregate efficiency and interregional equity over time.

Williamson's analysis has been criticized by many authors[6] for its heavy reliance on United States' data, for a lack of theoretical explanation and for its historical determinism.

Another argument for compatibility has been advanced by Higgins (1973). He argues that narrowing the regional income disparities among the Canadian provinces is necessary to avoid an accelerating inflation rate. His analysis, however, is based on the assumption that labour markets are regional while inflation is a national phenomena.

K. Mera (1975) analyzed the theoretical and empirical aspects of the relationship between equity and efficiency. He assumed different production functions for different regions and concluded that the most efficient distribution of factors of production and, consequently, of economic activities, is not necessarily compatible with the most equitable distribution of income across regions.

Empirically, he found that in the short run the equalization of per capita income among all nine regions of Japan would cost 30 per cent of Japanese national product, while in the long run, where factors of production can be treated as mobile between regions, the equalization process would cost only 12 per cent of the national product. He also concluded, however, that the trade-off between equity and efficiency could be avoided if the means of equalizing per capita income among regions were income transfers. This conclusion was the direct result of the assumption of equal resource cost of consumption activities among regions, which implied that a transfer of income from a high income region to a low income region did not entail any efficiency loss.

By reviewing the major theories that deal with equity and efficiency, one can conclude that the existence of possible conflicts between these two goals stems from the fact that regions have different production functions or that production functions exhibit increasing returns to scale. In other words, the stocks of inputs, their rates of expansion and technological "know-how" vary among regions. From an efficiency point of view, economic activities must be concentrated in regions that are most efficient. Any policy aiming for an equal distribution of these activities necessarily entails an efficiency loss.

Regardless of the conclusions of the above theories, the mobility of factors of production between regions plays an important role in each theory. The free mobility assumption, while it ensures the promotion of equity through efficiency in the neoclassical theory, leads to interregional income disparities in Myrdal's, Perroux's and Lefeber's theories.

In order to analyze and quantify the effects of mobility of factors of production on equity and efficiency and on possible trade-offs or compatibility between them in Canada, a multiregional, multisectoral, economic model is developed in chapter 3. In what follows a brief review of the treatment of mobility of factors of production in previous multiregional economic models is provided.

1.3 A REVIEW OF MULTIREGIONAL ECONOMIC MODELS

The first multiregional economic (ME) models were developed in the 1950s. The theoretical structure of ME models was first discussed by Isard (1951), followed by an extensive study by Chenery, Clark and Cao-pinna (1953) for Italy and by Moses (1955) for the United States. These studies emphasize inter-regional trade linkages and the connection between production, investment, and output.

While the input-output approach to ME models dominated during the fifties, disaggregated national econometric models were built during the sixties and seventies for Western and Eastern Europe, USSR, North America and Japan. Due to the development and improvement of data collection, some ME models were built to encompass a more or less complete description of the economic system (e.g., to include environment, energy, and demography).

The existing ME models, however, differ from each other in many respects depending on the purpose of the model, and in many cases, on the availability of data. Such differences include the size (number of regions and number of sectors), number of endogenous variables, type of regions (administrative regions, urban versus rural) and time dimension (short, medium, or long), as well as the production structure (factors of production and type of production function).

In this study we are most concerned with the differences in linkages and interaction between the different regions of the model. A number of the existing ME models neglect the interaction between regions, that is, direct links between individual regions are absent in the sense that the flow of goods and factors are not modelled explicitly so as to specify both the sending and the receiving regions. IDIOM (Income Determination Input-Output Model) by Dresch and Updegrove (1980) of the United States and REM (Regional Economic Model) by Van Hamel, Hetsen and Kok (1977) for the Netherlands are typical examples. Such models do not allow the assessment of the effects of the development of one region on other individual regions, but they could be used to examine the effect of such development on the national economy.

In other models where both sending and receiving regions are explicitly specified, the effects of a change in the economy of one region on other individual regions as well as on the national economy can be assessed[7]. The main linkages between the different regions of the model present themselves through one or both of the following:

-- interregional trade

-- interregional mobility of factors of production.

Let us consider each one in turn.

1.3.1 Interregional Trade Linkages

A general common feature of the existing ME model is their use of interregional trade as the major linkage between regions. Some models are based on Heckscher-Ohlin theories of interregional trade. Trade occurs because any two regions could gain from the exchange of goods when their relative production costs differ. The REGIS model of the French economy by Courbis and Cournilleau (1978) is an example of such an approach.

Other models adopt a linear programming approach to determine the most efficient interregional trade patterns. In the MRMI (Multi-region, Multi-Industry) model developed by Harris (1980), a linear programming model of an optimal transportation system is used to determine shadow transportation prices. These are subsequently used as proxies for the influence of transport cost on total regional production cost, which in turn, determine trade flows. Sharpe, Karlqvist, Batten and Brotchig (1978) in their DREAM (Dynamic Regional Economic Allocation Model) for Australia, used a different objective function in the linear programming approach. They maximized the total net surplus defined as total exports to the rest of the world minus total imports from the rest of the world, minus total transport cost. In calculating the flows from national sectors to all other sectors within and beweeen regions, a gravity model was applied where both the origin and destination were specified for each sector and for each region.

K. Polenske (1981) in MRIO (Multiregional Input-Output) model used an input-output model based on entropy and gravity theory to determine interregional trade. Trade patterns are explicitly related to transport cost.

Some multiregional econometric models such as MEPA (Massachusetts Economic Policy Analysis) developed by Treyz, Friedlaender and Stevens (1980) combine interregional differences in production cost and interregional transport cost to explain the flows of commodities between regions. Along the same line, Andersson Lundqvist, Persson and Snickars (1979) in their GISSIR (Growth Induced Sustainable Structure) model for Sweden, have analyzed regional trade in a transportation-location equilibrium context. A dynamic interregional growth and allocation model was taken as the a priori organizing principle to be fulfilled by the pattern of transportation. However, they based the transportation and location equilibria on different equilibrium concepts. The equilibrium in transportation was defined as the pattern that preserves a balanced situation for the individual regional markets and is consistent with political goals like full employment; while the equilibrium in location depends on the comparative advantages of production in each region and on transportation frictions.

The FRET (Forecasting Regional Economies and Transportation) model, developed by Los (1980) for Canada, treats transportation cost more explicitly than any other model. Different modes of transporta-

tion were considered (e.g., road, rail, air and water). The solution of the model determines transport cost and output of different modes of transportation by province.

While interregional trade provided the interaction among regions in the above discussed models, the mobility of factors of production represents the major interregional linking channel in the other models to be discussed below.

1.3.2 Factors of Production Linkages

The ME models that deal with the interdependency of regions through factor mobility instead of, or in association with, movement of commodities differ in their treatment of factor markets. Typically, two factors are dealt with in detail in these models, namely, labour and capital.

Labour is usually modelled at the regional level. The mobility of labour, however, generally takes the form of migration described by behavioural equations explaining the causes of labour movement between regions. The typical explanatory variables describe the "push factors" of the sending regions such as the unemployment rate and/or the "pull factors" of the receiving regions such as the wage rate, employment growth and income levels. Another characteristic of the labour market model is the disaggregation of the labour force. The most common disaggregations are based on one of two

criteria. The first, the age-sex criterion, was used in MAG (Multiregional Economic Model of the U.S.A.), developed by Milne, Adams and Glickman (1980), and also in REGINA (Regional National Model of France) by Courbis (1972), and in CANDIDE-R of Canada by D'Amour, Fortin and Simard (1979), to name a few. The second, the occupation criterion, was used in REGAM (Regional Labour Market Model) developed by Suyker and Van Delf for the Netherlands (1981).

Other models, such as MRIO and MEPA, treat the occupation and sectoral disaggregation simultaneously. The latter two categories imply some sort of labour market segmentation where there exists perfect labour mobility between sectors and limited or no mobility between occupations or between types of labour. However, in REMO (Regional Labour Market) by Schubat and Baumann (1980), the segmentation is based on educational attainment where a move between these segments requires entrance into the educational system.

Although there are many similarities among existing ME models in their treatment of the labour market, there are also some distinctive features of these models. For example, Treyz (1980) introduced new variables to explain migration between regions. These are the labour force deficit in the receiving regions and the labour force surplus in the sending regions. The quality of life was used as an explanatory variable for internal migration in some ME models. It was measured by the population density in MAG and by the change in housing stock in REGAM. REGAM, however, went a step

further and included environmental quality, measured by km^2 of woods per 1000 inhabitants, in the migration function. REGAM is also characterized by its emphasis on the unemployment rate which plays a major role in determining the regional differences in employment growth and in regional labour supply through the discouraged worker effect.

MACEDOINE II, developed by Glejser, van Daele and Lambrecht (1973) for the Belgian economy, is characterized by a dual labour market. For some categories of workers, a national labour market exists, whereas for the least mobile workers the market is limited to the province. In MACEDOINE II labour mobility is modelled by explicitly including the effect of each regional labour market on all the bordering regions.

The concept of the leading region was incorporated into some ME models. In the RENA (Regional National) model, built by Thijs and van Rompuy (1979) for Belgium, labour market conditions in the Brussels region largely explain the shuttle (commuting) labour process in the rest of the country. Courbis, in REGINA, hypothesized that the wage rate in the Paris region influences the wage rate in the rest of the country. In addition, labour mobility in REGINA was modelled at a double spatial level. The interregional flow of labour was explained, as in other models, by interregional differences of wage rates and by regional labour market conditions while intra-regional mobility was determined by a gravity model where the employment growth and unemployment rates at the subregional level are the main arguments.

Although labour mobility is explicitly dealt with in the existing ME models, the exclusion of fiscal variables from the set of explanatory variables represents a drawback. Recent migration studies[8] have shown an increasing effect of social security programmes and of federal transfer variables on the interregional movement of labour and have also shown a decreasing influence of traditional market variables such as unemployment rates and employment growth.

While labour mobility is explicitly dealt with in existing ME models, capital mobility is the most neglected aspect of the economic system. The most common assumptions are: (a) the existence of a national market for financial capital where funds are free to move across regions, and (b) that the existing physical capital is completely immobile. Although the first assumption is perhaps tenable given that in developed countries, the banking system facilitates the movement of funds betwen regions at little or no cost, the second assumption is far less tenable. A high level of disaggregation of the economy allows for treatment of the movement of physical capital among sectors. Moreover, the existence of multiregional firms facilitates the movement of physical capital across regions.

Capital formation, however, does not suffer the same degree of neglect. The national formation of capital is usually derived from a national model then allocated either among regions in some models, such as RENA and REGINA or among sectors, such as

DREAM, REM, and MORSE (Model for Analysis of Regional Development, Scarce Resources and Employment) by Lundqvist (1981) for Sweden.

In multiperiod models, capital formation is directly related to the production capacity of the economy. In MORSE, sectoral capacity at time t is defined to be equal to depreciated capacity at time t-1 plus depreciated investment made over the period t-1 to t.

In some models, however, investment is not considered while in others it is determined exogenously. Investment is determined endogenously in only a few models. The MRIO model, for example, treats investment exclusively as a component of final demand. Investment is residually determined in DREAM, where it is calculated as the remainder of total sectoral output after deducting consumption demand and input demand by all other sectors. However, this residual investment determines the available regional capacity which imposes an upper bound on regional production. Some other ME models split investment into two parts: exogenous and endogenous. Regional investment in RENA includes exogenous investment of the government, the agricultural sector, and endogenous private investment which is a function of earnings in manufacturing, the user cost of capital and regional value added. In REGINA the endogenous part of investment at the regional level is determined by attractive forces such as the urbanization rate and by repulsive factors such as local tax rates. However, regional capital stocks determine production only in "non-

restricted-location" industries such as the manufacturing and food industries. In REM, investment is endogenously determined at the national level, then distributed among regional sectors as a function of the existing regional capital stocks. Regional capital stocks, however, are determined endogenously in each sector as a function of the capital stocks of the previous period and the production level in the respective sectors, and also as a function of the regional population density so as to capture the effects of external economies.

The mobility of both labour and capital in current ME models is based mainly on the premise that they move to regions that offer better remuneration as well as better employment opportunities. This movement results in an increase in the production level of the aggregate economy. It is the transfer of resources from less productive sectors and regions to more productive ones that accounts for the gains in economic efficiency within a given state of technology. However, given that the mobility of factors, as modelled, reflects their historical movement, the question arises as to whether or not the historical mobility of factors (especially that of labour) has enhanced the aggregate efficiency of the economy. Moreover, the mobility of factors of production, while it increases efficiency, may also increase the disparities between sending and receiving regions. Given that resource supplies are limited, the use of any resource in one region implies a reduction in the amount available for other regions. Since existing regional economic theories predict

different outcomes regarding equity and efficiency, an empirical investigation is needed to examine the question of equity-efficiency compatibility.

1.4 THE METHODOLOGY AND ORGANIZATION OF THIS STUDY

This study is designed to analyze the spatial allocation of economic activities in Canada using a programming approach. The model used is a multiregional, multi-industry general equilibrium model. The constraints of the model include a description of inter-regional interaction in the goods, factor and financial markets. The results that emerge are based on the allocation of the scarce resources to industries and regions that are most efficient.

In chapter 2, the existence of interregional disparities across Canada is examined. Disparities are represented in two ways: first, disparities in equity where per capita incomes across provinces are compared, and second, disparities in efficiency where the productivity of factors of production across provinces as well as across industries are examined. An evaluation of government policies aimed at reducing these disparities is also presented.

Chapter 3 is devoted to the presentation of the economic model. An objective function is maximized subject to a set of constraints that depicts a fairly realistic approximation of the set

of feasible alternatives open to the economy. These include material balance constraints specified at the commodity level, financial constraints, and income constraints specified at the regional level, and a government budget constraint specified at the national level. Different resource availability constraints are imposed at all three levels of aggregation. The results of the optimization experiments are presented in chapters 4 and 5. While in chapter 4 the gains in efficiency that result from increasing the mobility of factors of production are examined, chapter 6 presents the results of the equity solution and discusses the magnitude of the cost of interregional equity in terms of aggregate efficiency under different configurations of factor mobility. In both chapters, a labour migration model is imposed on the analysis in order to see whether or not the historical migration pattern improves aggregate efficiency and/or interregional equity.

A general summary of the main results is presented in chapter 6. Some comments on the simplifying assumptions of this study and a brief discussion of further research are also presented.

FOOTNOTES

Chapter 1

1. This definition becomes inadequate if environmental qualities and other externalities are taken into account. Moreover, in less developed countries, some economists define efficiency in terms of satisfying human needs instead of optimal allocation of resources. See, for example, Alonso (1971).

2. Insofar as they are mobile, factors move in response to differences in their remuneration from employment. Even if factors don't move, industries most intensive in the region's abundant factors expand, exporting the excess of production over domestic consumption. Some factors are necessarily immobile (e.g., land), so, in the end, each region relative production by industry will differ from the other regions. Per capita income depends on where the more highly paid (skilled) workers are employed (which region winds up producing relatively more of the goods that require the higher paid workers), and on where people who own resources (other than labour) live.

3. See Note 2.

4. See G. Myrdal: Economic Theory and Underdeveloped Regions (1957), page 26.

5. For more on this issue see Hirschman (1958).

6. See Metwally and Jensen (1973), Parr (1974), and Gilbert and Goodman (1973).

7. Models that do not specify both sending and receiving regions are called multiregional, while models that do are called interregional. For more on this categorization, see K. Polenske (1980). However, F. Snickars (1982) calls the former category of models independent and the latter interdependent.

8. See, among others, Shaw (1986) and Winer and Gauthier (1983).

CHAPTER 2

INTERREGIONAL DISPARITIES IN CANADA

2.1 INTRODUCTION

It is a well known fact that significant regional disparities exist in Canada. In addition to the large size of Canada, the diversity that characterizes the Canadian provinces has contributed to such disparities. This diversity is noticeable in all aspects of Canadian society in general and in the economic structures of the Canadian provinces in particular. The agricultural industry is concentrated in the Prairie Provinces, the fishing industry is concentrated in British Columbia and the Atlantic Provinces, the manufacturing industry is concentrated in Ontario and Quebec, the oil and gas extraction industry is mainly in Alberta, and the pulp and paper industry is concentrated in British Columbia. As a result, any national policy will likely have different impacts on different regions. For example, the creation of a transport network to strengthen the links between the economies of different regions has mainly benefitted Central Canada through opening the Maritimes and the western markets to its manufacturing industries. It is also true that the imposition of

tariffs on imports of manufactured goods has also favoured these provinces at the expense of the others[1].

This chapter is devoted to a discussion of the disparities that exist among Canadian provinces and of the corrective measures which have been adopted by the government to deal with them. Section 2 presents the interregional disparities from an equity point of view, whereas Section 3 discusses such disparities from an efficiency point of view. In Section 4 Canadian regional policy aiming at the reduction of disparities among regions is evaluated and Section 5 contains some concluding remarks.

2.2 DISPARITIES IN EQUITY AMONG REGIONS

Many definitions of an economic region have been used in the economic literature. An economic region may be characterized by homogeneity in respect to some attributes such as the structure of economic activities, physical resources, market size, administrative jurisdiction and social or cultural features[2]. In empirical studies, however, the availability of regional data still dictates, to a large extent, the degree of disaggregation of the national economy into separate regions. As is often the case, administrative units (such as provinces or states), or some alternative grouping of such units are taken to present economic regions of a country.

In this study, the ten provinces are treated as the economic regions of Canada. The two terms "interregional" and "interprovincial" are, therefore, used interchangeably.

Significant interprovincial disparities in equity, measured in terms of per capita income, exist in Canada. Looking at the geographical distribution of per capita income as far back as available statistics allow, one observes an unchanging pattern of per capita income disparities among the Canadian provinces. From 1925 to 1985, the ranking of Canadian provinces in terms of per capita income has remained almost the same. The Atlantic Provinces were and still are substantially below the national average; Quebec, Manitoba and Saskatchewan preserve their rank around the national average; while Ontario, Alberta, and British Columbia remain the highest per capita income provinces[3]. The statistics of interest here, however, relate to the past two decades, when regional policy in Canada began to develop.

Table 2.1 reveals a clear picture of trends in the relative differences between the highest and the lowest per capita income provinces. In the 1961-1963 period personal income per person in Newfoundland and in Prince Edward Island were 44 and 41 percentage points below the national average, respectively, while in Ontario it was 17 per centage points above the national average, giving rise to a spread of 61 points between the highest and the lowest provinces.

TABLE 2.1

Personal Income Per Person by Province
(3 year average, national average = 100)

Year	Canada	N.F.	PEI	N.S.	N.B.	Que	Ont	Man	Sask	Alta	B.C.
61-63	1751	56	59	76	67	89	117	95	88	99	113
64-66	2109	58	60	75	68	89	116	93	89	97	112
67-69	2705	61	62	76	69	89	117	95	82	100	109
70-72	3467	63	65	78	72	89	116	93	77	99	109
73-75	5119	66	67	79	74	90	111	95	97	102	109
76-78	7420	67	68	79	75	93	109	92	93	102	109
79-81	10347	65	68	78	72	93	107	90	94	109	110

Sources: based on data from Statistics Canada: National Income and Expenditure Accounts, Catalogue 13-201.

The situation has improved somewhat during the past two decades, since there has generally been a slow convergence of personal income per person towards the national average. The most significant case of convergence from above was Ontario, which lost about 10 percentage points; and the most significant case of convergence from below were Newfoundland and Prince Edward Island which gained 9 percentage points relative to the national average. The most significant divergences occurred in Alberta, which gained 10 percentage points, and in Manitoba, which lost 5 percentage points. Despite improvement in

some provinces, the gap between the highest (British Columbia) and the lowest (Newfoundland) per capita income provinces was 45 percentage points in the 1979-1981 period. Moreover, this gap becomes even larger when one looks at the per capita provincial gross domestic product, where income transfers by the Federal Government are excluded.

TABLE 2.2

Provincial Per Capita Gross Domestic Product
(3 year average, national average = 100)

	Canada	N.F.	PEI	N.S.	N.B.	Que	Ont	Man	Sask	Alta	B.C.
61-63	2522	45	45	59	54	84	111	83	84	98	104
64-66	2878	51	48	63	61	90	118	88	93	104	112
67-69	3584	52	50	66	61	89	118	90	84	107	108
70-72	4454	53	62	69	64	89	117	90	81	108	106
73-75	6605	50	52	66	63	86	112	91	99	129	108
76-78	9224	54	52	66	64	88	108	90	100	139	109
79-81	12972	53	50	61	62	86	105	87	106	151	109

Sources: based on data from Statistics Canada: Pronvicial Economic Accounts, Catalogue 13-213.

Table 2.2 shows clearly that the gaps among the Canadian provinces are much larger, when gross domestic product per capita is compared, than when personal income per capita is compared. Table 2.2 also shows that there has been no convergence of gross domestic product per capita towards the national average. By comparing the first (61-63) and the last (79-81) observations of Table 2.2 one can see that the gap between the poorest and the richest provinces has almost doubled. While Prince Edward Island trailed Ontario by 66 percentage points in 1961-63, it trailed Alberta by 101 percentage in 1979-1981. Even if Alberta is excluded, the gap between Prince Edward Island and British Columbia is 59 percentage points in 1979-1981.

Having demonstrated the existence of substantial per capita income disparities among the Canadian provinces, the logical extension would be to examine the possible causes of such disparities. Three major factors are chosen for discussion: the participation rate, the unemployment rate, and the productivity of factors of production. In this section the participation rate and the unemployment rate are discussed while the productivity of factors are discussed in the following section in terms of efficiency differences.

Participation Rate

Labour force participation rate differences among provinces correspond to differences in per capita income. The low income provinces experience a relatively low participation rate while high income provinces have participation rates above the national average. Table 2.3 makes the above observations very clear.

TABLE 2.3

Labour Force Participation Rates by Province

Year	Canada	N.F.	PEI	N.S.	N.B.	Que	Ont	Man	Sask	Alta	B.C.
1966	57.3	44.8	54.3	52.3	51.3	56.0	59.8	57.4	54.0	61.7	56.7
1971	58.1	45.0	54.3	52.2	49.8	56.0	60.9	59.3	55.3	63.0	58.3
1976	61.1	59.4	56.7	52.2	53.6	58.3	63.9	61.2	60.5	66.9	61.3
1981	64.8	53.1	59.1	57.8	56.7	61.2	67.7	65.0	63.5	71.6	64.7

Source: Historical Labour Force Statistics, Catalogue 71-201.

The four Eastern Provinces have lower participation rates than the rest of Canada, with that of Newfoundland being the lowest.

Although the participation rate gap between Newfoundland and the national average declined by 3.8 percentage points between 1966 and 1981, it remained at 11.7 percentage points in 1981. In the other Maritime Provinces, while the participation rates have increased in absolute terms, the gaps relative to the national average increased by up to 3 percentage points between 1966 and 1981. Ontario and the Western Provinces (except British Columbia and Saskatchewan) remained at, or above, the national average.

Unemployment Rates

Differences in provincial unemployment rates have undoubtedly contributed to interprovincial disparities in per capita income. As Table 2.4 indicates, unemployment rates in the Atlantic Provinces have been significantly higher than in the rest of Canada (except British Columbia).

Newfoundland, on average, experienced the highest unemployment rate, which, at times, was three-and-a-half times larger than that of Saskatchewan or Alberta. The province with the second highest unemployment rate was Prince Edward Island, followed by Nova Scotia, New Brunswick and Quebec. The unemployment rate in Ontario, although below the national average, was greater than in the Prairie Provinces, but below British Columbia. Although unemployment and participation rates contribute substantially to interprovincial

TABLE 2.4

Unemployment Rates by Province (3 year average)

Year	Canada	N.F.	PEI	N.S.	N.B.	Que	Ont	Man	Sask	Alta	B.C.
66-68	3.9	6.2	--	4.9	5.4	4.7	3.1	3.2	1.8	2.8	5.2
69-71	5.4	7.7	--	5.7	6.3	6.8	4.3	4.7	3.6	4.7	6.6
72-74	5.9	10.7	--	6.8	7.4	6.9	4.5	4.5	3.5	4.8	6.9
75-77	6.4	14.2	9.1	9.2	11.3	9.0	6.5	5.0	3.7	4.2	8.5
78-80	7.8	14.8	10.5	10.1	11.5	10.1	6.8	5.7	4.5	4.1	7.5
81-83	10.1	16.5	12.1	12.2	13.4	12.6	8.9	7.9	6.1	7.4	10.8

Source: Based on data from Statistics Canada; Historical Labour Force Statistics

income disparities, they are not the only cuases. Differences in efficieny of factors of production, mainly labour and capital, can also be of crucial importance. These differences are discussed in the following section.

2.3 DISPARITIES IN EFFICIENCY AMONG REGIONS

Canadian provinces differ significantly in terms of efficiency, as measured by the partial productivities of factors of production. Although a total factor productivity index[4] would be more representative of efficiency, partial productivity indices, nevertheless, shed some light on differences of efficiency among provinces. Differences in labour and capital productivities are examined in this section.

Labour productivity for all provinces measured by total value added per person employed, as a percentage of the national average is presented in Table 2.5.

TABLE 2.5

Value Added Per Person Employed by Province
(3 year average, national average = 100)

Year	N.F.	PEI	N.S.	N.B.	Que	Ont	Man	Sask	Alta	B.C.
61-63	90	55	82	73	95	106	89	90	105	108
64-66	89	58	82	76	95	108	89	96	107	109
67-69	82	60	78	77	89	108	91	92	110	107
70-72	84	62	80	78	90	108	90	88	111	107
73-75	83	61	78	83	88	102	92	110	125	108
76-78	84	64	80	84	92	100	90	104	132	108
79-81	82	65	77	83	91	96	88	109	139	107

Sources: Statistics Canada: Historical Labour Force Statistics, Catalogue 71-201; Provincial Economic Accounts. Catalogue 13-213; Historical Statistics of Canada, Catalogue 11-516.

During the period 1961-1981, Quebec, Ontario and the Western Provinces were the most labour efficient. The relative ranking, however, changed during this period. While Ontario was the second most efficient province (behind British Columbia or Alberta) and was up to eight percentage points above the national average in the sixties, it placed fourth at the end of the seventies and was four percentage points below the national average. Saskatchewan and Alberta made the most remarkable advances during the seventies, particularly after 1972. During the 1973-1981 period, labour productivity relative to the national average in Saskatchewan and Alberta increased 21 and 28 percentage points, respectively[5]. British Columbia, Manitoba and Quebec did not experience any significant change in their labour productivity relative to the national average, with British Columbia being above the national average by 7 or 8 percentage points and Quebec and Manitoba being below that average by about 10 percentage points. As for the Eastern Provinces, they have remained at the bottom of the ranking in terms of labour productivity with Prince Edward Island being the least efficient.

Having examined the above statistics, one is lead to conclude that the disparity in labour productivity is fairly high among the Canadian provinces and that it is increasing over time. While in 1961 the gap between the most and the least efficient provinces was 53 percentage points, it increased to 75 percentage

points in 1981. Due, however, to the diversity of the economic structures of the Canadian provinces, an analysis based on aggregate provincial figures might not give a clear picture. Some sectors in the less efficient provinces could be more efficient than the same sectors in the more efficient provinces. An analysis conducted on a sectoral basis could give us a clearer picture regarding provincial variations in labour productivity. In Table 2.6 the labour productivities for five separate sectors, calculated as value added per worker are presented for each province as a percentage of the national sectoral average.

TABLE 2.6

Value Added Per Person Employed by Sector and Province
(3 year average, national average = 100)

Year	Sector	N.F.	PEI	N.S.	N.B.	Que	Ont	Man	Sask	Alta	B.C.
61-63	AGRICULTURE	--	46	55	48	57	104	91	138	123	119
64-66		--	60	52	61	55	97	104	142	122	100
67-69		--	50	62	68	67	111	99	115	116	106
70-72		--	66	75	81	69	109	99	120	103	98
73-75		--	40	58	68	57	97	118	148	100	102
76-78		--	64	85	92	85	95	109	125	124	105
79-81		--	75	79	73	82	88	99	136	115	98

....continued

Table 2.6 (continued)

Value Added Per Person Employed by Sector and Province
(3 year average, national average = 100)

Year	Sector	N.F.	PEI	N.S.	N.B.	Que	Ont	Man	Sask	Alta	B.C.
61-63	FORESTRY	51	--	40	43	84	94	48	148	72	167
64-66		73	--	42	50	82	97	28	52	33	171
67-69		92	--	42	47	77	90	23	62	35	164
70-72		79	--	32	51	74	91	30	69	46	137
73-75		86	--	47	60	88	91	51	76	57	160
76-78		81	--	61	71	94	107	72	69	73	179
79-81		--	--	30	64	70	86	37	77	60	155
61-63	MINING	107	--	30	33	67	82	89	335	176	94
64-66		84	--	29	64	76	71	91	285	182	96
67-69		112	--	32	57	68	72	68	208	196	103
70-72		103	--	36	49	58	69	75	205	195	87
73-75		60	--	28	45	40	66	53	161	213	87
76-78		107	--	33	46	45	57	43	153	185	108
79-81		78	--	24	57	43	72	77	143	147	93
61-63	MANUFACTURING	119	102	77	79	79	94	107	138	143	146
64-66		102	95	79	82	84	90	105	147	136	145
67-69		109	63	84	85	87	91	108	120	121	135
70-72		164	93	88	85	84	95	102	134	111	140
73-75		118	91	82	110	92	91	94	185	129	114
76-78		113	66	98	89	101	81	97	113	130	106
79-81		103	63	84	77	93	80	86	118	131	112

....continued

Table 2.6 (continued)

Value Added Per Person Employed by Sector and Province
(3 year average, national average = 100)

Year	Sector	N.F.	PEI	N.S.	N.B.	Que	Ont	Man	Sask	Alta	B.C.
61-63	CONSTRUCTION	81	59	72	85	91	106	88	105	114	107
64-66		75	62	71	83	92	106	83	99	111	106
76-69		72	60	71	74	89	108	81	96	106	108
70-72		72	64	71	70	89	108	81	98	103	109
73-75		78	53	79	88	88	107	85	108	119	108
76-78		77	64	80	85	91	104	85	95	114	121
79-81		75	67	80	97	96	101	90	98	111	112

Sources: Statistics Canada: Estimates of Employees by Province and Industry, Catalogue 72-516, and System of National Account, Domestic Product by Industry, Survey of Production, Catalogue 61-202.

By closely observing Table 2.6, the following remarks could be made.

-- Output per worker in the Atlantic Provinces was substantially lower than in the rest of Canada. The low productivity was evident in every sector, except in the mining and manufacturing sectors of Newfoundland.

-- Output per worker in the Western Provinces (except Manitoba) was substantially above the national norm in almost every sector. In particular, the forestry sector in British Columbia, the agriculture and mining sectors in Alberta and Saskatchewan, and the manufacturing sector in Alberta, British

Columbia, and Saskatchewan are substantially above the national average in labour productivity.

-- Output per worker in Ontario was slightly above (construction) or slightly below (agriculture, forestry and manufacturing) the national average except in the mining sector where the output per worker averaged about 25 percentage points below the national norm between 1961 and 1981.

-- Output per worker in Quebec was below the national average in every sector. The manufacturing and construction sectors were below the national average by only a few percentage points.

Among the many factors[6] that are known to affect labour productivity, only the capital/employment ratio is discussed. This is due to the fact that increasing capital stocks in the low income regions is one of the main instruments of Canadian regional policy (more on this in the next section).

It is a widely held view that the higher the capital/employment ratio, the higher is the output per worker. A high capital/employment ratio implies more and perhaps, better machinery and equipment, which increases the productivity of labour. Our intention here, however, is not to test this hypothesis, but to provide the reader with a description of the differences in capital stocks per worker across the Canadian provinces. Table 2.7 presents capital/employment ratios for the Canadian provinces measured as percentages of the national average.

TABLE 2.7

Capital/Employment Ratios, by Province

(3 year average, national average = 100)

Year	N.F.	PEI	N.S.	N.B.	Que	Ont	Man	Sask	Alta	B.C.
67-69	124	83	87	95	87	93	106	121	120	133
70-72	133	83	92	97	86	93	109	119	121	127
73-75	138	83	92	97	85	93	109	118	119	124
76-78	139	79	93	102	88	93	110	115	119	120
79-81	133	79	92	104	91	94	109	113	119	114

Sources: Statistics Canada. Historical Labour Force Statistics. Catalogue 71-201. Data for Capital Stocks by Province generated by author (see chapter 3).

Table 2.7 reveals the following:

-- Newfoundland and the Western Provinces have capital/employment ratios above the national average with that of Newfoundland being the highest with up to 39 percentage points lead on the national average.

-- The other provinces have capital/employment ratios below the national average with that of Prince Edward Island and Quebec being the lowest.

The differences in capital/employment ratios across provinces become even more pronounced when the comparison is made at the sectoral level. Table 2.8 presents the capital/employment ratios by province for five separate sectors. These ratios are again presented as percentages of the national average.

TABLE 2.8

Capital/Employment Ratios by Sector and Province

(3 year average, national average = 100[7])

Year	Sector	N.F.	PEI	N.S.	N.B.	Que	Ont	Man	Sask	Alta	B.C.
67-69	AGRICULTURE	--	58	102	107	78	103	102	110	102	87
70-72		--	57	97	112	79	110	104	115	100	85
73-75		--	62	95	108	85	106	114	105	107	82
76-78		--	63	93	109	89	99	105	106	113	91
79-81		--	60	98	115	90	87	107	113	102	93
67-69	FORESTRY	139	--	60	78	93	105	34	40	39	131
70-72		123	--	40	65	76	87	32	34	35	148
73-75		120	--	38	52	80	86	26	29	35	153
76-78		103	--	52	51	96	85	35	31	32	132
79-81		101	--	48	65	94	80	38	35	36	146
67-69	MINING	119	--	33	60	85	75	75	191	137	142
70-72		114	--	44	54	87	75	75	199	146	142
73-75		108	--	54	59	82	80	70	196	139	121
76-78		104	--	53	55	80	77	78	162	147	115
79-81		100	--	50	52	80	80	84	142	135	111
67-69	MANUFACTURING	141	60	128	175	78	103	78	143	97	156
70-72		143	61	158	138	80	98	88	169	108	156
73-75		198	61	174	155	80	97	95	134	112	150
76-78		183	68	177	170	82	96	87	114	122	138
79-81		146	64	145	163	83	98	78	119	143	124
67-69	CONSTRUCTION	118	83	60	83	92	72	91	109	114	169
70-62		110	89	61	88	75	77	125	116	118	218
73-75		130	62	84	82	83	81	105	143	122	182
76-78		139	67	110	94	119	79	98	99	93	146
79-81		110	63	96	92	103	75	99	95	113	127

Sources: Statistics Canada: Estimates of Employees by Province and Industry, Catalogue 72-516. Data for capital stocks by province and industry generated by the author.

Table 2.8 reveals large differences in capital/employment ratios across provinces in every sector. Newfoundland and the three Western-most Provinces have, in general, higher capital/employment ratios than the rest of Canada. They are particularly high (at times double the national average) in the mining sectors in Saskatchewan and Alberta, the forestry and the construction sectors in British Columbia, and the manufacturing sector in Saskatchewan and British Columbia. Capital/employment ratios in the Atlantic Provinces, except Newfoundland, are significantly less than average in all sectors except manufacturing and agriculture in New Brunswick. The capital/employment ratio in the manufacturing sector in New Brunswick and Nova Scotia were the second highest among provinces during the period 1967-1981. Newfoundland has a higher than average capital/employment ratio in all sectors while Quebec and Ontario have capital/employment ratios below the national average in most sectors. In particular, the mining and construction sectors in Ontario trailed the national average by about 20 percentage points between 1967 and 1981, and the mining and manufacturing sectors in Quebec were also below the national average by about 20 percentage points during the same period.

The impact of capital/employment ratios on labour productivity across the Canadian provinces was estimated by Auer (1979). This impact varied widely across provinces as well as across industries. Auer's main results are summarized below.

In the case of Alberta, Saskatchewan and British Columbia the high capital/employment ratios have contributed fairly

significantly to high labour productivity in the manufacturing industry. In all other provinces, the impact of capital on labour productivity was far less consistent. In particular, the high capital/employment ratios in the manufacturing industries of New Brunswick and Nova Scotia have failed to increase the productivity of labour.

Another interesting indicator of capital use and performance is the partial productivity of capital measured by the output/capital ratio. Table 2.9 shows wide variations in output/capital ratios across provinces.

TABLE 2.9

Output/Capital Ratio by Province
(3 year average, national average = 100)

Year	N.F.	PEI	N.S.	N.B.	Que	Ont	Man	Sask	Alta	B.C.
67-69	74	69	89	79	104	117	84	71	87	78
70-72	61	76	87	79	105	118	82	68	89	80
73-75	54	78	83	81	102	111	83	89	103	86
76-78	57	79	85	76	101	108	82	88	112	88
79-81	58	81	83	76	100	105	79	90	114	93

Sources: Statistics Canada: Provincial Economic Accounts. Catalogue 13-213. Data on capital stocks per province generated by the author.

Ontario and Quebec had the highest output/capital ratios up to 1975, after which they experienced a gradual decline relative to the national average. Alberta has shown a significant increase in its output/capital ratio during the 1967-1981 period to take the lead at 14 percentage points above the national average in 1981. The other provinces have experienced lower than average output/capital ratios. However, while some provinces (British Columbia, Saskatchewan and Prince Edward Island) have increased their output/capital ratios relative to the national average, other provinces (Manitoba, New Brunswick, Nova Scotia and Newfoundland) have experienced a decline in their ratios relative to the national average.

What emerges from the examination of all of the above tables is that the Canadian provinces differ widely in terms of per capita incomes, factor productivities and factor intensities. These differences become more pronounced when examined on a sectoral basis. These differences tend to persist and are increasing in some cases. In the next section we examine Canadian regional policies aimed at narrowing these differences.

2.4 CANADIAN REGIONAL POLICY

2.4.1 Historical Review

In order to narrow the gap between the Canadian provinces, the Federal Government has adopted both fiscal and developmental policies.

Fiscal policy includes federal transfers to provincial governments as well as to individuals. Transfers to provincial governments in the form of tax concessions and equalization grants are justified theoretically by the fiscal equity criterion[8]. That is, the residents of a country should receive the same level of public service and incur the same tax burden irrespective of where they reside. The importance of such transfers has increased over the years, especially to the poor provinces where they account for almost 50 per cent of local and provincial government revenue per capita[9].

The importance of transfers to individuals, such as unemployment insurance, welfare payments, and family allowances is illustrated in Table 2.10, which shows transfers to individuals as a percentage of personal income. As a percentage of personal income, government transfers to the Atlantic Provinces are the most important and their importance has been increasing over time. In 1981 they represented, on average, about 20 per cent of

TABLE 2.10

Government Transfers as a Percentage of Personal Income Per Person, Geographical Distribution

N.F.	PEI	N.S.	N.B.	Que	Ont	Man	Sask	Alta	B.C.
16	17	11	14	9	9	9	13	8	7
18	17	12	12	8	6	9	8	9	8
23	20	14	16	11	9	11	12	11	10
27	22	17	19	15	10	11	12	10	12
27	23	17	19	15	9	12	13	9	11

Source: Statistics Canada: National Income and Expenditure Accounts. Catalogue 13-201.

personal income, and between 1961 and 1981 their importance increased by 68 per cent in Newfoundland, by 54 per cent in Nova Scotia, and by 35 per cent in New Brunswick and Prince Edward Island. The importance of individual transfers in Ontario and the Western Provinces is not only smaller, but has also increased more slowly during the past two decades.

Fiscal transfers are recognized to be a temporary remedy which do not offer a long term solution to regional disparities. In order to involve all the Canadian provinces in the growth process and in particular to stimulate the economies of the lagging regions, developmental measures were begun in the 1950s and were intensified during the 1960s and thereafter.

During the 1950s the problems confronting specific regions (mainly agricultural regions) were emphasized. A Royal Commission was appointed (the Gordon Commission) and its recommendations lead to the creation of ARDA (Agricultural and Rural Development Act). The focus of ARDA was the improvement of the standard of living of farmers, since a large proportion of them, particularly in Eastern Canada, were living very near the subsistence level. The main emphasis of policy was to increase the use of marginal land as well as to improve its quality, in order to slow migration from rural areas to urban centers. However, stable demand for food products in the face of rapid technological change in agriculture led to the failure of this policy. The income of farmers declined and a reduction in the number of farmers occurred[10].

The emphasis of policy in the sixties shifted from a preoccupation with land towards education and training of the rural labour force. In 1966 new legislation known as FRED (Fund for Rural Economic Development) was introduced. Its main goal was to identify severely disadvantaged areas to be eligible for special assistance. Under FRED the expenditure on training and education of the labour force was almost four times that on land improvement and development[11].

Policy has also been directed toward the industrial sector. In 1963 ADA (the Area Development Agency) was established.

Its major aim was to give incentives in terms of tax concessions and capital grants to industrial firms which locate in regions where unemployment was severe.

The Atlantic Provinces have received special attention from policy makers since they are the most disadvantaged region in Canada in terms of unemployment and income levels (see Section 2.2). In order to improve the welfare of the Atlantic Provinces and to stiumlate their economic development, legislation was passed in 1962 establishing ADB (the Atlantic Development Board). This board assumed the role of studying measures and projects to enhance the economic growth and development of the Atlantic region. Later it was given the power to prepare new plans and to coordinate existing plans for the promotion of economic growth. The expenditure of the board was mainly on infrastructure investments such as power and transportation facilities. ADB was replaced later by the ADC (Atlantic Development Council), which took the reduction of unemployment as its main objective.

The recognition of potential conflict and the lack of coordination among the many existing programmes and agencies led to the creation, in 1969, of the Department of Regional Economic Expansion, known as DREE. It was given the responsibility of coordinating and improving earlier programmes and of reconciling federal and provincial efforts in order to best serve the

slow-growth regions. DREE differed from previous agencies in its structure as well as its tasks. The power in DREE was decentralized. Different officials were made responsible for particular regions in order to better understand the specific problems of each region. The major objective of DREE was to reduce unemployment in the poorer regions of the country. In order to realize this objective a major new programme known as RDIA (Regional Development Incentive Act) was advanced. RDIA attempted to continue and correct the policy of ADA by giving capital subsidies to firms which are located in the depressed regions. RDIA officials believe that investment subsidies would create job opportunities for local people and therefore reduce unemployment.

The brief review presented above reveals that reduction of unemployment and increased levels of income in the poorer regions have been the major objectives of Canadian regional policy. Twenty years later, statistics show (see Tables 2.1 and 2.4) not only that such an objective is as far out of reach today as it was in the early sixties, but also that the unemployment problem in the depressed regions is getting worse. The above observation allows one of two conclusions: either that regional policy has failed, in the sense that it did not contribute to unemployment reduction in the depressed regions, or that the unemployment problem might have been even worse had regional

policy not been implemented.

What the economic situation might have been had the government refrained from following regional policy can never be known with any certainty. However, one can be sure that regional policy has not succeeded in solving the economic problems of the poor regions. The desirability of improved economic conditions in poorer regions is uncontested. However, the means of achieving it and the costs to be incurred were very much in question and remain a debatable issue among economists and policy makers. In the following subsection the means by which Canadian regional policy sought a solution to the economic problems of the lagging regions is discussed and the cost of such means is assessed.

2.4.2 The Cost of Canadian Regional Policy

The brief review of regional policy programmes reveals that the Federal Government seeks to reduce income disparities across provinces directly through fiscal transfers and indirectly through developmental measures aiming at reducing unemployment.

Fiscal measures such as government transfers and equalization payments have been attacked on the ground that they are costly in terms of aggregate efficiency. Courchene (1970, 1978) has argued that fiscal transfers induce people to remain in

-- or even move into -- poorer regions where their marginal productivity is lower than it would be in wealthier areas. In contrast, Boadway and Flatters (1982) argued that greater efficiency cost will arise if governments fail to eliminate interprovincial differences in net fiscal benefits. Efficiency requires that factors of production move between regions solely in response to differences in their productivities. Differences in net fiscal benefits across regions may distort the productivity signals, and thus factors may move from highly productive activities to less productive ones in other regions.

As for developmental policy, the government is seeking to reduce the unemployment rate in the low income regions by moving investment capital into these regions. The industrialization of the lagging regions, according to government officials, will absorb unemployed labour and at the same time will increase the productivity of labour by increasing the capital/labour ratio in these economies. Economists argue that the policy of giving locational subsidy to industrial firms does not ease the unemployment problem. Woodward (1974) argued that the DREE subsidy was capital biased in the sense that it lowers the cost of capital by a greater percentage points than it lowers the cost of labour and, therefore, reduces employment. The argument runs as follows: if a firm receives a capital subsidy in order to expand an existing plant or to locate a new plant in a given region, it increases the use of capital

relative to other inputs (labour in particular). However, the increase of production due to the expansion requires an increase in the number of employed people. The net result of those two opposing effects on employment could be either positive or negative.

In addition to Woodward's argument, Brewis (1969) argued that locational subsidies may represent windfall gains to capital owners if firms are willing to locate in designated areas without the subsidies[12]. Moreover, the question of long term profitability is also important. The amount of grants received is small when compared with the future returns of investment. If these grants are not a major element in the location decision of firms, then they would represent windfall gains to capital owners and thus not contribute to the development of the designated areas. On the other hand, firms that base their decision solely on the grants received may not be able to generate self-sustained growth in the future. In such a case, the locational subsidy may promote a decrease in unemployment in the short run but it may aggravate the problem in the long run, for it could slow down the movement of labour out of the depressed areas.

Regional policy based on discriminating capital subsidies is not the answer to the unemployment and income problems of slow-growth regions, according to the comparative advantage theory. Specialization of provinces in their comparatively efficient sectors is the policy recommendation of the advocates of this

theory. Green (1974) argues that concentration of activities in which the poor provinces have unique comparative advantages such as fishery-related industries in the Atlantic Provinces, would lead to an increase in their productivity and thus to an increase in their per capita income.

Apart from the above arguments and reservations, it seems that Canadian regional policy is aiming at the reduction of inequalities across provinces without any consideration of the cost to the aggregate economy. According to the policy act, DREE's major task is "to ensure that economic growth is dispersed widely enough across Canada to bring employment and earnings opportunities in the slow-growth regions as close as possible to those in other parts of the country without interfering with a high overall rate of national growth"[13]. One cannot claim that such an interference would not occur without formal study of the question in the Canadian context. The question of equity-efficiency compatibility is yet to be solved theoretically and the possible existence of a trade-off should be investigated empirically. Moreover, the question should not only be whether or not any regional programme interferes with national growth, but also whether the funds expended on such programmes have better alternative uses. Capital subsidies to firms in the slow-growth regions may well interfere with an efficient allocation of capital. Promoting, for example, manufacturing industries in the Atlantic region will

most probably have negative consequences for the aggregate efficiency of the economy. As Table 2.6 clearly shows, manufacturing industry in the Atlantic Provinces is far less efficient than in Central and Western Canada. Besides, the subsidy programme may lead to an inefficient allocation not only of capital but also of labour. The creation of short run employment opportunities could slow the movement of the labour force out of the depressed areas and consequently, labour may be employed in relatively inefficient activities.

Moreover, government agencies have carried out developmental programmes without any reference to any optimality criterion. If we are concerned with national growth, shouldn't we look at alternative uses of our resources that may allow us to achieve the same equity goals but at lower cost in terms of aggregate efficiency? It is well understood that the main concern of regional policy is the economic growth of the lagging regions, but what is the cost of promoting such a growth? Why was capital subsidy chosen as the means of promoting regional growth rather than labour or migration subsidy? Does a migration subsidy have the depopulation of certain areas as an inevitable consequence? Even if we believe that capital subsidy is effective in reducing the level of unemployment in the depressed regions, the method used in allocating those subsidies is still based on "partial equilibrium" analysis. It totally ignores other "bottlenecks" in the regional economies that are more restrictive than the capital constraint.

The interdependence and interaction between the factor supplies and other constraints of the economic system such as demand constraints, the balance of trade, the availability of finance and the constraints imposed by the accumulation (decumulation) of wealth are typically ignored in this analysis.

2.5 CONCLUDING REMARKS

In this chapter we have presented some indicative measures of regional disparities in Canada. The discussion has emphasized the degree of disparity, some of the associated factors and attempts to narrow the interregional gap. Among the main indicators of disparities are divergence in the income level, unemployment rates, participation rates, and productivity of factors of production. While the Federal Government has used fiscal as well as developmental measures to remedy the situation, its efforts did not lead to a significant reduction of regional disaprities. The efforts of the Department of Regional Economic Expansion (DREE) seem to lack a consistent and comprehensive basis. It has concentrated its activities on promoting the industrialization of the slow-growth regions. Capital subsidies were given to firms in order to locate in these regions without any comprehensive sutdy of either the possible policy alternatives or the cost of the pursued policies in terms of efficiency losses due to

misallocation of resources.

In the following chapter an economic model is presented that allows us to determine the optimal allocation of resources across regions and across industries. Such an allocation could be used, for example, to determine whether or not the movement of capital into the slow growing regions best serves the growth process. Moreover, the relationship between interregional equity and aggregate efficiency is investigated to see whether or not they are compatible, and if not, in order to quantify the cost of equity in terms of efficiency, the analysis is carried out within a general equilibrium framework where the interactions in the goods, factor and financial markets are explicitly introduced, thus allowing us to identify the most binding constraints facing the regional economies.

FOOTNOTES

Chapter 2

1. See T.N. Brewis (1978).

2. For a detailed discussion of the definition of economic regions, see among others, T.N. Brewis (1969).

3. See Economic Council of Canada, Third Annual Review (1966), and Table 2.1 (below).

4. The total factor productivity index has been widely used as a measure of efficiency since the late fifties. See, for example, Solow (1957), Kendrick and Sato (1963), and Denison (1967).

5. This increase, however, may be attributed to the increase in oil prices over this period.

6. Other factors that are known to affect labour productivity are: industrial structures, labour quality, technobogy, and management. See, for example, Denison (1967), and Auer (1979).

7. Data for capital stocks is generated for every sector in every region; see chapter 3. However, in order to make comparisons across sectors and across regions, one of two assumptions must apply: either capital stocks were fully employed in all sectors and all regions during the fifteen-year period, 1967 to 1981, or the rate of capacity utilization of capital was the same across sectors and regions.

8. See J.F. Grahan (1978).

9. See Economic Council of Canada, Second Annual Review (1965).

10. See T.N. Brewis (1969).

11. See T.N. Brewis (1969).

12. According to RDIA, locational subsidies are given to industrial firms that are not willing to locate in the depressed areas without the subsidies and that have positive long term profitability profiles. For more on this issue see T.N. Brewis (1969).

13. See Canada Yearbook (1969), pp. 1133.

CHAPTER 3

THE MULTIREGIONAL LINEAR PROGRAMMING MODEL

3.1 THE GENERAL CHARACTERISTICS OF THE MODEL

The use of the model to analyze aggregate efficiency and interregional equity, specifically necessitates the incorporation of both a number of regional features and general economic considerations. Three basic aspects are, however, critical for this model: the multiregional aspect, the general equilibrium aspect, and the optimality aspect. Let us consider each in turn.

3.1.1 The Multiregional Aspect

Economic activities are generally distributed unevenly over space. This is particularly the case in Canada, where there is substantial regional specialization. To take account of this feature of the Canadian economy, different spatial parameters are explicitly introduced into our model. The ten Canadian provinces are considered as ten separate economies characterized by different technologies (or production functions) and different limitations on their abilities to grow and sustain economic activities. The interaction among these regional economies is captured

by an interregional trade matrix and by the interregional mobility of factors of production.

3.1.2 The General Equilibrium Aspect

A number of bottlenecks constrain regional economic performance. They generally interact with one another in such a way that a general equilibrium framework is needed to capture this complex interrelatedness. The model takes into consideration three types of market in the economic system: goods markets, factor markets, and financial markets. In goods markets the supply side is constrained by the availability of factors of production and by the existing technology while the demand side is determined by intermediate demand and by the different components of final demand. Factor markets are constrained by the availability of factors of production. These factor market constraints impose upper limits on the output of each commodity in each region. However, these constraints can be relaxed by allowing for factor mobility across regions.

The financial market is introduced in order to intermediate between consumption and production. The ability of different regions to borrow from, or to lend to, other regions or abroad is specified in an explicit manner. Borrowing from outside the

region to finance consumption or investment reduces future wealth because of the cost of repayments, and lending outside the region increases regional wealth due to the accumulation of income-generating assets outside the region. Financial restrictions are viewed as necessary because one cannot allow some regions to borrow indefinitely in order to finance final demand. However, these regional financial constraints can be relaxed via the transfer of funds from the government sector.

3.1.3 The Optimality Aspect

The actual performances of the regional economies rarely reach their potential. To explore the potential capacity of the economy, an optimization exercise is needed. Linear programming is one available technique that fulfills this need. The linear programming exercise consists of optimizing an objective function subject to a set of constraints that depict a fairly realistic approximation of the set of feasible alternatives open to the economy. Linear programming allows us to get out to the boundaries of the constraint set and to select the best patterns of final demand and resource allocation from the many feasible alternatives.

The remainder of this chapter is devoted to a description of the model and the data sources. The various equations of

the model are described in Section 3.2. Section 3.3 discusses the ways in which some of the data were generated and Section 3.4 describes the general nature of the experiments to be conducted.

3.2 THE MODEL

This section is devoted to the presentation of the linear programming model, which includes the objective function to be optimized and a set of constraints describing the limitations of the economy. Subsection 3.2.1 describes the constraints of the model and subsection 3.2.2 presents the objective function. An analysis of the model is presented in subsection 3.2.3.

3.2.1 The Constraints

The constraints of the model are imposed at three levels of aggregation. The commodity balances are formulated at the commodity level. The financial constraints are imposed at the regional level, whereas the government budget constraint is imposed at the national level. Factor supply (or mobility) constraints may be imposed at four different levels: by industry and region; by region, by industry, or nationally. Let us consider each type of constraint in turn.

Commodity Balances

A set of commodity balances based on the 1979 regional input-output tables for Canada is formalized for each of 43 commodities in each of 10 regions (provinces). (The rectangular Canadian input-output data separates commodity and industry outputs). Thus, the commodity balances are made up of 430 equations (43 commodities × 10 provinces) relating the supply of each commodity in each region to the various sources of demand. The supply of each commodity consists solely of local production. The demand for each commodity consists of deliveries to intermediate demand and to final demand in the home region and in other regions, and of deliveries abroad (exports). Commodities produced in other regions and abroad are treated as non-competing imports. The final demand in the home region and in other regions consists of three components: consumption, investment (including inventory change), and government. While consumption and government represent two single final demand categories in each region, investment in fixed capital is broken down by industry in each region. The use of each commodity for intermediate input and final demand is broken down by supplying region (including abroad) according to the trade matrices in the regional input-output data. Thus the model would be classified as a "multi-regional" model in the regional input-output literature.[1]

The commodity balance equation for commodity i in region r can be written as:

$$(3.1) \qquad Q_i^r \geq \sum_{s=1}^{10} \left(\sum_{j=1}^{J^S} u_{ij}^{rs} X_j^S + c_i^{rs} C^s + g_i^{rs} G^s + \sum_{j=1}^{J^S} b_{ij}^{rs} I_j^s \right) + \overline{E}_i^r$$

$$r = 1,\ldots,10 \qquad i = 1,\ldots,43$$

where u_{ij}^{rs} is the amount of commodity i produced in region r used as intermediate input per unit of output of industry j in region s.

c_i^{rs} is the amount of commodity i produced in region r used per unit of consumption in region s.

g_i^{rs} is the amount of commodity i produced in region r used per unit of government spending in region s.

b_{ij}^{rs} is the amount of commodity i produced in region r used per unit of investment in industry j in region s.

Q_i^r is the output of commodity i in region r.

X_j^s is the output of industry j in region s.

C^s is the level of consumption in region s.

I_j^s is the level of investment of industry j in region s.

G^s is the level of government spending in region s.

and $\overline{E}_i^r$ is the fixed level of exports abroad of commodity i from region r.

The reader should notice that the structure of inter-regional trade is tightly constrained in this model since imports and exports by commodity and region are related by fixed coefficients

to gross output and fixed investment by industry and region and to consumption and government by region. This structure is necessary in order to reflect the spatial structure of the economy. Moreover, foreign trade is determined in a similarly tight manner. Exports by commodity and region are fixed in order to limit the ability of the economy to export abroad while foreign imports are determined in a manner identical to provincial imports and exports and can be written as:

$$(3.2) \qquad M_i^r = \sum_{j=1}^{J^r} u_{ij}^{fr} X_j^r + c_i^{fr} C^r + \sum_{j=1}^{J^r} b_{ij}^{fr} I_j^r + g_i^{fr} G^r$$

where M_j^r is the imports of commodity i to region r from abroad.

u_{ij}^{fr} is the imports of commodity i used as intermediate input per unit of output of industry j in region r.

c_i^{fr} is the imports of commodity i used per unit of consumption in region r.

b_{ij}^{fr} is the imports of commodity i used per unit of investment in industry j in region r.

and g_i^{fr} is the imports of commodity i used per unit of government spending in region r.

The second set of constraints relates commodity output to industry output. These constraints are based on the fixed-market-share assumption applied to the "make" matrix and distribute the total output of each commodity across supplying industries.

$$(3.3) \qquad X_j^r = \sum_{i=1}^{43} m_{ji}^r \, Q_i^r \qquad (\sum_j m_{ji}^r = 1)$$

where m_{ji}^r is the fraction of commodity i produced by industry j in region r.

Financial Constraints

A set of financial constraints is introduced that requires a balance in regional transactions with the outside. In these balances, and in the model, the government is treated as a non-resident sector.

$$(3.4) \qquad DNFA^r = \sum_{i=1}^{43} [(\overline{E}_i^r - M_i^r) + \sum_{s \neq r} \{(\sum_{j=1}^{J^s} u_{ij}^{rs} X_j^s - \sum_{j=1}^{J^r} u_{ij}^{sr} X_j^r +$$

$$+ (c_i^{rs} C^s - c_i^{sr} C^r) + (\sum_{j=1}^{J^s} b_{ij}^{rs} I_j^s - \sum_{j=1}^{J^r} b_{ij}^{sr} I_j^r)\}$$

$$+ \sum_{s=1}^{10} \sum_{j=1}^{J^r} g_i^{rs} G^s] + (\sum_{j=1}^{J^r} ncm_j^r X_j^r + ncm_j^r C^r) + gw^r G^r$$

...continued

$$+ GTR^r - DT^r - IT^r + \overline{PTR}^r$$

where $DNFA^r$ is the change in assets held outside region r.

ncm_j^r is the level of noncompeting imports per unit of output of industry j in region r.

ncm_c^r is the level of noncompeting imports per unit of consumption in region r.

gw^r is the amount of labour income per unit of government spending in region r.

GTR^r is the level of government transfers into region r.

DT^r is the level of direct taxes in region r.

IT^r is the level of indirect taxes in region r.

$\overline{PTR}^r$ is the fixed level of private transfers into region r.

Equation (4) indicates that the change in assets held outside region r is equal to the differences between injections into and leakages from the region.

The injections into the region include the exports to other regions and to the rest of the world, government transfers, government spending on commodities and government wage payments and net private transfers. The leakages from the region include imports from abroad and from other regions and direct and indirect taxes collected by the government.

Direct taxes include income taxes levied on labour income and income of unincorporated business, employers and employees'

contributions to unemployment insurance and to public service pensions, employers and employees' contributions to Canada and Quebec pension plans, succession duties and estate taxes and corporate taxes. Direct taxes are determined by the following equation:

$$(3.5) \qquad DT^r = \sum_{j=1}^{J^r} (t1^r\, val_j^r + t2_j^r\, va2_j^r + U1^r\, em_j^r) X_j^r + (U2^r + t1^r) gw^r\, G^r + \ldots$$

$$\ldots + t1^r\, va_c^r C^r + \overline{SD}^r$$

where $t1^r$ is the average tax rate on labour and unincorporated business income in region r.

val_j^r is labour and unincorporated business income per unit of output of industry j in region r.

$t2_j^r$ is the average tax rate on operating surplus of industry j in region r.

$va2_j^r$ is the operating surplus per unit of output of industry j in region r.

$u1^r$ is the average tax for unemployment insurance and public pension plans per employed person in region r.

em_j^r is employment per unit of output of industry j in region r.

$u2^r$ is the average tax for public service pension per unit of government wages in region r.

$\overline{SD}^r$ is the fixed level of succession duties and estate taxes in region r.

Indirect taxes include taxes collected on production, consumption and investment. The equation determining indirect taxes can be written as

$$(3.6) \qquad IT^r = \sum_{j=1}^{J^r} (it_j^r X_j^r + it_{bj}^r I_j^r) + it_c^r C^r$$

where it_j^r is the amount of net indirect taxes collected per unit of output of industry j in region r.

it_{bj}^r is the amount of net indirect taxes collected per unit of investment in industry j in region r.

and it_c^r is the amount of net indirect taxes collected per unit of consumption in region r.

Export and import duties associated with each region are not included in the definition of IT^r. Commodity exports are measured net of export duties in the input-output data. Export duties are treated as a transfer from abroad to the government, and thus, do not need to be deducted in the regional financial constraints (3.4). Imports are measured inclusive of duties so that import duties have already been included in the "$-M_i^r$" terms in equation (3.4). These duties must, however, be incorporated into the government financial constraint (see equation (3.9) below).

Regional Disposable Income and Consumption

Another important part of the model is a set of regional disposable income definitions and consumption equations. Regional disposable income is defined as the total value added at factor cost in production and consumption plus government wage payments and government transfers plus net private transfers into the region minus direct taxes. The disposable income definition is written as

$$(3.7) \qquad YD^r = \sum_{j=1}^{J^r} va_j^r X_j^r + va_c^r C^r + gw^r G^r + GTR^r + \overline{PTR}^r - DT^r$$

where YD^r is the level of disposable income in region r.

va_j^r is the amount of value added at factor cost per unit of output of industry j in region r.

va_c^r is the amount of value added at factor cost per unit of consumption in region r.

Related to the disposable income definition is a set of consumption equations. Consumption in this model is assumed to be a fixed proportion of disposable income.

$$(3.8) \qquad C^r = c_r YD^r$$

where c_r is the amount of consumption per unit of disposable income in region r.

Thus consumption is made endogeneous using a 'Keynesian' consumption function, implying that the model has the same basic structure as a simple 'Keynesian' macroeconomic model. In the input-output literature the model would be called a "closed" input-output model.

Government Budget Constraint

The disposable income definition (3.7) implies that regional income can be increased without limit through government transfers. Thus, a government budget constraint that limits the borrowing ability of the central government becomes necessary in order to limit the size of these transfers. This constraint relates government expenditures to government revenues. Government expenditures include government purchases of goods and services from the private sector and from abroad, government wage payments and government transfers into the regions. The revenue side includes direct and indirect taxes and customs duties. The difference between expenditures and revenues is defined to be the change in government assets. Thus, the government budget constraint can be written as:

$$(3.9) \qquad DNAG = \sum_{s=1}^{10} (DT^s + IT^s - gw^s G^s - GTR^s) - \sum_{i=1}^{43} \sum_{r=1}^{10} \left(\sum_{s=1}^{10} g_i^{rs} G^s + g_i^{rf} G^r \right) + \sum_{s=1}^{10} \sum_{i=1}^{43} (it_{ei}^s \, \overline{E}_i^s + it_{mi}^s \, M_i^s)$$

where DNAG is the net increase in government assets.

g_i^{rf} is the amount of foreign imports of commodity i used

per unit of government spending in region r.

it^s_{ei} is the amount of export duty collected per unit of export of commodity i in region s.

and it^s_{mi} is the amount of import duty collected per unit of import of commodity i in region s.

To limit the borrowing ability of the government an upper limit is imposed on the government deficit.

(3.10) $DNAG \geqq - \overline{DNAG}$

where $\overline{DNAG}$ is the upper limit on government borrowing.

This constraint imposes a limitation on the use of government policy, which is represented in the model by the allocation of both government transfers, GTR^r, and government spending, G^r, across regions.

Factor Endowment Constraints

A set of constraints on the availability of factors of production are imposed on the economy. Unless a factor is in excess supply, its availability may place an upper limit on production. The formulation of these constraints varies between two extremes. At one extreme, factors of production are totally immobile, the output of each industry in each region is constrained by the available capital

stocks and labour force in that industry and that region. Thus the maximum output of industry j in region r that can be produced given its endowments of capital and labour is constrained by

$$k_j^r \, X_j^r \leqq \overline{K}_j^r$$

(3.11)

$$l_j^r \, X_j^r + l_{cj}^r \, C^r + lg_j^r \, G^r \leqq \overline{LF}_j^r$$

where k_j^r is the capital stock required per unit of output of industry j in region r.

l_j^r is the labour required per unit of output of industry j in region r.

l_{cj}^r is the labour required per unit of consumption in region r.

l_{gj}^r is the labour required per unit of government spending on region r.

and $\overline{K}_j^r$, $\overline{LF}_j^r$ are the capital stocks and labour force available for industry j in region r.

Note that labour types are identified with industries and not with occupation or skill categories.

At the other extreme, factors are allowed to move freely across industries and across regions. In this case outputs by region and industry are constrained by the national availability of labour and capital.

$$\sum_{j=1}^{J^r} \sum_{r=1}^{10} k_j^r \, X_j^r \leqq \overline{K}$$

(3.12)

$$\sum_{j=1}^{J^r} \sum_{r=1}^{10} (l_j^r \, X_j^r + l_{cj}^r \, C^r + l_{gj}^r \, G^r) \leqq \overline{LF}$$

where $\overline{K}$ and $\overline{LF}$ are the national capital stock and labour force, respectively.

Other variants of the mobility assumption allow factors to move across industries within regions or across regions within industries. Cross-sectoral mobility within regions implies that the regional output is constrained by the regional availability of factors of production. In this case the factor constraints can be written as:

$$\sum_{j=1}^{J^r} k_j^r X_j^r = \overline{K}^r$$

(3.13)

$$\sum_{j=1}^{J^r} (l_j^r X_j^r + l_{cj}^r C^r + l_{gj}^r G^r) \leqq \overline{LF}^r$$

where $\overline{K}^r$ and $\overline{LF}^r$ are the capital stock and labour force available in region r.

Interregional mobility of factors within the same industries implies that factors of production are specialized. That is, factors can move across regions to perform the same jobs but cannot move to perform different jobs in the same region or in other regions. In this case the national output of a given industry is constrained by the availability of factors of production that are specialized in the production of that industry, and the constraints can be written as:

$$\sum_{r=1}^{10} k_j^r X_j^r = \overline{K}_j$$

(3.14)

$$\sum_{r=1}^{10} (l_j^r X_j^r + l_{cj}^r C^r + l_{gj}^r G^r) \leqq \overline{LF}_j$$

where $\overline{K}_j$ and $\overline{LF}_j$ are the capital stock and labour force available for industry j.

The interregional mobility of factors of production as specified in (3.12) and (3.14) is assumed to be costless and instantaneous. That is, the labour force and capital stocks are optimally allocated across industries and across regions, regardless of their historical allocation or the spatial frictions that may limit or retard their interregional mobility. Thus, experiments using these constraints may be interpreted as showing alternative configurations of the economy which could have arisen if existing labour and capital had been used in different industries and/or regions. While the specifications of capital mobility are left as described above, some measures are taken, in some experiments, to further constrain the spatial mobility of labour. These measures are introduced through a labour migration model.

Labour Migration Model

The spatial frictions which limit labour movement among regions are introduced in this study via a migration model. Interregional labour mobility is specified as a function of a family of socioeconomic variables, some of which are taken as exogenous and others as endogenous. The migration model adopted in this study was developed by Liaw and Ledent (1986). In this model interprovincial migration is the result of two decisions: first, the decision to outmigrate; and, second, the choice of a destination.

The operational form of the destination choice model is written as

$$(3.15) \qquad P_s/r.t = \exp(\beta' V_{rst}/\mu) / \sum_{k \neq r} \exp(\beta' V_{rkt}/\mu)$$

where $P_s/r.t$ is the probability that a person residing in province r at time t who has decided to migrate chooses province s as his destination,

V_{rst} is a vector of socioeconomic variables,

β is a vector of unknown parameters,

and μ is an unknown parameter.

The departure model takes the following form

$$(3.16) \qquad P_{r.t}(\Delta t) = \exp(\alpha_0 + \alpha' U_{rt} + \mu I_{rt}) / [1 + \exp(\alpha_0 + \alpha' U_{rt} + \mu I_{rt})]$$

and

$$(3.17) \qquad I_{rt} = \ell n[\sum_{k \neq r} \exp(\beta' V_{rkt}/\mu)]$$

where $P_{r.t}(\Delta t)$ is the probability that a person residing in province r at time t will outmigrate during the time interval $(t, t + \Delta t)$,

U_{rt} is a vector of socioeconomic variables at the origin.

I_{rt} is called the inclusive variable and is interpreted as the drawing power of all potential destination in the system on the residents of region r at time t.

α' is a vector of unknown parameters,

and α_0 is an unknown aprameter.

The model was estimated using the Maximum-Quasi-Likelihood Method and the results of the estimation are fairly satisfactory. All of the coefficients of the explanatory variables had the expected signs and were statistically significant at a 5 per cent level of confidence. The reported coefficient of determination had a value of 0.86. For our purposes, the destination and departure models were collapsed into a single model that accounts for both decisions:

$$P_{srt} = P_s/r.t \times P_{rt}(\Delta t) \tag{3.18}$$

where P_{srt} is the probability that a person residing in province r decides to migrate to province s in time interval $(t, t + \Delta t)$.

Substituting (3.15) and (3.16) in (3.18), we obtain

$$(3.19) \qquad P_{srt} = \{\exp(\beta' V_{rst}/\mu)/\sum_{k\neq r} \exp(\beta' V_{rkt}/\mu)\} \{\exp(\alpha_0 + \ldots$$

$$\ldots + \alpha' U_{rt} + \mu I_{rt})/[1 + \exp(\alpha_0 + \alpha' U_{rt} + \mu I_{rt})]\}$$

Equation (3.19) is nonlinear and cannot be incorporated into the linear programming model unless it is linearized. A linear version of (3.19) (see Appendix 3.1) takes the following form:

$$(3.20) \qquad M^{rs} = [1 + \{1 + \exp(k_{rs} - I_r)b_r\} \sum_i \frac{\beta_{rsi}}{\mu} (V_{rsi} - V^0_{rsi})$$

$$+ d_r \sum_j \alpha_j (U_{jr} - U^0_{jr})]M^{rs}_0$$

where M^{rs} represents the number of migrants from province r to province s,

and M^{rs}_0 represents the historical number of migrants from province r to province s.

Equation (3.20) explains the interregional movement of population. In order to convert it to labour force movement, equation (3.20) is multiplied by the participation rate at the province

of origin. Most of the explanatory variables are taken as exogenous in our model. The variables that are taken as endogenous include:

- the relative employment growth at the destination, which reflects the difference in employment opportunities between origin and destination, REG;
- the relative level of per capita government transfers to persons at the origin versus the rest of the nation, GTR; and
- the national unemployment rate which reflects the hypothesis that when this rate is high the risk of becoming (or remaining) unemployed is relatively high for migrants

The rest of the variables[2] are represented by the constant term Z in equation (3.21). The final form of the labour migration equation from province r to province s can be written as:

$$(3.21) \qquad LF^{rs} = Z + \alpha_1 REG + \alpha_2 GTR + \alpha_3 NUR$$

where α_1, α_2, α_3 are estimated coefficients.

Thus, the labour constraints imposed on the regional level become

$$(3.22) \qquad LF^r = LF_0^r + \sum_{s \neq r} (LF^{sr} - LF^{rs})$$

where LF^r is the labour force available in province r.

LF_0^r is the historical labour force in province r.

LF^{sr} is the labour force migrating from province s to province r.

LF^{rs} is the labour force migrating from province r to province s.

Equation (3.22) indicates that the available labour force in province r equals the historical labour force plus the net migration into the province.

Another spatial friction on labour force movement between provinces is introduced in the form of resource cost. Movement of people requires the use of resources mostly in the transportation sector. The resources used in the historical movement of the labour force are already included in the material balance equations. The movement of people generated by the model, however, might differ from its historical level and thus the requirement of resources for transportation will be different from that included

in the material balance equations. In order to take full account of the use of resources, interregional migration is split into historical migration and the difference between the historical level and the level generated by the model. Equation (3.22) can thus be rewritten as:

$$(3.23) \qquad LF^r = LF_0^r + \sum_{s \neq r} (LF_0^{sr} + \Delta LF^{sr}) - \sum_{s \neq r} (LF_0^{rs} + \Delta LF^{rs})$$

where ΔLF^{sr} is the difference between the actual and the historical levels of labour force movement from province s to province r.

and LF_0^{sr} is the historical level of labour force movement from province s to province r.

The requirement of resources necessary to accommodate the differences in labour force movement, ΔLF^{sr} are added to the material balance constraints[3].

The constraints which have been described in this section constitute a fairly realistic approximation to the barriers and the bottlenecks that are present in the economic system and which could constrain the optimal value of the objective function. The formalization of an objective function is presented in the following section.

3.2.2 The Objective Function

Ideally, the objective function should represent the welfare function of society. Since a social welfare function may, however, contain some noneconomic aspects which are difficult to measure or quantify, and since it can not be derived without being, in some sense, imposed[4], the level of disposable income is taken as a proxy for it. The optimization exercise consists then, of the maximization of the sum of regional disposable incomes.

$$(3.24) \qquad \text{Max } W = \sum_{r=1}^{10} YD^r$$

The maximization of the objective function implies that economic activities are allocated across industries and across regions in an optimal way, subject to the constraints of the model. Since we are dealing with fixed technology as well as fixed final demand coefficients, one would expect that production activities as well as final demand activities will be concentrated in the most efficient industries and regions of the economy. There are, however, some factors that may limit the concentration of economic activities. On the production side, these limiting factors are inherent in the structure of the interregional trade coefficients and in the availability of resources and their mobility. On the demand side, while

the concentration of consumption activities may be limited by the availability of resources to supply consumption goods, the concentration of investment is limited by the imposition of investment constraints on the regional level. These constraints restrict regional investments to be equal to their historical levels and take the following form:

$$(3.25) \qquad \sum_{j=1}^{J^r} I_j^r = \overline{I}^r$$

where $\overline{I}^r$ is the fixed level of investment in region r. The allocation of investment across industries, however, is left to be determined by the optimization process.

3.2.3 Analysis of the Model

In this subsection we attempt to analytically examine the implications of the specification of the model on the value of national disposable income (the objective function) and on the allocation of that income across regions. Aggregating the commodity balance constraints over all commodities yields an expression for regional exports abroad.

$$(3.26) \qquad \sum_{i=1}^{43} \overline{E}_i^r \leq \sum_{i=1}^{43} Q_i^r + \sum_{i=1}^{43} M_i^r - \sum_{i=1}^{43} \Big(\sum_{j=1}^{J^s} u_{ij}^{rs} X_j^s + c_i^{rs} C^s + g_i^{rs} C^s + \sum_{j=1}^{J^s} b_{ij}^{rs} I_j^s \Big)$$

The regional financial constraint (3.4) also yields an expression for regional exports abroad.

$$(3.27)\quad \sum_{i=1}^{43} \overline{E}_i^r = DNFA^r + \sum_{i=1}^{43} M_i^r - \sum_{i=1}^{43} \sum_{j=1}^{J^r} \sum_{s\neq r} [(u_{ij}^{rs} X_j^s - u_{ij}^{sr} X_j^r)$$

$$+ (b_{ij}^{rs} I_j^s - b_{ij}^{sr} I_j^r)] - \sum_{i=1}^{43} \sum_{s\neq r} (c_i^{rs} C^s - c_i^{sr} C^r)$$

$$- \sum_{i=1}^{43} \sum_{s=1}^{10} g_i^{rs} G^s + \sum_{j=1}^{J^r} ncm_j^r X_j^r + ncm_c^r C^r - gw^r G^r$$

$$- GTR^r + DT^r + IT^r - \overline{PTR}^r$$

Aggregating the industry's output (3.3) across industries yields

$$(3.28)\quad \sum_{j=1}^{J^r} X_j^r = \sum_{i=1}^{43} \sum_{j=1}^{J^r} m_{ji}^r Q_i^r = \sum_{i=1}^{43} Q_i^r$$

Aggregating the foreign import equation (3.2) over commodities yields

$$(3.29)\quad \sum_{i=1}^{43} M_i^r = \sum_{i=1}^{43} (\sum_{j=1}^{J^r} u_{ij}^{fr} X_j^r + c_i^{fr} C^r + \sum_{j=1}^{J^r} b_{ij}^{fr} I_j^r + g_i^{fr} G^r)$$

...continued

Substituting (3.28) into (3.26) and (3.29) into (3.27) using the indirect tax equation (3.6), and equating (3.26) and (3.27) yields:

$$(3.30)\quad DNFA^r + [\sum_{i=1}^{43}\sum_{j=1}^{J^r}(\sum_{s=1}^{10} b_{ij}^{sr} + b_{ij}^{fr}) + \sum_{j=1}^{J^r} it_{bj}^r I_j^r] + [\sum_{i=1}^{43}(\sum_{s=1}^{10} c_i^{sr}$$

$$+ c_i^{fr}) + it_c^r + ncm_c^r c^r] \leq \sum_{j=1}^{J^r}[1 - \sum_{i=1}^{43}(\sum_{s=1}^{10} u_{ij}^{sr} +$$

$$+ u_{ij}^{fr}) - ncm_j^r - it_j^r]X_j^r + gw^r G^r + GTR^r - DT^r + \overline{PTR}^r$$

Using the following identities

$$(3.31)\quad 1 = \sum_{i=1}^{43}(\sum_{s=1}^{10} b_{ij}^{sr} + b_{ij}^{fr}) + it_{bj}^r$$

$$(3.32)\quad 1 - va_c^r = \sum_{i=1}^{43}(\sum_{s=1}^{10} c_i^{sr} + c_i^{fr}) + it_c^r + ncm_c^r$$

$$(3.33)\quad 1 - va_j^r = \sum_{i=1}^{43}(\sum_{s=1}^{10} u_{ij}^{sr} + u_{ij}^{fr}) + ncm_j^r + it_j^r$$

$$(3.34)\quad \overline{I}^r = \sum_{j=1}^{J^r} I_j^r$$

and also using the regional disposable income definition (3.7), (3.30) yields a saving-investment relation:

$$(3.35) \qquad YD^r - C^r \geqq \bar{I}^r + DNFA^r$$

The inequality in (3.35) indicates that regional savings defined as disposable income minus consumption may exceed regional investment at home plus investment outside the region. This inequality is a consequence of the inequalities in the commodity balance constraints that allow the supply of each commodity to exceed the level of demand. In such a case the model is said to be supply determined. Gross output and disposable income is constrained only by the exhaustion of factors of production. The excess supply takes the form of unused output which contributes, however, to increasing the income level. Thus, income may exceed the sum of consumption and investment at home and abroad, and equation (3.35) can be written as

$$(3.36) \qquad YD^r \geqq C^r + \bar{I}^r + DNFA^r$$

In this case the use of disposable income as the argument in the objective function may be questionable. However, experiments with a supply determined model help in highlighting the role of the resource constraints and help also in exploring the productive capacity of the regional economies.

On the other hand, if the material balance constraints are specified as equalities, relation (3.36) will hold as an equality and the model is said to be demand determined. In such a case, no surplus output is allowed and regional income is limited by the level of demand in the home region, in other regions and abroad. Gross output in the demand determined model, will be constrained by the short side of the market.

In a multiregional context where the aggregate (national) disposable income is the objective, (3.36) yields

$$(3.37) \qquad \sum_{r=1}^{10} YD^r \geq \sum_{r=1}^{10} \frac{\bar{I}^r + DNFA^r}{(1 - c_r)}$$

(3.37) indicates that government spending and transfers should be allocated so as to increase asset accumulation ($DNFA^r$) in the region with the largest multiplier[5]. Regional multipliers, however, are not the only factors influencing the allocation process. The availability of factors of production also plays an important role in determining the cost of production of commodities that are delivered to final demand, which in turn affects the allocation of activities across regions. In particular, the cost of consumption in terms of primary resources plays a vital role in allocating the consumption activities among regions. Since regional consumption is directly related to regional disposable income, the maximization

process increases the disposable income of the region that has the lowest per unit cost of consumption first. Moreover, regional consumption levels largely determine the allocation of other economic activities across industries and across regions. Production activities (and consequently factors of production) are allocated in such a way that they support regional consumption levels. However, while consumption may be concentrated in a few regions in the optimal solution, production activities always exhibit a positive level in all industries across regions. Consumption in a given region may be set at a zero level in the solution, if resources can be transferred to other regions where the consumption activities are less costly so that total disposable income level is enhanced. Production, on the other hand, is tightly constrained by the material balance constraints and, in particular, by the interregional trade coefficients so that industry outputs across provinces are always positive. The value added generated by the production activities in the zero income (and consumption) level provinces are channelled out to other regions via the government transfer variables. As for investment, although it is fixed at the regional level, its allocation across industries within regions is based on two potentially conflicting goals. The first is to generate the largest value added, while the second is not to compete with consumption activities for scarce resources. The solution represents the optimal balance between these two goals.

3.3 DATA

The data used in this empirical exercise are based on the regional input-output tables and on interregional trade statistics for Canada. The value of some of the variables of the model, however, were not given in the above sources. They were either taken from other sources or were estimated or extrapolated. The variables that had to be estimated include: government transfers to provinces, GTR^r; direct taxes by province, DT^r; net private transfers into the provinces, PTR^r, and labour forces and capital stocks for each industry in each province.

Government transfers were computed from the provincial economic accounts as the sum of transfers to persons, subsidies, capital assistance and interest on debt less transfers from persons.

Direct taxes, as explained in the previous section (see equation (3.5)), are specified in terms of their components and are given in the provincial economic accounts. Direct taxes on corporations are specified in our model, per unit of output by industry and by province. While these figures are not available, total corporate tax by province are given in the provincial economic accounts. These figures were split among industries using the ratio of taxable income of corporations in a given industry to the

taxable income of corporations in the province as a whole (available in Taxation Corporations; Statistics Canada) as weights. An average of five years, centered on 1979, was calculated, which was then divided by industry output.

Net private transfers, PTR^r, were calculated indirectly from the provincial economic accounts. First, regional private saving was obtained by adding personal saving to corporate profits net of corporate profit taxes and dividends. Dividends were the only figures that were not available by province. A national dividend to corporate profit ratio was applied to regional corporate profits to obtain dividends by region. Second, regional private gross investment was deducted from regional private savings to obtain the change in assets held outside the province by the provincial private sector. Third, this estimate replaced the term $DNFA^r$ in the regional financial constraint, equation (3.4) and the value of net private transfers into the region was calculated as a residual.

Finally, a series of capital stocks by industry and province had to be generated. While data on national capital stocks per industry is available and published on a regular basis by Statistics Canada (catalogue 13-211), their regional counterpart were generated in a way that they add up to the national totals. A time series of investment by industry and province obtained from Statistics Canada (catalogue 61-205) starting in 1964 was used in the following formula:

(3.38) $$K_j^r(t) = (1 - d_j)K_j^r(t - 1) + I_j^r(t)$$

where $K_j^r(t)$ is the capital stock in industry j in province r at time t.

d_j is the national rate of depreciation of capital stocks in industry j.

$I_j^r(t)$ is the level of investment in industry j in region r at time t.

A national depreciation rate per industry was assumed to be uniform across regions and was calculated as the average over five years of the ratio of the capital consumption allowances to the capital stocks in a given industry. Capital stocks by industry and region for the base period (1964) were obtained as the average over five years of the ratio of repair expenditures to depreciation rates. Repair expenditures figures by industry and province are available from Statistics Canada (Catalogue 61-205).

The investment series, however, lumps all of the primary industries and the construction industry together. In order to allocate the the total capital stock for this group to its individual components a five-year average of the ratios of the value added of each individual industries to the total value added of the primary sector and of the construction sector were used in the following formula:

$$(3.39) \qquad I_j^r(t) = \frac{VA_j^r(t+1)}{\sum_{j=1}^{5} VA_j^r(t+1)} \sum_{j=1}^{5} I_j^r(t)$$

where $I_j^r(t)$ is the share of investment of industry j in region r, at time t;

and $VA_j^r(t+1)$ is the value added of industry j in region r at time t+1.

In this way total investment of the primary sector and the construction sector was allocated to its five components, namely: agriculture, fishing and hunting, forestry, mining, and construction.

The sum of capital stock for a given industry across regions is bounded by the given national capital stocks for that industry and the sum across industries of regional capital stocks is bounded by a given regional capital stocks. Since there are no data available on total regional capital stocks a series of data had to be generated. The same method as that of equation (3.38) was used. The regional depreciation rates used (d^r) were the weighted sums of the depreciation rates of industries. The weights used are the ratios of investment in provincial industries to total provincial investment.

$$(3.40) \qquad d^r = \sum_j d_j \left(\frac{I_j^r}{\sum_j I_j^r}\right)$$

where d^r is the depreciation rate in region r.

The generated total regional capital stocks were adjusted so as to make them equal to the total national capital stocks by the following formula:

$$(3.41) \qquad K^r = \frac{\sum_r GK^r}{\sum_j NK_j} \times GK^r$$

where GK^r is the generated capital stock in region r.

NK_j is the given (Statistics Canada) national capital stock in industry j.

A final adjustment to the capital stocks by industry and province was carried out to ensure that both sums -- across industries and across regions -- add up to the given national total. The biproportional constrained matrix method known as RAS[6] was used.

The value of other variables that were taken directly from other sources are employment and labour force by industry and province. They were obtained from Statistics Canada (unpublished data).

3.4 THE DESIGN OF EXPERIMENTS

Equity among the Canadian provinces is a major concern of regional policy-makers in Canada. The question of how to make the slow growing regions of Canada share in the general prosperity of the national economy without interference with overall national growth defines the focus of Canadian regional policy. The model developed here is used for a series of experiments that will help determine whether or not equality among the Canadian provinces unfavourably affects the aggregate efficiency of the economy. Aggregate efficiency is determined by an optimizing model that allocates economic activities to the regions and industries that are most efficient. The role of increasing the mobility of factors of production across regions and/or across industries in enhancing the efficiency of the Canadian economy is examined in detail. Free mobility of factors across industries within regions allows us to analyze the degree to which any region can raise its income by the mere reorganization of the production structures to make it more comformable with local resource endowments. A relaxation of this constraint that allows for free mobility of factor across regions and across industries shed some light on the importance of the role that the government can play by influencing labour migration and internal capital flows to steer the national economy towards its optimal level. Some other variants of this constraint are also considered; by allowing for one or both factors to be mobile and by allowing for mobility

across regions within industries reveals which industry should be expanded and in which region.

The free mobility of labour is assumed away in some experiments by incorporating a migration model that governs the movement of labour between regions. Such experiments allow us to examine whether or not the historical migration of labour is helping to improve the efficiency of the Canadian economy.

Interregional equity is introduced through constraints which impose equality of per capita incomes across regions. The question of whether or not the imposition of the equity constraints reduces the level of national income below that attainable otherwise is addressed under various assumptions of factor mobility. Such experiments reveal whether equality among provinces is achievable only through the depopulation of the slow growing regions or whether such equality can be achieved by increasing the level of economic activities in these regions.

FOOTNOTES

Chapter 3

1. For more on this specification see Miller and Blair (1985).

2. For a definition of these variables see Liaw and Ledent (1986).

3. Resources requirements that are necessary to accommodate labour movement between regions are introduced through cost coefficients. These coefficients were considered to reflect the cost of transportation per member of the labour force. They were calculated as the average transport cost by airplane per km multiplied by the distance between the major centers in the provinces. Since the movement of a member of the labour force entails the movement of his family the transport cost was multiplied by the inverse of the participation rates. This cost was split equally between the origin and destination provinces and was included in the material balance constraint equations.

4. For a detailed discussion of this issue see K.J. Arrow (1965).

5. The multipliers, however, are much more complex than indicated by equation (3.37). The substitution of the variable $DNFA^r$ by its value given in equation (3.4) and the use of the direct tax equation (3.5) yield a multiplier that accounts for all leakages out of the region.

6. For a detailed discussion of RAS see M. Bacharach (1970).

APPENDIX 3.1

In this appendix the linearization of equation 3.17 is presented. Rewriting equation (3.19) as equation (3.A.1) we get

$$(3.A.1) \quad P_{srt} = \{\exp(\beta' V_{rst}/\mu)/\sum_{k\neq r} \exp(\beta' V_{rxt}/\mu)\}\{\exp(\alpha_0 + \ldots$$

$$\ldots + \alpha' U_{rt} + \mu I_{rt})/[1 + \exp(\alpha_0 + \alpha' U_{rt} + \mu I_{rt})]\}$$

Since P_{srt} is the probability that a person residing in province r at time t decides to move to province s, the number of migrants from r to s can be obtained by multiplying P_{rst} by the population of province r at time t. The number of migrants from province r to province s can thus be represented after rearranging terms, by the following equation:

$$(3.A.2) \quad M^{rs}=P_t^r \exp[(\sum_i \beta_{rsi} V_{rsi}/\mu) + (\alpha_0 + \sum_j \alpha_j U_{jr} + \mu I_r)]/\{(\exp I_r)[1 + \ldots$$

$$\ldots + \exp(\alpha_0 + \sum_j \alpha_j U_{jr} + \mu I_r)]\}$$

where M^{rs} represents the number of migrants from province r to province s.

and P_t^r is the population of region r at time t.

A linear approximation of (3.A.2) taken about the historical values, is written as:

$$(3.A.3)\quad M^{rs} \simeq M_0^{rs} + \left(\frac{\partial M^{rs}}{\partial V_{rsi}} + \frac{\partial M^{rs}}{\partial I_r}\frac{\partial I^r}{\partial V_{rsi}}\right)\Bigg|_0 (V_{rsi} - V_{rsi}^0) + \frac{\partial M^{rs}}{\partial U_{jr}}\Bigg|_0 (U_{jr} - U_{jr}^0)$$

Let us calculate each term separately.

$$(3.A.4)\quad \frac{\partial M^{rs}}{\partial V_{rsi}} = \frac{\beta_{rsi}}{\mu} M^{rs}$$

$$(3.A.5)\quad \frac{\partial M^{rs}}{\partial I_r} = \mu M^{rs} - \Bigg| \{\exp[(\sum_i \beta_{rsi} V_{rsi}/\mu) + (\alpha_0 + \sum_j \alpha_j U_{jr} + \mu I_r)]\}$$

$$/\{(\exp I_r)[1 + \exp(\alpha_0 + \sum_j \alpha_j U_{jr} + \mu I_r)]\}^2 \Bigg|$$

$$\Bigg| (\exp I_r)\,[1 + \exp(\alpha_0 + \sum_j \alpha_j U_{jr} + \mu I_r)] + \mu(\exp I_r)[\exp(\alpha_0 + \ldots$$

$$\ldots + \sum_j \alpha_j U_{jr} + \mu I_r)] \Bigg|$$

Substituting for M^{rs} by its value from (3.A.2) in (3.A.5) and rearranging terms we get

$$(3.A.6)\quad \frac{\partial M^{rs}}{\partial I_r} = M^{rs} \Bigg| \mu - \{(\exp I_r)[1 + \exp(\alpha_0 + \sum_j \alpha_j U_{jr} + \mu I_r)] + \ldots$$

$$\ldots + \mu(\exp I_r)[\exp(\alpha_0 + \sum_j \alpha_j U_{jr} + \mu I_r)]\}/(\exp I_r)[1 + \ldots$$

$$\ldots + \exp(\alpha_0 + \sum_j \alpha_j U_{jr} + \mu I_r)] \Bigg|$$

The final form of (3.A.6) can be written as:

$$(3.A.7) \quad \frac{\partial M^{rs}}{\partial I_r} = M^{rs} \left| -1 + \frac{\mu}{1 + \exp(\alpha_0 + \sum_j \alpha_j U_{jr} + \mu I_r)} \right|$$

The other terms in equation (3.A.3) are equal to

$$(3.A.8) \quad \frac{\partial I_r}{\partial V_{rsi}} = \frac{\beta_{rsi}}{\mu} \exp(\sum_i \beta_{rsi} V_{rsi}/\mu - I_r)$$

and

$$(3.A.9) \quad \frac{\partial M^{rs}}{\partial U_{jr}} = \alpha_j M^{rs} \frac{1}{1 + \exp(\alpha_0 + \sum_j \alpha_j U_{jr} + \mu I_r)}$$

Substituting (3.A.9), (3.A.8), (3.A.7) and (3.A.4) into (3.A.3), and using the simplifying terms (3.A.10) to (3.a.12):

$$(3.A.10) \quad K_{rs} = \sum_i \beta_{rsi} V_{rsi}/\mu$$

$$(3.A.11) \quad b_r = -1 + \frac{\mu}{1 + \exp(\alpha_0 + \sum_j \alpha_j U_{jr} + \mu I_r)}$$

$$(3.A.12) \quad d_r = \frac{1}{1 + \exp(\alpha_0 + \sum_j \alpha_j U_{jr} + \mu I_r)}$$

(3.A.3) can be written as

$$(3.A.13)\quad \frac{M^{rs}}{M_0^{rs}} = 1 + \{1 + \exp(K_{rs} - I_r)b_r\}\sum_i \frac{\beta_{rsi}}{\mu}(V_{rsi} - V_{rsi}^0)$$

$$+ d^r \sum_j \alpha_j (U_{jr}' - U_{jr}^0)$$

CHAPTER 4

RESULTS OF THE EFFICIENCY EXPERIMENTS

4.1 INTRODUCTION

This chapter and the next are devoted to the presentation and explanation of the results that have emerged from the optimization experiments. This chapter deals with the efficiency experiments where the model allocates economic activities to those industries and regions that most increase the value of national disposable income regardless of its allocation across regions. In the next chapter the equity experiments are analyzed when the equality of income per member of the labour force across provinces is imposed on the model. In each of those two cases the importance of factor mobility across industries and/or across regions is examined and the relative significance of supply versus demand specifications of the model is investigated.

The analysis is concentrated around the following variables: regional disposable income; government transfers into the regions; regional asset accumulation outside the regions; gross output by industry and region, and the government budget deficit (or surplus). The three facets of the results that are stressed are: the value

that the relevant variables attain; the extent to which upper or lower bounds are binding, and the value of the shadow prices of the constraints. While the first two relate to the solution values of each variable, the third can be interpreted as the extent to which the value of the objective function could be raised by relaxing the relevant constraint by one unit.

In what follows, the efficiency gains resulting from the reallocation of labour and capital are discussed in Section 4.2. Section 4.3 examines the allocation of economic activities across regions associated with different configurations of mobility of labour and capital. The relative significance of supply versus demand specifications of the model is examined in Section 4.4. Section 4.5 analyzes the effects of imposing labour migration equations and the cost of labour movement on the programming model, and Section 4.6 summarizes the main results of the chapter.

4.2 THE EFFICIENCY GAINS FROM THE REALLOCATION OF LABOUR AND CAPITAL

In this section, the efficiency gains, measured by the increase in the value of the objective function, that result from the allocation of factors of production across regions and/or across industries are examined. For this purpose, several optimization experiments were performed under different mobility configurations of labour and capital.

Different factor mobility configurations generate different patterns of consumption and production as can be clearly seen from the results displayed in Tables 4.1 and 4.2. Restricting the mobility of labour and capital results in efficiency losses to the economy. As the allocation of primary resources becomes more constrained, production and consumption activities are forced into less efficient industries and regions. The magnitude of those efficiency losses can be assessed by comparing the values of the objective function associated with different experiments (or different configurations of primary resource mobility). The following pattern emerges:

First, the efficiency losses resulting from constraining resource mobility are large, with the value of total disposable income (and consumption) under the least constrained solution being 36 per cent higher than its value under the most constrained solution. In this most constrained case where both labour and capital were fixed by industry and region at the historical level capital stocks were totally exhausted in some industries across regions. The most binding capital constraints (i.e., those that carried relatively high shadow prices) were those of the mining industry in New Brunswick, the manufacturing industries in Ontario and Quebec and the construction and housing industries in Ontario and in the four Western Provinces. The labour constraints were not binding in any industry across regions due to the relatively high level of unemployment that existed across the Canadian provinces in 1979. Thus, increasing the mobility of labour movement when

TABLE 4.1

Values of the Objective Function Associated with Different Mobility Configurations of Labour and Capital

Capital \ Labour	No Mobility	Regional Mobility	Mobility Within Industries	Full Mobility
No mobility	182304.9	182304.9	182304.9	182304.9
Regional mobility	222855.9	223681.4	224505.1	224505.1
Mobility within industries	213989.0	222395.3	230563.6	230563.6
Full mobility	225282.9	233901.5	245129.6	248090.6

Figures are in millions of 1979 dollars

TABLE 4.2

Values of Gross Output Associated With Different Mobility Configurations of Labour and Capital

Capital \ Labour	No Mobility	Regional Mobility	Mobility Within Industries	Full Mobility
No mobility	387264.1	387264.1	387264.1	387264.1
Regional mobility	425407.5	423613.8	425559.9	425559.9
Mobility within industries	414259.9	426650.2	438965.8	438965.8
Full mobility	432824.7	452193.0	461964.0	466044.5

Figures are in millions of 1979 dollars

capital is not mobile does not increase the value of the objective function (Table 4.1, row 1).

Second, increasing the mobility of capital with fully constrained labour results in significant increases in income. When capital is fully mobile across industries and regions, income rises to $225.8 billion. The mobility of capital is more productive across industries within regions ($222.8 billion) than across regions within industries ($213.9 billion). This indicates that a reallocation of capital across industries within regions improves efficiency more than its reallocation across regions. The inter-industry mobility of capital allows unused capital stocks to be shifted to industries in which capital is in short supply. As a result, regional capital stocks were completely utilized when capital was reallocated across industries within regions. All of the regional capital constraints displayed positive shadow prices in the solution. On the other hand, when capital was mobile across regions within industries, all of the sectoral capital constraints, except that of the housing industry, were nonbinding. Five per cent of the national capital stock was idle. The unused stocks were mostly in the utilities industry and in the trade and finance industry. In this experiment, the labour constraints became the most binding, as they displayed relatively high shadow prices in the solution.

Third, when labour and capital are both mobile across regions within industries, the efficiency gains ($230.7 billion)

are higher than in the case where both are mobile across industries within regions ($224.6 billion). In both cases capital stocks were the binding factors. They were completely utilized in all provinces except in Newfoundland, Prince Edward Island and British Columbia, when capital was allowed to move within regions and in the agriculture, fishing, forestry and housing industries, when capital was allowed to move across regions within industries.

Fourth, the full mobility of capital coupled with regional or within industry mobility of labour results in higher income gains than in the case when labour is fully mobile and capital is mobile either within regions or within industries. Again, capital stocks are the binding constraints. Increasing the flexibility of capital contributes significantly to increasing the value of the objective function. As for the contribution of labour mobility, it becomes more important when coupled with some flexibility of capital. However, the best results in terms of efficiency gains are achieved when both factors move together and in the same direction.

The changes in the value of total gross output do not always respond to different factor mobility assumptions in the same manner as disposable income. Increasing national disposable income does not necessarily mean increasing total production. The changes in production levels are affected mainly by the level and composition of regional consumption. In order to satisfy regional consumption demand, production activities may be shifted to industries that do not

necessarily have the lowest factor/output ratios. The values of total gross output associated with different factor mobilities are reported in Table 4.2. Increasing the flexibility of one or both factors contributed to increasing the value of gross national output except in one case: when both factors are mobile across industries within regions. The value of the objective function has increased from $222.8 billion to $223.7 billion, whereas the value of gross output has decreased from $425.4 billion to $423.6 billion, as a result of increasing labour mobility (Tables 4.1 and 4.2).

In order to get further insight into these results, the allocation of activities across regions are examined. The next section deals specifically with this issue.

4.3 THE ALLOCATION OF ACTIVITIES ACROSS REGIONS

In this section, the allocation of economic activities across regions is analyzed in detail. The values of the aggregate variables of the previous section are further investigated by focusing on the allocating mechanisms of economic activities and on specific limitations of the regional economies.

Although consumption and production are separated in this model, their allocation across provinces are not. The allocation of production responds mainly to satisfy the level of regional consumption due to its close relation to disposable income.

Production activity in any industry ceases to increase, however, as soon as the available primary inputs or the required intermediate inputs necessary to support consumption are exhaused. The allocation of consumption (and income) on the other hand, is the result of two effects: the regional multipliers (equation 3.37) and the cost of regional consumption -- the cost of production of commodities that are delivered to consumption. Consumption activity in a given region is costly if the output of commodities needed to satisfy consumption in that region is in short supply; that is, when the production of these commodities is no longer possible due to the exhaustion of resources that are used in their production. The shadow prices allow the costs and benefits of regional consumption to be compared. The benefits are given in the primal problem by the term $1/c_r\ YD^r$; because by increasing regional consumption by one unit, the objective function increases by $1/c_r$ units. The cost of regional consumption is obtained from the marginal valuations (shadow prices) of the regional consumption equations (3.8), which can be written as:

$$(4.1) \qquad - C^r + c_r\ YD^r = 0$$

The shadow prices of these equations, which represent the increase in the value of the objective function due to an increase of the right hand side of these equations by one unit, can be written in

terms of the benefit-cost equations in the dual problem. (The tableau representing both the primal and dual problems is presented in Appendix 4.1). By going down the YD^r column in the tableau , the corresponding dual equation can be written as:

(4.2) $$- \lambda_{yd^r} + \lambda_{c_r} c_r \geqq 1$$

where λ_{yd^r} and λ_{c_r} are the marginal valuations (shadow prices) of YD^r and C^r, respectively.

If YD^r is positive, the equality holds in equation (4.2) and the corresponding consumption activity must cost out. That is, the cost of an extra unit of consumption is exactly equal to the extra benefits contributed to the objective function. On the other hand, if the marginal cost of a consumption activity exceeds its marginal benefits, that activity and the associated YD^r will be zero. Thus, if equation (4.2) is an inequality the corresponding level of regional consumption is zero in the optimal solution.

Equation (4.2) implies that the marginal valuation of regional consumption includes not only the resource cost but also the cost of increasing disposable income. Solving equation (4.2) for the marginal valuation of consumption yields:

(4.3) $$\lambda_{c_r} \geqq (1 + \lambda_{yd^r})/c_r$$

The term λ_{yd^r}/c_r represents the cost of increasing disposable income in region r by one unit. One way in which disposable income in region r can be increased is by the transfer of funds. Increasing the consumption of one region in this way increases the income of that region at the expense of other regions, (or at the cost of additional government borrowing). Since all regions are competing for government transfers, increasing these transfers to one region reduces the amount of transfers allocated to the rest of the nation. In the case where the government budget constraint is binding, that is when the government budget deficit has reached its lower level (imposed in our case as the historical level), increasing regional income by increasing government transfers entails a positive cost. This cost is reflected in the shadow price of the definition of disposable income, which is equal in absolute value to the shadow price of the government budget constraint.

The cost of regional consumption, however, varies with the availability of factors of production. The allocation of consumption (and income) and production across regions is altered as a result of allowing for different degrees of mobility of these factors. Four cases are studied at length: First, factors are fixed by industry and region at the historical level; second factors are mobile across industries within regions; third, factors are mobile across regions within industries, and fourth, factors are mobile across both industries and regions.

4.3.1 Factors Fixed at Historical Levels

In this experiment, the binding constraints facing the regional economies are identified under the assumption that both labour and capital are fixed by industry and region at their historical values. Moreover, the results of this experiment serve two purposes: first, as a checking devide to see whether or not the model can reproduce the historical values of national income, and second, as a reference point for other experiments.

The results of the experiment where both labour and capital are fixed are presented in Tables 4.5 and 4.6. Table 4.5 displays the allocation of gross output by industry and region and Table 4.6 displays the regional allocation of other activities, namely, disposable income, consumption and its shadow price, government transfers, private asset accumulation, government accumulation and its shadow price. A comparison of Table 4.5 and Table 4.3, where the historical values of output by industry and province are presented, reveals that total gross output in the optimal solution was less than its historical value by 12 per cent. The variation of regional gross outputs from their historical values, however, were more significant. Gross output were particularly low in the Atlantic Provinces where the reduction below the historical value amounts to 36 per cent in Newfoundland, 67 per cent in Prince Edward Island, 54 per cent in Nova Scotia and 46 per cent in New Brunswick.

TABLE 4.3

Historical Values of Gross Output by Province and Industry

	Nfld	PEI	NS	NB	Que	Ont	Man	Sask	Alta	BC	Total
Agriculture	29.3	123.5	187.9	128.9	2077.6	4154.7	1302.0	2730.1	2958.2	726.2	14418.4
Forestry	55.1	0.1	94.3	233.6	707.6	571.7	37.3	57.9	74.1	2617.2	4449.3
Fishing	158.9	29.8	228.8	55.6	53.7	44.8	21.4	13.6	12.7	338.1	957.2
Mining	1128.7	0.5	238.6	282.7	1675.5	2377.3	478.9	1944.3	14060.5	2649.7	24837.1
Manufacturing	1040.7	222.0	3377.2	3250.2	41844.1	79603.3	4396.6	1919.1	9165.2	1555.1	160371.2
Construction	864.7	183.3	1121.1	1105.3	8860.6	12081.8	1522.3	2168.5	9662.4	5781.6	43280.0
Utilitiex	666.6	110.0	1085.9	982.6	7949.0	14197.9	2411.1	1547.4	4740.8	5220.3	38912.1
Trade and Finance	891.8	223.8	1693.5	1588.0	16930.3	27123.1	2955.1	2810.9	10577.9	8257.3	73052.0
Institutions	1111.5	225.5	1609.2	1325.6	16477.2	25402.8	2531.5	2280.0	7270.2	9035.7	67269.4
Housing	225.9	66.4	449.5	331.2	2237.6	6122.0	588.6	527.0	1649.4	2088.5	14286.1
Total	6173.4	1185.1	10086.3	9283.8	98813.6	171607.7	16245.1	15999.3	60171.8	52267.6	441834.2

Figures are in millions of 1979 dollars

TABLE 4.4

Historical Values of Selected Variables

	YD^r	GTR^r	NFA^r	c^r	LF^r	EMP^r	DNAG
Nfld	3279.0	1379.0	-397.0	0.774	201.1	170.8	
PEI	702.4	265.0	-95.0	0.689	53.3	47.5	
NS	5421.6	1765.0	-547.0	0.755	368.9	333.98	
NB	4468.0	1479.0	-510.0	0.716	279.1	249.1	
Que	44707.0	13009.0	-3495.0	0.758	2917.9	2640.1	
Ont	71715.9	15828.0	-1143.0	0.707	4304.6	4026.6	
Man	7526.8	1902.0	-312.0	0.726	481.2	455.8	
Sask	6659.7	1962.0	-880.0	0.664	433.2	415.5	
Alta	15788.2	3344.0	-6887.0	0.686	1055.0	1014.2	
BC	21547.2	4457.0	-3345.0	0.734	1252.4	1157.7	
Total	181816.0	45390.0	-17611.0		11347.2	10511.2	-28787.2

All figures except c^r are in millions of 1979 collars.

TABLE 4.5

Values of Gross Output by Province and Industry; Capital and Labour are Fixed by Province and Industry

	Nfld	PEI	NS	NB	Que	Ont	Man	Sask	Alta	BC	Total
Agriculture	7.5	71.1	82.6	70.4	1658.4	3862.7	1242.4	2663.0	2737.4	693.1	13088.6
Forestry	39.2	0.1	54.8	172.5	635.5	540.7	36.2	52.7	70.4	2754.8	4176.7
Fishing	121.3	17.6	158.5	52.8	59.3	43.5	21.4	13.4	12.7	323.8	804.3
Mining	1045.3	0.1	161.3	282.7	1579.2	2196.8	397.6	1879.9	13227.1	2549.4	23319.4
Manufacturing	790.6	125.2	2172.6	2445.6	3593.7	72235.8	4034.9	1184.1	8605.7	14981.1	143121.0
Construction	864.8	30.7	527.4	228.2	5642.9	12009.8	1522.3	2168.6	9662.4	5781.6	38438.9
Utilities	303/7	35.6	407.8	507.9	6208.2	12477.7	2102.7	1399.3	4283.3	4823.1	32549.5
Trade and Finance	278.9	66.3	583.6	720.6	14015.1	25402.8	2840.1	2801.7	10577.9	8257.3	65504.4
Institutions	548.0	50.3	495.3	562.1	12237.0	21295.6	2046.8	1915.7	6300.8	7941.4	53393.1
Housing	0.0	0.0	0.0	0.0	1735.0	6122.0	588.6	527.0	1649.4	2088.5	12711.3
Total	3999.2	396.9	4643.9	5032.9	79697.1	156187.4	14833.1	15215.3	57127.1	50014.1	387264.1

Figures are in millions of 1979 dollars

TABLE 4.6

Allocation of Activities Across Provinces; Capital and Labour are Fixed by Province and Industry

	YD^r	C^r	$\lambda_c{}^r$	GTR^r	$DNFA^r$	DNAG	λ_{DNAG}
NFLD	0.0	0.0	2.24453	-448.0	-1059.6		
PEI	0.0	0.0	5.78864	-4.1	-209.4		
N.S.	0.0	0.0	2.24665	-671.1	-1412.6		
N.B.	0.0	0.0	8.94718	-1026.9	-1658.8		
Que	38115.1	28922.6	1.31783	16091.0	-3580.0		
Ont.	80992.1	57304.6	1.41336	31909.2	4244.3		
Man.	8461.5	6148.6	1.37617	3808.3	48.5		
Sask	8172.4	7427.7	1.50568	3507.2	-5758.5		
Alta	21905.8	15048.5	1.45568	7296.7	-6051.8		
B.C.	24657.9	18120.7	1.36076	8622.0	-1812.9		
Total	182304.3	130972.7		69084.3	-12070.6	-10419.5	0.0

All figures except λ_{c^r} and λ_{DNAG} are in millions of 1979 dollars.

This reduction was evident in every industry except the construction industry of Newfoundland and the mining industry of New Brunswick, where the output levels were equal to their historical levels. Gross output in the other provinces was also lower than the historical level, but the percentage reduction was much less than that in the Atlantic Provinces: 20 per cent in Quebec, 8 per cent in Ontario and Manitoba, and about 5 per cent in Saskatchewan, Alberta and British Columbia. The reduction of gross output was also evident in almost all the industries in these provinces except the housing and construction industries in Ontario and in the Western Provinces and the trade and finance industries in Ontario, Alberta and British Columbia.

The fact that the level of gross output is below the historical level in most industries is not surprising. Fixing both factors of production at their historical levels implies that the gross output of any industry in any region cannot exceed its historical value, since in calculating the capital coefficients, we have assumed that capital stocks are fully employed[1]. The historical level of output thus represents an upper bound that cannot be exceeded.

The allocation of output across regions is the consequence of the allocation of disposable income (and consumption). The fairly low level of output in the Eastern Provinces is directly linked to the zero level of disposable income in these provinces (column 1,

Table 4.6). This is because consumption activities in these provinces do not cost out. The marginal cost of producing consumption goods exceeds their marginal benefit. As can be seen from column 3, Table 4.6, the marginal costs of consumption represented by the shadow prices on the consumption equations have exceeded the marginal benefits represented by $1/c_r$ for the four Eastern Provinces. The marginal cost of consumption in Newfoundland, for example, which is equal to 2.24, exceeds $1/c_r = 1/.774 = 1.291$.[2] (The values of the marginal propensities to consume are given in Table 4.4).

The consumption activities in these provinces are costly due to the fact that the scarce resources needed to produce consumption goods for local consumption can be used in other provinces where consumption activities cost less in terms of these resources. The most scarce resource in this case was the output of the mining industry in New Brunswick. Since the gross output of this industry has reached its upper limit and since this industry delivers heavily to consumption in the Eastern Provinces in the form of final demand as well as intermediate demand, the model minimizes the deliveries of this industry to the Eastern Provinces, in order to satisfy the high level of demand in other provinces, by driving the level of consumption down to zero. As a result of the zero consumption level, the production activities in the Atlantic Provinces are operated only

to meet the requirements of investment at home and of intermediate and final demand in other regions and abroad as implied by the interregional trade matrix and by the fixed level of exports abroad. The value added generated by the positive production levels in these provinces was channelled out to other provinces through the government transfer variables, as they display negative values in the solution (column 5, Table 4.6).

The lower than historical output levels in the other provinces can be similarly explained. The deliveries to the Eastern Provinces of intermediate and final demand are lower than their historical values due to the low level of production and to the zero level of consumption in these provinces. Moreover, government spending in these regions and in the rest of the country is set at a zero level. The reason being that government transfers are more efficient in increasing national income than is government spending, which uses up scarce resources that could otherwise be used to produce consumer goods. Thus, government transfers into all provinces have increased by 52 per cent over their historical level. This increase, combined with a zero government spending level has generated a budget deficit which is 64 per cent lower than its historical value.

As for the total private regional transactions with the outside, they show a net deficit of $12.1 billion, which is 32 per cent lower than the historical deficit. The level of this deficit varies considerably among regions when compared to its historical

level. While there were surpluses in Ontario and Manitoba, the deficits in Quebec and the other Western Provinces were moderately lower, and the deficits in the Eastern Provinces were much higher than their historical levels. On average, the deficit in the Eastern Provinces was 2.8 times the historical deficit. The reason for this large deficit is the zero level of income (and saving) in these provinces. As implied by equation (3.35), the fixed regional level of investment is totally financed by borrowing from the outside.

The allocation of economic activities across provinces described above is viewed as better than the historical allocation from an efficiency point of view. Since the objective function represents the sum of regional disposable incomes which are equally weighted in the objective function, any allocation of activities that increases the values of the national disposable income is considered more efficient. By fixing both factors of production by industry and region at their historical levels, the value of the objective function obtained is almost the same as the historical one. (In fact, it is 0.27 per cent higher.) This result gives us some confidence in the model as a good representation of the Canadian economy and facilitates the comparisons of aggregate efficiency that results from increasing the mobility of factors with the historical efficiency.

Allowing more mobility of labour but keeping the capital stocks fixed at the historical levels, did not change either the value of the objective function nor the allocation of activities

across regions. This is the result of the redundancy of the labour constraints when both factors were fixed. A different value of the objective function and a different allocation of activities emerged, however, when both factors are allowed to move. In the next subsection the results of allowing mobility of factors across industries within regions is examined.

4.3.2 Factors Mobile Across Industries Within Regions

The mobility of factors of production across industries within regions implies a segmentation of the labour market by region. The results of this experiment allows us to analyze the degree to which regions can raise their incomes by the reorganization of production structures to make them more comformable with the local resources endowments.

When both factors are mobile across industries within regions, the value of the objective function increased by 22.7 per cent and that of total gross output by 9.4 per cent compared to the no mobility case. The allocation of both income and output across regions also changed. The largest increase in gross output (see Table 4.7) occurred in the Atlantic Provinces where the output levels almost doubled. The relative increase of output in the other provinces was much smaller: 14.6 per cent in Quebec, 6.8 per cent in Ontario, 8 per cent in Manitoba, and less than 5 per cent in

TABLE 4.7

Values of Gross Output by Province and Industry; Capital and Labour are Mobile Across Industries Within Provinces

	Nfld	PEI	NS	NB	Que	Ont	Man	Sask	Alta	BC	Total
Agriculture	29.0	115.1	190.8	127.5	2229.7	4313.6	1294.0	2642.3	2907.0	682.5	14531.5
Forestry	55.4	0.1	91.6	227.8	649.4	562.0	38.8	57.1	68.4	2556.3	4306.9
Fishing	157.8	29.3	227.1	54.8	55.2	45.1	214.	13.8	12.8	339.5	956.7
Mining	1093.6	0.1	190.9	310.9	1619.2	2260.1	434.6	1959.4	13294.8	2629.4	23793.1
Manufacturing	1032.8	218.9	3313.2	3176.6	41246.7	78275.7	4472.2	1956.5	9211.8	15256.9	158161.3
Construction	1118.8	45.7	418.2	409.4	3944.9	11515.5	1638.9	3309.2	6306.3	6987.6	35694.5
Utilities	616.1	87.6	955.1	931.0	7489.3	13502.3	2280.5	1480.5	4546.6	5008.0	36897.0
Trade and Finance	868.9	189.2	1759.0	1616.5	17073.9	27130.5	2976.2	2757.5	10554.1	9080.3	74006.1
Institutions	961.9	139.8	1336.2	1185.0	14632.8	22778.7	2218.7	2062.3	6479.5	8200.9	59995.8
Housing	225.9	49.3	521.5	364.3	2420.8	6532.4	647.0	559.1	1849.9	2100.7	15270.9
Total	6160.4	875.2	9003.9	8403.5	91361.9	166915.9	16022.2	16797.7	55231.1	52842.0	423613.8

Figures are in millions of 1979 dollars

the other three Western Provinces. This increase in regional production was associated with an increase in consumption activities. More goods were available to satisfy a higher level of intermediate and consumption demand in all regions, especially in the Eastern Provinces. This was made possible by shifting capital stocks and labour force to the industries producing commodities that were in high demand. The increased production fully utilized available capital stocks in all regions except Newfoundland, Prince Edward Island, and British Columbia. The unused capital stocks in Newfoundland and British Columbia were fairly small, amounting to 2 and 1 per cent of the respective regional capital stocks. As for Prince Edward Island, the idle capital stock constituted about 20 per cent of the total available. Production in Prince Edward Island, although more than doubled compared to the case of no mobility of factors, remained about 26 per cent less than its historical value. This low production level in Prince Edward Island is attributed to the relatively high demands on intermediate goods from other provinces. These intermediate inputs would contribute more to the objective function if they were used elsewhere.

The level of income (and consumption) was positive in all provinces. As can be verified from Table 4.8, the cost benefit relationship holds with equality for every province (equation 4.2). For example, by subsittuting the shadow values of income and consumption for Newfoundland in relation 4.2 we obtain

TABLE 4.8

Allocation of Activities Across Provinces; Capital and Labour are Mobile Across Industries Within Provinces

	YD^r	C^r	λ_{c^r}	GTR^r	$DNFA^r$	DNAG	λ_{DNAG}
Nfld.	3652.1	2326.8	0.79218	1916.7	-234.4		
PEI	593.9	409.8	0.88875	348.4	-25.2		
N.S.	7037.6	5314.8	0.81192	4309.4	310.1		
N.B.	5479.0	3923.0	0.85637	3042.8	-102.6		
Que	53155.1	40335.4	0.80806	26564.1	47.3		
Ont	86421.9	61146.3	0.8668	33798.8	5832.4		
Man	9301.4	6758.9	0.84383	4149.2	278.1		
Sask	8670.5	5758.5	0.92324	3461.5	-411.2		
Alta	24568.4	16877.6	0.89258	10360.0	-5218.3		
BC	2489.5	18226.2	0.83438	7637.4	-1774.8		
Total	223681.4	161577.3		95589.3	-1298.6	-28787.2	0.38683

All figures except λ_{c^r} and λ_{DNAG} are in millions of 1979 dollars.

$$-(-\ 0.38683) + (0.79218)(0.77402) = 1$$

Moreover, the improvement of income levels over the previous case, where factors were fixed by industry and region, is evident in every province. The most significant beneficiaries were the Atlantic Provinces, since their income was zero in the previous case. Quebec gained the most among the other provinces from the reallocation of factors of production across industries. The income level in Quebec increased by 29 per cent over the previous case (Tables 4.8 and 4.6). The increased disposable income in Quebec is mainly the result of the reallocation of capital, not only within Quebec, but also in the other provinces. In the previous case the capital constraints were binding in some industries in other provinces from which the consumption activity in Quebec has high intermediate and final demand. In particular, the capital constraints in the mining industry in New Brunswick carried a fairly high shadow value. When the reallocation of capital was allowed, capital stocks in New Brunswick were shifted to the mining industry, thus increasing its output. A part of this increased output was used in the production of goods that support a higher level of consumption in Quebec. Ontario and the Western Provinces experienced increases in disposable income, between 7 and 9 per cent, with the exception of British Columbia, where the increase was less than one

per cent. These increases were also due to the reallocation of factors within provinces in favour of industries that support the production of consumption goods.

The increase in the levels of regional incomes contributed to a significant increase in private asset accumulation abroad. This increase, which is evident in every province (column 5, Table 4.8), is the result of the increase in income. Regional savings, defined as income less consumption, are used to finance private investment at home and the accumulation of assets abroad as implied by equation (3.35). However, since private investment at home is fixed in each region, the extra savings are used to finance investment abroad. The higher the level of saving the lower is the deficit in the private regional financial market.

The reduction in the deficit of the private sector was, however, associated with an increase in the deficit of the government sector. The government budget deficit reached its upper limit which is fixed at the historical level. Again, in this case, government expenditures were totally allocated to direct transfers rather than government spending. The increase in the level of transfers to the regions is made possible by the increase in the level of production activities that supported higher regional consumption levels.

Keeping capital stocks mobile within regions, but fixing

labour supplies at the industry level within regions lead to slightly reduced levels of income and production as compared to the experiment with both factors mobile within regions. As can be seen from tables 4.1 and 4.2, the reduction was less than one per cent of either the income or the gross output of the previous case. The most significantly binding labour constraints were in the manufacturing industries of Quebec, Ontario and Alberta, and in the trade and finance, and construction industries of British Columbia. The limited supplies of labour in these industries contributed to lower production levels and consequently to lower value added and income levels in the corresponding regions.

On the other hand, keeping capital stocks mobile within regions, but allowing labour to be mobile across regions within industries lead to a slightly increased value of the objective function (Table 4.1). The results, however, changed significantly when both labour and capital were allowed to move across regions. The following two subsections deal with these experiments.

4.3.3 Factors Mobile Across Regions Within Industries

The mobility of factors of production across regions within industries implies a segmentation of the factor markets by industry. Capital and labour can move between regions to perform similar jobs but cannot move to perform different jobs in the

same region or in other regions. The results of this experiment shed some light on the comparative advantages of the Canadian provinces. Due, however, to the tight structure of inter-regional trade, regional specializations in production based on comparative advantages do not fully materialize.

Allowing both factors of production to be mobile across regions within industries leads to significant increases in the efficiency of the aggregate economy. The value of national disposable income (the objective function) increased by 26.5 per cent over its value associated with no mobility of factors and by 3 per cent over that associated with regional mobility of factors. This increase is attributed to two elements: first, to the increase in the degree of concentration of consumption activities[3], and second, to the increase in the total production level. Consumption activities showed a high degree of concentration across the Canadian provinces. In fact, total consumption was allocated mostly to Alberta, whose disposable income constituted 57 per cent of the national disposable income and then to Ontario and to New Brunswick with disposable income shares of 23 and 20 per cent, respectively (Table 4.10). This high level of concentration is, again, the result of the cost advantage of consumption activities in these provinces. As a result of a fixed supply of scarce resources, consumption is shifted to the provinces where it is less costly, thus increasing further the value of national disposable income.

TABLE 4.9

Values of Gross Output by Province and Industry; Capital and Labour are Mobile Across Provinces Within Industries

	Nfld	PEI	NS	NB	Que	Ont	Man	Sask	Alta	BC	Total
Agriculture	8.3	96.6	150.2	382.8	1147.7	3311.4	1017.6	2456.7	5385.2	588.9	14545.5
Forestry	39.0	0.1	80.9	440.8	628.4	529.4	36.0	48.2	102.6	2531.1	4436.7
Fishing	122.3	32.7	235.6	95.4	49.4	43.2	21.1	12.2	13.9	285.5	911.4
Mining	1073.6	0.3	183.6	371.9	1650.0	2368.6	466.0	1888.3	14609.4	2465.6	25077.5
Manufacturing	789.4	230.9	3251.8	5731.4	35259.6	78176.8	2916.9	1690.3	16841.2	14395.2	160283.3
Construction	125.3	88.5	164.5	969.3	10723.7	11454.5	1948.7	3015.5	5522.7	6506.8	40519.6
Utilities	277.0	103.9	645.2	3229.0	4623.1	11992.9	1644.6	1086.4	11129.4	3794.5	37826.3
Trade and Finance	325.3	136.6	1015.2	7206.6	8371.7	23251.2	1847.4	1903.0	28768.0	5718.9	78544.1
Institutions	525.4	98.5	676.5	5026.3	8174.5	19218.5	1176.4	1251.4	18345.9	5139.5	59638.9
Housing	0.0	0.0	0.0	2966.3	0.0	4054.1	0.0	0.0	9962.4	0.0	16982.8
Total	3285.6	788.2	6403.5	26419.9	70628.1	153700.6	12074.9	13558.1	110680.8	41426.1	438965.8

Figures are in millions of 1979 dollars

TABLE 4.10

Allocation of Activities Across Provinces; Capital and Labour are Mobile Across Provinces Within Industries

	YD^r	C^r	λ_{C^r}	GTR^r	$DNFA^r$	DNAG	λ_{DNAG}
Nfld	0.0	0.0	1.59459	-229.6	-1059.6		
PEI	0.0	0.0	1.78862	-175.1	-209.4		
N.S.	0.0	0.0	1.24485	-1372.0	-1412.6		
N.B.	44617.6	31946.8	1.09543	34239.1	11012.1		
Que	0.0	0.0	1.15475	-17104.2	-12772.5		
Ont	53634.9	37948.5	1.10856	7119.6	-3756.7		
Man	0.0	0.0	1.29232	-3063.6	-2264.4		
Sask	0.0	0.0	1.25950	-3331.1	-3323.2		
Alta	132311.1	90892.9	1.14176	89335.6	28509.1		
B.C.	0.0	0.0	1.28838	-11656.2	-8350.2		
Total	230563.6	160788.2		93762.5	6372.6	-28787.2	0.21566

All figures except λ_{C^r} and λ_{DNAG} are in millions of 1979 dollars.

The cost-benefit relationship (equation (4.2)) holds with equality for New Brunswick, Ontario and Alberta and with inequality for the rest of the provinces as can be verified from Table 4.10. The concentration of consumption activities is made possible by allowing the scarce resources to be mobile across regions. This cross-regional mobility of resources has allowed production activities (Table 4.9) to be allocated in such a way that it better supports consumption in those regions where it is least costly. Production activities shifted away from provinces with zero or lower than historical levels of consumption (and income) to the provinces with high levels of consumption. A comparison of Table 4.9 with Table 4.3, where the historical allocation of output is presented, makes this point fairly clear. Gross output is well below the historical level in the zero or below historical level income provinces. The reduction amounts to 47 per cent in Newfoundland, 34 per cent in Prince Edward Island, 37 per cent in Nova Scotia, 29 per cent in Quebec, 11 per cent in Ontario, 26 per cent in Manitoba, 15 per cent in Saskatchewan, and 21 per cent in British Columbia. This reduction in output is evident in almost every industry in these provinces, although in different proportions. The reduction in different industries depends on the delivery requirements to intermediate and final demand in the regions with high levels of production and consumption activities as dictated by the interregional trade coefficients. Some industries in these

regions, however, showed a slight increase in their production levels. They are the fishing and manufacturing industries in Prince Edward Island, the fishing industry in Nova Scotia, and the construction industries in Quebec, Manitoba, Saskatchewan, and British Columbia. The increase in the production levels of the fishing and manufacturing industries in Prince Edward Island and Nova Scotia is due to high levels of intermediate and final demand from New Brunswick. The increase in the output of the construction industry is due to the concentration of investment activities in this industry (not reported). Since the deliveries to investment in the construction industry are mostly required from local production, (95 per cent on average), the model allocates total regional investments to this industry in order to reduce the deliveries of Alberta and of New Brunswick to the other provinces. The production levels in Alberta and New Brunswick are 1.9 and 2.8 times their historical values, respectively. The increase was significant in every industry except in the construction industry where the output level was actually reduced below its historical level. Investment in the construction industry in Alberta and New Brunswick is set at a zero level because investment demand in this industry competes for resources needed to support the high level of consumption in these provinces.

As for total gross output, the cross-regional mobility of factors lead to a value that is fairly close to the historical

one (0.6 per cent less). The allocation of gross output across industries, however, is different from the historical allocation. By comparing total industry outputs (last column, table 4.9), to their historical values (last column, table 4.3), one notices that the levels of output in the agriculture, mining, housing and trade and finance industries are higher than their historical values. This is the result of a better allocation of resources across the Canadian provinces. In particular, capital stocks in these industries were shifted to Alberta and New Brunswick, where the capital/output ratios are lower than other provinces, thus increasing the level of production in those industries over their historical value. Capital stocks in those industries were fully utilized giving rise to a relatively high shadow prices (not reported), for the corresponding capital constraints.

Once more, government transfers to provinces play the role of a common pool to which zero income provinces deliver their value added and out of which, provinces with high levels of consumption withdraw funds. Government transfers to the provinces with zero income levels are negative in the solution and those to the high income level provinces show high positive values (Table 4.10). Total government transfers to provinces, however, are twice as high as their historical value. This was made possible by the zero level of government spending.

The government borrowing constraint is binding and has a positive shadow price, indicating that disposable income and

consumption could be increased further. Thus the economy could supply more consumption goods, but income has reached its upper limit.

Total private asset accumulation outside the regions shows a surplus of $6372.6 million compared to a historical deficit of $17611 million. The reason being that the high income provinces, namely New Brunswick and Alberta, have accumulated net assets in other regions and abroad, which has more than offset the asset decumulation by other provinces.

Keeping capital mobile across regions within industries but allowing labour to be mobile across industries within regions lead to a decrease of both output and income levels (Tables 4.1 and 4.2). Moreover, the allocation of income and output across provinces (not reported) was changed. The degree of concentration of consumption (and income) activities was lower than in the previous case. Nova Scotia and Saskatchewan are added to the positive income level provinces (besides Ontario, New Brunswick and Alberta). Production increased in the provinces that had increased consumption levels (Ontario, Nova Scotia and Saskatchewan) and decreased in the provinces with lower consumption levels (Alberta and New Brunswick).

The imposition of further restrictions on the mobility of labour, by fixing the labour supply by industry and region at the historical level while keeping capital stocks mobile across regions within industries, further reduced the values of both

income and output (Tables 4.1 and 4.2). The degree of concentration of consumption was further lowered by adding Quebec and Newfoundland to the positive income provinces. The production activities were allocated, as a result, in a way that was more consistent with the allocation of consumption.

The reduction in both income and output that occurred by further restricting the mobility of labour is the result of two elements. First, the labour constraints in some industries and provinces became binding, restricting the output in these industries. Second, these output limitations reduced the levels of consumption (and income) which could be supported in the provinces.

In the case where labour is fully mobile and capital is allowed to move across regions within industries, the level and allocation of economic activities did not change. The highest efficiency gains were obtained when both factors are fully mobile. This experiment is discussed in the next subsection.

4.3.4 Factors Fully Mobile Across Regions and Across Industries

The last experiment in this section allows both labour and capital to be fully mobile across regions and across industries. As expected, the values of both income and output are higher in this case than in any other cases, increasing by 36 and 20 per cent,

respectively, as compared to the no mobility case. The consumption (and income) activities under this specification of factor mobility were concentrated in one province, namely Alberta (Table 4.12), while the remaining nine provinces had zero income levels. Production activities in Alberta increased drastically, to about 50 per cent of total production (Table 4.11). The increase in the production level in Alberta showed wide variations across industries. Compared with their historical levels, the housing industry experienced an increase of more than 11-fold while the mining industry showed a modest 37 per cent increase. These wide variations are due to the compsoition of intermediate and final demands on these industries. The industries that deliver a large portion of their outputs to local use experienced larger increases than those that deliver mostly to other regions and abroad.

The variables of the government sector behaved in a way similar to the previous cases. All government expenditures are allocated to direct transfers rather than to spending on goods and services. Transfers, together with the negative transfers to other regions, were allocated to Alberta to support the high consumption level in this province. Regional private asset accumulation was negative for all provinces except Alberta. The fixed levels of investment in those provinces are totally financed by borrowing from outside the regions. But in the case of Alberta, net private asset accumulation was very large, giving rise to

TABLE 4.11

Values of Gross Output by Province and Industry; Capital and Labour are Mobile Across Both Provinces and Industries

	Nfld	PEI	NS	NB	Que	Ont	Man	Sask	Alta	BC	Total
Agriculture	6.9	54.5	82.8	71.5	808.5	2377.4	1038.6	2902.6	8671.7	829.5	16844.1
Forestry	39.3	0.1	58.1	180.2	605.7	501.8	38.5	52.9	164.9	2782.9	4424.4
Fishing	121.4	14.6	162.9	44.0	46.8	38.7	21.1	12.4	15.4	364.8	841.9
Mining	1100.2	0.6	174.2	295.8	1625.3	2263.5	493.5	1840.5	18187.5	2576.8	28557.9
Manufacturing	792.1	98.2	2245.8	2559.1	32994.9	70826.6	4247.2	2068.7	26494.8	16773.3	159102.7
Construction	1038.3	210.4	850.2	1539.9	11832.9	12654.5	2149.6	3185.2	17216.5	7730.5	58408.3
Utilities	230.5	30.3	363.3	491.4	3572.5	7855.2	1806.2	1307.2	18906.1	4665.8	39408.3
Trade and Finance	245.0	37.5	460.5	541.0	5591.5	12351.6	1688.5	1882.7	48770.0	5143.4	76711.7
Institutions	555.2	53.8	599.1	604.9	7590.8	12892.7	1254.7	1421.4	32380.4	5812.2	63065.2
Housing	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18680.0	0.0	18680.0
Total	4129.2	499.5	4898.9	6327.7	64848.9	121762.0	12737.9	14673.5	189487.4	46679.1	466044.5

Figures are in millions of 1979 dollars

TABLE 4.12

Allocation of Activities Across Provinces; Capital and Labour are Mobile Across Both Provinces and Industries

	YD^r	C^r	λ_{c^r}	GTR^r	$DNFA^r$	DNAG	λ_{DNAG}
Nfld	0.0	0.0	0.66324	-470.7	-1059.6		
PEI	0.0	0.0	0.70263	-13.4	-209.4		
N.S.	0.0	0.0	0.54095	-717.1	-1412.6		
N.B.	0.0	0.0	0.63553	-1402.4	-1658.6		
Que	0.0	0.0	0.50941	-14791.8	-12772.5		
Ont	0.0	0.0	0.66125	-32998.3	-19443.2		
Man	0.0	0.0	0.53197	-3307.4	-2264.4		
Sask	0.0	0.0	0.58203	-3880.6	-3323.2		
Alta	248090.7	170429.2	0.56270	167832.9	64752.3		
BC	0.0	0.0	0.52601	-13336.7	-8349.9		
Total	248090.7	170429.2		96915.2	14258.9	-28787.2	.61344

All figures except λ_{c^r} and λ_{DNAG} are in millions of 1979 dollars.

positive net private asset accumulation. Keeping capital stocks fully mobile but restricting the mobility of labour decreased the values of both income and output (tables 4.1 and 4.2). Labour constraints become binding as the mobility of labour is restricted.

All of the above experiments are carried out under the demand constrained version of the model. As mentioned earlier, economic growth may be limited by either supply or demand factors. The investigation of the relative importance of these factors is carried out in the next section.

4.4 SUPPLY VERSUS DEMAND SPECIFICATIONS

The demand specification of the model through the equality relationships in the material balance constraints (equation (3.1)) means that the output of any commodity cannot exceed the level of demand for that commodity. Unused resources (if any), will remain idle. This implies that regional income cannot exceed the sum of its components; namely, consumption, investment spending at home, and investment in other regions and abroad. On the other hand, the supply specification of the model, which allows inequality relationships in the material balance constraints, implies that the output of any commodity may exceed the level of demand and that production activities

and income are only constrained by the availability of resources that are employed in the production process. In order to assess the relative importance of the supply versus the demand constraints, the results of the experiments associated with these two specifications are compared. Experiments with the supply determined model were performed under the same configurations of factor mobility as those associated with the demand determined model described in the previous section. The results obtained under the two specifications were fairly close. The slight differences observed, however, do not affect the discussion in the previous section of the impact of different assumptions concerning factor mobility. For this reason the results of only one experiment with the supply determined model -- that associated with full mobility of both factors -- are reported in tables 4.13 and 4.14, and compared with those of the correspondent experiment with the demand determined model reported in tables 4.11 and 4.12. The value of the objective function associated with the supply determined model ($249.2 billion) is higher than that of the demand determined model ($248.1 billion), but only slightly. This increase is due mainly to the reorganization of production activities across industries as well as across regions.

A comparison of tables 4.11 and 4.13 reveals that the production activities have shifted -- in the supply determined case -- towards British Columbia and specifically towards the fishing

TABLE 4.13

Values of Gross Output by Industry and Province in the Supply Determined Model; Capital and Labour are Mobile Across Both Provinces and Industries

	Nfld	PEI	NS	NB	Que	Ont	Man	Sask	Alta	BC	Total
Agriculture	6.6	53.8	80.9	68.5	798.2	2376.9	1039.0	2906.9	8705.7	832.9	16869.4
Forestry	38.1	0.1	54.7	171.1	532.0	469.2	37.8	52.7	163.6	2697.6	4216.8
Fishing	118.5	14.3	160.2	42.1	46.8	38.8	21.1	12.3	15.4	8317.4	8786.9
Mining	1021.7	0.6	143.3	281.5	1555.8	2181.3	475.4	1831.3	18418.0	2605.6	28515.1
Manufacturing	771.8	96.6	2216.2	2419.6	32450.7	71812.4	4217.9	2069.1	26601.7	17302.3	159958.4
Construction	198.9	210.3	271.2	306.3	3860.6	9914.8	505.5	3185.3	17249.4	5136.5	40838.8
Utilities	210.8	28.4	344.9	466.8	3581.3	7756.1	1779.5	1305.4	18986.3	4730.7	39190.2
Trade and Finance	245.7	38.1	445.7	560.0	6009.1	12731.2	1738.1	1900.3	49061.3	5492.1	78221.6
Institutions	479.3	50.6	451.2	533.8	7008.2	12724.9	1159.3	1419.4	32512.5	5957.9	62296.9
Housing	0.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0	18764.9	0.0	18764.9
Total	3091.3	492.9	4168.2	4849.6	55842.7	120005.6	10973.5	14682.5	190478.8	53073.7	457658.8

Figures are in millions of 1979 dollars

TABLE 4.14

Allocation of Activities Across Provinces in the Supply Determined Model; Capital and Labour are Mobile Across Both Provinces and Industries

	YD^r	C^r	λ_{c^r}	GTR	$DNFA^r$	DNAG	λ_{DNAG}
Nfld	0.0	0.0	0.97300	-117.5	-1059.6		
PEI	0.0	0.0	1.05534	-10.1	-209.4		
N.S.	0.0	0.0	0.82461	-471.9	-1412.6		
N.B.	0.0	0.0	0.92457	-936.6	-1658.6		
Que	0.0	0.0	0.77966	-12060.7	-12772.5		
Ont	0.0	0.0	0.94738	-32329.2	-19443.2		
Man	0.0	0.0	1.00719	-2721.5	-2264.4		
Sask	0.0	0.0	0.89080	-3887.4	-3323.2		
Alberta	249217.8	171203.5	0.86122	168473.6	65105.1		
BC	0.0	0.0	0.80506	-16992.3	-16224.5		
Total	249217.8	171203.5		98946.4	6737.1	-28787.2	0.40838

All figures, except λ_{c^r} and λ_{DNAG} are in millions of 1979 dollars.

industry. The level of output of this industry associated with the demand determined model constitutes only 5 per cent of that associated with the supply determined model. The fishing industry in British Columbia is the most efficient in converting capital to income (i.e., it has the highest product of the output/capital ratio and the value added coefficient). Capital stocks and the labour force were shifted to that industry increasing its output and value-added. The increased value added was shifted to Alberta via government transfers, thus increasing the value of the objective function. Gross outputs in all other provinces, were slightly smaller in the supply determined model giving rise to a small decrease in the value of national gross output of less than one per cent.

The small differences[4] observed in the values of both national income and gross output between the supply and demand determined versions of the model would lead one to conclude that growth in the Canadian economy is constrained by the supply of resources rather than the demand for products. In particular, capital stocks are the most binding constraint facing the national economy and carry relatively high shadow prices even under the least constrained mobility assumption. Labour, however, is also binding across industries and regions when it is restricted to less than full mobility, and in particular, when capital stocks are relatively flexible. Table 4.2 reveals that the contribution of labour mobility to the aggregate efficiency of the Canadian economy was most significant when labour is mobile across provinces.

In the experiments performed thus far, we have assumed that the mobility of labour is costless and instantaneous. The results can then be interpreted as the results of "counterfactual" experiments, in which we examine alternative configurations of labour and capital stocks. In fact, the allocation of the labour force across regions and industries is based on the historical allocation of labour and the spatial social and economic frictions that limit its mobility. In the next section a migration model is imposed on the optimization experiments in order to incorporate the effects of these frictions.

4.5 THE EFFECTS OF IMPOSING A MIGRATION MODEL

The migration model incorporated into the programming experiments limits the free mobility of labour between regions. People now move in order to enhance their wellbeing. They move in response to interregional differences in a family of socioeconomic variables. Moreover, there are costs associated with labour mobility. These costs reflect the resource requirements necessary to move members of the labour force and their families between locations (see chapter 3). The effects of imposing behavioural restrictions on the mobility of labour on the efficiency of the aggregate economy as well as on the allocation of production and consumption across provinces are analyzed in this section. Here we describe only the

results of the experiment in which capital can move across both industries and regions, while labour can move freely across industries within regions but is constrained by the migration equations in its movement across regions[5].

In order to analyze the effects of the migration constraints on aggregate efficiency, one has to compare the results of the optimization experiments that contain these constraints with those of the two extreme specifications of labour mobility; first, that labour in each region is fixed at the historical level and second, that labour is free to move between regions (the comparison is done under the same specification of capital mobility). The value of the objective function (reported in table 4.16) associated with the migration equation is about 6 per cent lower than in the free mobility case.

The degree of concentration of income (and consumption) across provinces was less extreme than in the free mobility case. While all income was allocated to Alberta in the free mobility case (Table 4.12), it was allocated to five provinces when the migration constraints were imposed on the model. These provinces are: Nova Scotia, New Brunswick, Ontario, Saskatchewan and Alberta (table 4.16). The reason for this concentration is again the cost advantages of consumption activities in these provinces relative to other provinces. The production activities (table 4.15) shifted towards the provinces with high income and away from the provinces with zero income levels.

TABLE 4.15

Values of Gross Output by Province and Industry When Migration Constraints are Imposed; Capital and Labour are Mobile Across Both Provinces and Industries

	Nfld	PEI	NS	NB	Que	Ont	Man	Sask	Alta	BC	Total
Agriculture	9.1	102.7	277.3	180.6	1081.9	5197.3	1183.1	2990.7	3218.0	439.0	14680.0
Forestry	42.4	0.1	124.4	272.9	670.2	752.0	34.5	64.5	84.3	2616.1	4561.7
Fishing	131.0	31.6	275.5	62.8	49.3	49.5	21.1	13.1	12.8	248.2	895.3
Mining	1131.4	0.6	224.9	323.7	1634.4	2362.7	431.8	2007.0	14537.9	2455.1	25109.8
Manufacturing	852.2	235.1	4139.1	3693.2	35130.1	84747.4	3959.8	2215.7	10378.9	13523.0	158874.1
Construction	1062.8	216.8	583.3	1759.1	11877.5	16525.5	2150.6	3280.6	10156.9	7633.1	55246.6
Utilities	341.7	85.6	1532.9	1332.9	4772.0	16911.8	1719.9	1874.7	5906.1	3379.7	37929.7
Trade and Finance	360.0	140.9	3100.0	2484.7	8917.1	35759.3	1719.5	3866.4	14092.8	3712.2	74153.3
Institutions	629.7	102.7	314.5	1842.3	8531.2	29780.2	1225.7	2751.1	9173.7	4880.8	61232.3
Housing	0.0	0.0	1173.4	745.0	0.0	1069.0	0.0	984.8	3488.4	0.0	17360.7
Total	4560.6	916.2	13745.7	12697.5	72663.7	202954.7	12518.3	20049.0	71050.3	38887.5	450043.5

Figures are in millions of 1979 dollars.

TABLE 4.16

Allocation of Activities Across Provinces When Migration Constraints are Imposed; Capital and Labour are Mobile Across Both Provinces and Industries

	YD^r	C^r	λ_{c^r}	GTR^r	$DNFA^r$	DNAG	λ_{DNAG}
Nfld	0.0	0.0	0.61273	-684.4	-1059.6		
PEI	0.0	0.0	0.65605	-208.6	-209.3		
N.S.	15834.3	11958.2	0.57080	10806.9	2663.6		
N.B.	11206.8	8024.2	0.60205	7069.6	1524.1		
Que	0.0	0.0	0.66165	-17787.0	12772.4		
Ont	145116.8	102674.9	0.60926	77706.6	22998.8		
Man	0.0	0.0	0.65075	-3229.4	-2264.3		
Sask	15272.5	10143.2	.64906	8231.2	1806.1		
Alta	46329.7	31826.8	.62751	24743.2	1593.8		
B.C.	0.0	0.0	.70992	-10263.9	-8350.1		
Total	233760.2	164627.3				28787.2	0.56893

All figures except λ_{c^r} and λ_{DNAG} are in millions of 1979 dollars.

The migration constraints were all binding, but their shadow prices are different in signs and magnitudes (not reported). The positive (negative) shadow prices are associated with those constraints where migration is towards the provinces in which the level of production is high (low). That is to say, increasing the migration towards the provinces where labour is needed increases the value of the objective function. By constrast, increasing the migration towards the provinces with excess supply of labour will decrease the labour force available in the other provinces, and therefore, contributes negatively to the objective function. The highest positive values of these shadow prices were observed on the migration constraints towards Alberta and then Ontario from all other provinces, followed by those on the migration towards New Brunswick, Nova Scotia and Saskatchewan. In these provinces labour is fully employed, while the other provinces experience high unemployment rates. A relaxation of the migration constraints allows labour to move towards those provinces, thus increasing production and income levels.

A comparison of the results of this experiment, in which the interregional migration constraints are imposed on the model, with those which do not allow labour to cross regional boundaries (Table 4.1) reveals that the values of the objective function are fairly close. In fact, the objective function is

is slightly higher when labour is not allowed to cross the regional boundaries ($233.9 billion) than when labour is mobile but constrained according to the migration equations and costs of movement are accounted for ($233.7 billion). The reason for this result is that the migration constraints impose on the model some degree of mobility among provinces regardless of its contributions to the objective function, and since labour mobility has a cost attached to it, the gains associated with the mobility of labour in the right direction are outweighed by the cost of labour mobility in the wrong direction. The gains from mobility in the right direction are represented in this experiment by the shadow prices on migration towards Alberta, Saskatchewan, Ontario, New Brunswick, and Nova Scotia, because the labour constraints in these provinces are binding. The cost of migration includes not only the cost of resource requirements necessary to transport labour between provinces, but also the opportunity cost of moving labour out of provinces where there are shortages to provinces where there are surpluses of labour. This opportunity cost is represented by the negative shadow prices on the migration out of the above provinces.

In order to compare the behaviourally determined pattern of migration with the otpimal pattern, a second experiment was performed in which the migration constraints were relaxed. The only friction that remained in the model was the cost of labour mobility. The optimization process now chooses migration between

provinces according to two criteria: first, the relative abundance of provincial labour and second, the cost of transportation of labour across space. These two criteria indicate that the movement of labour from one province to another occurs as long as the benefits obtained from increasing the employment level in the receiving province by one unit, outweighs the opportunity cost of reducing the labour supply in the sending province by one unit plus the cost of transport of this unit between the two provinces. Minimizing the cost of labour movement implies that the model will choose the provinces with excess supply of labour as the origin provinces so that the opportunity cost of labour movement is zero, and in order to minimize the transportation cost, the origin provinces are chosen as near as possible to the destination provinces. The destination provinces are chosen which have the largest contribution to the objective function.

Under the above specifications, the values of the objective function associated with different configurations of mobility of factors of production significantly exceeded those associated with the experiments in which the labour migration constraints were imposed. In fact, the values obtained were fairly close to those associated with free mobility of labour. The primary difference was the transport cost of labour between provinces, which amounted to less than one per cent of the value of the objective function.

The allocation of income (and consumption) across provinces and of production across provinces and industries (not reported) were also fairly close to those associated with free mobility of labour. The optimal levels and directions of the labour migration, however, are very different from those based on the behavioural migration constraints. In some experiments (when labour was allowed to move within industries and capital across industries), the optimal migration level was zero. The labour constraints were not binding in any province, so there was no need for labour to move between provinces. In other experiments there were positive unidirectional migration levels. Migration occurred only when there were shortages of labour in some provinces. For example, in the case where both labour and capital were fully mobile across provinces and industries, and, given the concentration of economic activities in Alberta (tables 4.11 and 4.12), labour migrated towards this province from the neighbouring provinces, namely, British Columbia, Saskatchewan and Manitoba, until all unused labour had migrated. The remaining labour needed in Alberta came from Ontario. The value of the objective function in this case ($247.4 billion) exceeded that associated with the migration constraints ($233.7 billion) by 5.8 per cent. Although the behaviourally determined movement of people showed some net migration towards Alberta, it also showed significant net

migration towards British Columbia, which is certainly incompatible with the optimal migration pattern. The gains from the behaviourally determined migration in the right direction (towards Alberta) were more than offset by the costs of migration in the wrong direction, resulting in an overall negative effect on the efficiency of the Canadian economy.

4.6 CONCLUSIONS

In this chapter the results of optimization experiments under different assumptions regarding the mobility of labour and capital were presented. It was shown that alternative counter-factual allocations of factors were associated with higher national disposable income. The value of national income associated with complete reallocation of both factors across regions and industries was 36 per cent larger than the value associated with the historical allocation.

Associated with these gains was the reallocation of economic activities across regions. Consumption activities were allocated to the regions where the cost of consumption was the least and production activities were allocated across industries and regions that contribute most to increasing income and also support consumption.

The relative importance of supply and demand constrained specifications of the model was analyzed and the main conclusion was that differences were small. The Canadian economy appeared to be constrained most by the supply of resources rather than the demand for products. In particular, the capital constraints were the most binding in most of the experiments.

A migration model and the cost of labour movement were incorporated into the programming model in order to analyze the role of behavioural constraints on the migration of labour in determining the efficiency of the Canadian economy. The main results were that behaviourally determined migration does not improve aggregate efficiency. In fact, the cost associated with labour migration in the wrong direction outweighed the gains that resulted from labour migration in the right direction.

A linear programming framework naturally leads to extreme results in which there is an unrealistic degree of specialization. Thus, the above results should not be interpreted as showing realistic or desirable allocation of labour and capital across the Canadian provinces. However, the extreme nature of the results reveals certain features of the regional structure of Canada which would not be obvious in other contexts. For example, the results suggested that reallocation of resources <u>within</u> provinces can lead to significant increases in income. This observation, in

turn, suggests that one approach to increasing income in poorer provinces is internal restructuring. Secondly, differences in the resource costs of consumption across provinces have been identified. These suggest that aggregate efficiency could be improved by channelling migration towards provinces with lower consumption costs. Thirdly, particular industries in particular provinces have been identified as key suppliers of consumption goods and services, both in their own province and in neighbouring provinces; for example, mining in New Brunswick. Thus, any policy aimed at increasing incomes in those provinces should be accompanied by increased capacity in these "potential bottleneck" industries. Observations of this nature can also be made in regard to the equity experiments which are discussed in the following chapter.

FOOTNOTES

Chapter 4

1. The assumption of full capacity utilization stems from two factors. First, there is no data on capacity utilization by industry and province; and second, the available data for the manufacturing industry indicates a high level of capacity utilization in 1979.

2. The cost of increasing regional income is zero in this case since the government budget constraint is not binding.

3. The concentration of consumption (and income) is made possible by the specification of the regional financial constraints. In these experiments the financial constraints are left free at the regional level. The imposition of an upper bound on the deficit that a given region may incur implies a positive regional income level.

4. The small difference in the results between the supply and demand versions of the model may be attributed to the specifications of the model. A large proportion of final demand, namely, consumption and government expenditures, is endogenous. Moreover, it could be attributed to the full capacity-utilization assumption discussed in note 1.

5. Experiments with different configurations of mobility of factors have resulted in similar effects on the performance of the aggregate economy.

APPENDIX 4.1

Detached Coefficients Tableau of the Programming Model

	Q_i^r	X_i^r	C^r	G^r	M_i^r	NCM^r	IT^r	$VA1^r$	$VA2^r$	M^r	YD^r	DT^r	TRC^r	ΔNFA^r	ΔNAG	EMP^r	LIG^r	LF_j^r	LF^r	LF_J	K_j^r	K^r	K_J	GT	I_j^r	
$\lambda_{X_j^r}$	m^*	$-\hat{X}$																								$= 0$
$\lambda_{Q_i^r}$	$-\hat{Q}$	U^*	C^*	G^*																					I^*	$\leq -\bar{E}_i^r$
$\lambda_{M_i^r}$		U_F^*	C_F^*	G_F^*	$-\hat{M}$																				IF^*	$= 0$
λ_{NCM^r}		$NCMU^*$	$\widehat{NCMC}$			$-\widehat{NCM}$																			$NCMI^*$	$= 0$
λ_{IT^r}		ITU^*	$\widehat{ITC}$	$\widehat{ITG}$			$-\widehat{IT}$																			$= 0$
λ_{VA1^r}		$VAU1^*$	$\widehat{VA1C}$	$\widehat{LIG1}$				$-\widehat{VA1}$																		$= 0$
λ_{VA2^r}		$VAU2^*$	$\widehat{VA2C}$	$\widehat{LIG2}$					$-\widehat{VA2}$																	$= 0$
λ_{M^r}					M^*	$\widehat{NCM}$				$-\hat{M}$																$= 0$
λ_{YD^r}								$\widehat{VA1}$	$\widehat{VA2}$		$-\hat{yd}$	$-\widehat{DT}$	$\widehat{TRG}$													$= -\overline{PTR}$
λ_{C^r}			$-\hat{C}$								$\hat{c}$															$= 0$
$\lambda_{\Delta NFA^r}$		PMU^*	PMC^*	$-\widehat{GLOP}$			$\widehat{IT}$			$\hat{M}$		$\widehat{DT}$	$-TRG$	$\widehat{\Delta NFA}$											PMI^*	$= \bar{E}^r + \overline{PTR}^r - \overline{ITE}^r$
$\lambda_{\Delta NAG^r}$				$GLOP'$	$-ITM'$		$-\widehat{IT}$					$-DT'$	$-TRG'$		ΔNAG											$= -\overline{ITE}^r$
λ_{DT^r}		$-\widehat{T2}$						$-\widehat{T1}$				$\widehat{DT}$				$-\widehat{UB}$	$-\widehat{PSPT}$									$= \overline{SD}^r$
λ_{LIG^r}				$-\widehat{LIG}$													$\widehat{LIG}$									$= 0$
λ_{EMP^r}		EU^*	EC^*	EG^*												$-\widehat{EMP}$										$= 0$
$\lambda_{LF_j^r}$		EU^*	EC^*	EG^*														$\widehat{LF_s^r}$								$= 0$
λ_{LF^r}																		$LF_J^{r'}$	$-\widehat{LF^r}$							$= 0$
λ_{LF_J}																		$LF_j^{r'}$		$-\widehat{LF_J}$						$= 0$
λ_{LFT}																			$LF^{r'}$							$= \overline{LF}$
$\lambda_{K_j^r}$		KU^*																			$-\widehat{K_j^r}$					$= 0$
λ_{K^r}																					$K_j^{r'}$	$-\hat{K}^r$				$= 0$
λ_{KT}																						$K^{r'}$				$= \bar{K}$
λ_{GT}				G'																				$-GT$		$= 0$
λ_{I^r}																										
λ_{EQ}											EQ^*														I^*	$= \bar{I}^r$
Max											$1'$															$= 0$

The terms that are not defined in the text are:

$$PMU^* \equiv \sum_{i=1}^{43} \sum_{s \neq r} \left(\sum_{j=1}^{J^s} u_{ij}^{rs} X_j^s - \sum_{j=1}^{J^s} u_{ij}^{sr} X_j^r \right)$$

$$PMC^* \equiv \sum_{i=1}^{43} \sum_{s \neq r} (c_i^{rs} C^s - c_i^{sr} C^r)$$

$$GLOP^* = \sum_{i=1}^{43} \sum_{j=1}^{J^r} g_i^{rs} G^s + g_w^r G^r$$

$$PMI^* = \sum_{i=1}^{43} \sum_{s \neq r} \left(\sum_{j=1}^{J^s} b_{ij}^{rs} I_j^s - \sum_{j=1}^{J^r} b_{ij}^{sr} I_j^r \right)$$

* represents a full matrix

^ represents a diagonal matrix

' represents a row vector

The primal problem can be written as

$$\text{(4.A.1)} \quad \begin{aligned} &\text{Max } C' X \\ &\text{subject to } AX \leq b \end{aligned}$$

The activities of the primal problem here (elements of the vector X) are written along the top of the table and the constraints (corresponding to b) are written in the right margin.

The corresponding dual problem is written as

(4.A.2) Min $\lambda' b$

subject to $\lambda' A \geq C'$

The dual variables (elements of λ in the dual problem) are written in the left margin, and the dual constraint vector, C', is written along the bottom of the problem matrix.

The EQ^* matrix that represents the equity constraints takes the following forms:

a) When the regional labour forces are fixed and Province 9 (Alberta) is taken as the base of comparison

$$EQ^* \equiv \begin{vmatrix} -eq_1 & 0 & \cdots & 1 & 0 \\ 0 & -eq_2 & \cdots & 1 & 0 \\ \vdots & & & & \vdots \\ 0 & 0 & -eq_8 & 1 & 0 \\ 0 & 0 & \cdots & 1 & -eq_{10} \end{vmatrix}$$

b) When the regional labour forces are endogenous and Province 1 (Newfoundland) is taken as the base of comparison,

$$EQ^{*} \equiv \begin{vmatrix} -LF^{2} & LF^{1} & 0 & 0 & \cdots\cdots & 0 \\ -LF^{3} & 0 & LF^{1} & 0 & \cdots\cdots & 0 \\ \vdots & & & & & \vdots \\ -LF^{10} & 0 & 0 & 0 & \cdots\cdots & LF' \end{vmatrix}$$

Here, the constraints are nonlinear since the LF^{r} are endogenous variables.

CHAPTER 5

REGIONAL EQUITY AND AGGREGATE EFFICIENCY

5.1 INTRODUCTION

This chapter discusses the results of optimization experiments in which equity constraints are imposed on the model. Specifically the income level per member of the labour force is forced to be the same across provinces.[1] These constraints may be written in the following way:

$$(5.1) \qquad \frac{YD^1}{LF^1} = \frac{YD^2}{LF^2} = \ldots. = \frac{YD^{10}}{LF^{10}}$$

The results reported in this chapter are an extension of those in chapter 4, so that the organization of this chapter is similar to that of chapter 4. The same experiments were carried out, but here the equity constraints were imposed. In section 5.2, the efficiency losses from the imposition of the equity constraints are discussed. Section 5.3 presents the allocation of activities across provinces associated with different configurations of mobility of factors of production. Section 5.4 discusses the relative importance of the supply versus demand specifications of the model. Section 5.5

imposes the labour migration model on the equity experiments and discusses the resulting effects on equity and efficiency, and finally, section 5.6 offers some concluding remarks. In each of these cases, the results are compared with those of the previous chapter.

5.2 THE EFFICIENCY LOSSES FROM THE IMPOSITION OF THE EQUITY CONSTRAINTS

A number of experiments were carried out with the equity constraints imposed on the model under different specifications of factor mobility. The values of disposable income and gross output associated with different mobility assumptions are reported in Tables 5.1 and 5.2, respectively. A comparison of these values with those reported in Tables 4.1 and 4.2, shows the effects of the equity constraints on the level of economic activities. The values reported in Tables 5.1 and 5.2 are lower than those of 4.1 and 4.2, for every specification of mobility of labour and capital. The difference, however, decreases as labour is allowed to cross regional boundaries. The reduction in the level of economic activities is to be expected because equity is generally achieved by lowering the per capita income levels in all regions to the level of the poorest region,

TABLE 5.1

Values of the Objective Function Associated With the Equity Constraints Under Different Configurations of Factor Mobility

Capital \ Labour	No Mobility	Regional Mobility	Mobility Across Regions Within Industries	Full Mobility
No Mobility	121636.7	122636.7	166902.7	166902.7
Regional Mobility	131387.8	136113.8	224447.3	224447.3
Mobility across regions within industries	131387.8	136113.8	218149.2	218149.2
Full mobility	131387.8	136113.8	231620.9	231620.9

Figures are in millions of 1979 dollars

TABLE 5.2

Values of Gross Output Associated With the Equity Constraints Under Different Configurations of Factor Mobility

Capital \ Labour	No Mobility	Regional Mobility	Mobility Across Regions Within Industries	Full Mobility
No mobility	327118.6	327118.6	375264.3	375264.3
Regional mobility	369443.7	363581.6	425485.6	425485.6
Mobility across regions within industries	369443.7	363581.6	410841.9	419634.2
Full Mobility	369443.7	363581.6	435265.0	435265.0

Figures are in millions of 1979 dollars

or to the level of the region with the lowest potential for increasing income. The efficiency gains that could result from the concentration of consumption activities in the regions where consumption is least costly are eliminated by the imposition of the equity constraints. There are also losses of production efficiency because output levels are raised to the bounds allowed by factor availabilities and/or by the levels of demand in the low income regions, in order to increase their income levels, and this does not necessarily coincide with the most efficient allocation of production. The difference in the values of the objective function with and without the equity constraints represent the cost of interregional equity in terms of aggregate efficiency. This cost varies widely, however, under different assumptions about labour and capital. While the cost of interregional equity amounts to 33.3 per cent of income when both labour and capital are fixed at historical levels, it is equal to only 6.7 per cent of national income when both factors are freely mobile across regions and industries. Labour mobility across regions contributes most to the reduction of the cost of equity. When this is coupled with mobility of capital within regions, the cost of equity was reduced to less than one per cent of maximum national income. In this case, the optimal allocation of factors across regions coincides with the equitable allocation. The mobility of labour across regions becomes important due to its direct relation to the equity constraints. The

value of the objective function can be increased, with the equity constraints being satisfied, by moving labour out of low income regions until the remaining labour force becomes fully employed.

The contribution of capital mobility to the reduction of the cost of equity is not as significant as that of labour mobility. Capital reallocation across industries within provinces, however, contributes to more cost reduction than its reallocation across provinces. Regional and national capital constraints for example, give the same value of the objective function when labour is not allowed to cross regional boundaries (table 5.1). Thus, in this case once capital has been reallocated within regions there is no further benefit from its reallocation between regions.

The values of total gross output associated with the equity experiments (Table 5.2) are also below those of the efficiency experiments discussed in the previous chapter (Table 4.2), under all assumptions concerning factor mobility. However, in terms of percentages, the reduction is not as large as that of national income. It varies from a high of 15.4 per cent when both factors are fixed by industry and regions, to a low of 6.6 per cent when both factors are fully mobile. The allocation of production across regions shows significant differences when the equity constraints are introduced. The above results can be explained by examining in detail the effects of the imposition of the equity constraints on the allocation of economic activities across regions.

5.3 THE ALLOCATION OF ACTIVITIES ACROSS REGIONS

The imposition of the equity constraints reduces the concentration of economic activities across regions. The pattern of concentration becomes closely related to the allocation of the labourforce. However, due to the fixity of the interregional trade coefficients which results in positive production levels in all regions, the labour force in any province cannot fall short of the employment level necessary to support the required production. Thus, under any specification of factor mobility, income (and consumption) levels are positive in all provinces. Limited concentration, however, does occur in the cases where the unemployed labour is moved to one (or a few) province(s).

The effects of the reduced concentration of economic activities that results from the imposition of the equity constraints on aggregate efficiency are examined under three specifications of factor mobility; factors are fixed by industry and province; factors are mobile within provinces, and factors are mobile across provinces.

5.3.1 Equity Constraints With Factors Fixed by Province and Industry

The cost of achieving interregional equity in this case is the highest among all experiments. The value of the objective function is lower by 33 per cent as compared to the unconstrained (efficiency) solution. There are, however, winners and loosers as a result of imposing equity constraints across regions. The largest beneficiaries are the Eastern Provinces, which had zero income levels in the previous case due to the cost disadvantages of their consumption activities. All other provinces experience drastic reductions in their income levels that amount to 49 per cent in Alberta, 44 per cent in Ontario, British Columbia and Saskatchewan, 29 per cent in Manitoba, and 18 per cent in Quebec. These reductions are the result not only of sharing the economic pie equally with the Eastern Provinces but also of sharing a smaller pie. In order to achieve equity, the income level per member of the labour force in all the provinces has to be reduced to that of the lowest income province. In this case, New Brunswick is the province that cannot support a higher income level due to the limited availability of consumption goods supported by output from the mining industry. The output of the mining industry in New Brunswick reaches its upper limit due to the complete utilization of the

available capital stock. In the unconstrained solution, the consumption level of New Brunswick was driven down to zero, so that the output of the mining industry was able to support higher levels of consumption in other provinces. The claim that New Brunswick cannot support a higher level of consumption and is forcing down the income levels of all other provinces is supported by the analysis of the dual equations associated with the equity constraints. The equity constraints in this experiment take the following form:

$$(5.2) \qquad \frac{YD^9}{YD^s} = \frac{LF^9}{LF^s} \equiv eq_s \qquad s = 1,2,\ldots,8,10$$

where YD^9 and LF^9 are the disposable income and the labour force of Alberta[2].

eq_s is a constant.

Since regional labour forces are fixed in this experiment the equity constraints are imposed by equating the relative income levels of provinces to the relative size of their labour forces. Equation (5.2) can also be written as:

$$(5.3) \qquad - eq_s \, YD^s + YD^9 = 0$$

The costs of the equity constraints are represented by the shadow prices of these equations, which represent the change

in the value of the objective function due to an increase of the right-hand side by one unit. The shadow prices of the equity constraints are related to other shadow prices by the dual equation that represents the benefit-cost relationships. By going down the YD^r column in Appendix 4.1, the dual equation is written as

$$(5.4) \qquad -\lambda_{yd^s} + \lambda_{c_s} c_s - \lambda_{eq_s} eq_s = 1 \qquad s \neq 9$$

where λ_{eq_s} is the shadow price of the equity constraint in region s.

The equity constraints force positive income (and consumption) in all provinces so that equation (5.4) is an equality. Solving equation (5.4) for the shadow price of regional equity yields:

$$(5.5a) \qquad \lambda_{eq_s} = -\frac{1}{eq_s} \left| 1 + \lambda_{Yd^s} - \lambda_{c_s} c_s \right|$$

The term between brackets represents the net benefit to the objective function that results from increasing the income level of region s by one unit. The term, $-1/eq_s$, represents the amount that income in region s must be reduced if the right hand side of equation (5.3) increases by one unit <u>and</u> if no other regional income changes. The product of these two terms, the right hand side of equation (5.5a), represents the reduction in the objective function if this change is made. The negative values of λ_{eq_r} for Ontario,

Manitoba, Saskatchewan and British Columbia reported in Table 5.3 can be interpreted in this way. Positive values of λ_{eq_r} correspond to increases in regional disposable incomes. An alternative impact of increasing the right-hand side of equation (5.3) is an increase in YD^9 of 1 unit, no change in YD^s, and changes in YD^r $(r \neq s,9)$ equal to $1/eq_r$. This change increases the objective function by

$$(5.5b) \qquad \lambda_{eq_s} = (1 + \lambda_{yd^9} - \lambda_{c_9} c_9) + \sum_{s \neq r,g} \frac{1}{eq_r} (1 + \lambda_{yd^r} - \lambda_{c_r} c_r)$$

This equation may be used to interpret the positive values of λ_{eq_s} in table 5.3. Equations (5.5a) and (5.5b) are equivalent (see footnote 3). The shadow prices, listed in table 5.3, are properly interpreted as the benefits of relaxing equity by one unit. New Brunswick has the highest shadow price (2.24) on its equity constraint. This is due to the high level of demand for the output of the local mining industry. The output of this industry is in short supply due to the full utilization of the available capital stock and that makes the consumption activities relatively costly, not only in New Brunswick but also in other provinces that have a high level of consumption demand for the output of this industry. In addition consumption and income in these regions cannot be increased due to this limitation. Thus, Quebec and the other Eastern Provinces carry positive shadow prices on their equity constraints due to

TABLE 5.3

Allocation of Activities Across Provinces Associated with the Equity Constraints; Labour and Capital are Fixed by Industry and Province

	YD^r	C^r	$\lambda_c{}^r$	GTR^r	$DNFA^r$	$\lambda_{eq}{}^r$	EMP^r	DNAG	λ_{DNAG}
Nfld.	2155.9	1668.7	2.93680	1276.7	-572.4	0.24270	107.7		
PEI	571.7	394.5	10.12005	394.6	-32.1	0.30243	22.6		
NS	3955.3	2987.1	3.06779	2369.3	-444.3	0.46053	159.1		
NB	2991.8	2142.2	13.20857	1373.9	-808.9	2.23735	133.2		
Que	31278.9	23735.2	1.62008	13270.9	-5228.7	0.63433	1501.0		
Ont.	46144.2	32648.5	0.70390	8833.1	-5947.5	-2.04806	2459.2		
Man.	5159.0	3748.8	0.57421	1905.2	-854.1	-0.26583	274.9		
Sask	4644.4	3084.6	0.70131	1270.5	-1763.3	-0.21939	269.2		
Alta	11309.7	7769.3	0.63569	1136.9	-9368.8	--	669.2		
B.C.	13425.4	9866.1	0.46576	981.1	-4790.7	-0.78076	762.4		
Total	121636.6	88045.0		32812.2	-29810.8		6358.5	15215.2	0.0

EMP^r is measured in thousands, while the other variables except $\lambda_c{}^r$, $\lambda_{eq}{}^r$, λ_{DNAG} are in millions of 1979 dollars.

TABLE 5.4

Values of Gross Output by Province and Industry Associated with the Equity Constraints Labour and Capital Are Fixed by Industry and Provinces

	Nfld	PEI	NS	NB	Que	Ont	Man	Sask	Alta	BC	Total
Agriculture	19.9	100.4	135.7	96.4	1390.2	2926.1	1059.3	2317.4	2094.9	473.6	10614.1
Forestry	36.5	0.1	70.4	191.3	585.7	479.3	31.1	44.5	63.2	2436.1	3938.3
Fishing	137.9	23.5	184.4	46.4	44.9	39.5	21.2	12.5	12.4	241.5	764.2
Mining	987.7	0.1	160.2	282.7	1544.1	2081.2	355.6	1795.0	1177.1	2390.8	21369.0
Manufacturing	900.9	172.9	2600.6	2647.7	31947.1	62998.6	3295.7	1437.7	6889.1	13348.3	126238.4
Construction	458.8	41.7	366.5	276.5	4261.2	10622.9	1522.4	2168.6	9662.4	5781.7	35162.7
Utilities	428.6	68.7	631.1	677.2	5248.0	9394.5	1577.5	1063.7	3120.9	3637.3	25847.7
Trade and Finance	582.6	154.7	1131.5	1114.6	11576.9	17997.6	2108.8	2147.2	8502.5	6464.0	51780.7
Institutions	709.8	119.9	898.9	843.5	10583.0	16113.1	1516.5	1468.2	4753.1	6159.9	43171.0
Housing	133.3	117.5	293.1	198.9	1424.5	3487.9	358.9	299.5	851.6	1137.1	8232.3
Total	4396.4	729.6	6472.4	6375.5	68605.6	126140.7	11847.1	12754.3	47726.7	42070.3	327118.6

Figures are in millions of 1979 dollars.

the cost disadvantages of their consumption activities. The equity constraints of Ontario and the Western Provinces, except Alberta[4], carry negative shadow prices which indicates that the income level would have been higher had the equity constraints not been imposed.

The value of total gross output is also lower in this case compared to its level in the unconstrained solution. The reduction amounts to 15.5 per cent of the unconstrained level. The allocation of production across regions (table 5.4) is influenced by the allocation of consumption. The four Eastern Provinces experience significant increases in their output levels. Prince Edward Island is the largest beneficiary of the imposition of the equity constraints, increasing its output level by 2.5 times, followed by Nova Scotia, New Brunswick and Newfoundland with increases of 39, 26 and 10 per cent, respectively. The other provinces experienced a decline in their output levels that varied from a high of 25 per cent in Manitoba to a low of 16 per cent in Quebec.

Total government transfers into the regions are small compared to those in the unconstrained solution due to the lower levels of consumption and, as a consequence, the government budget shows a surplus of $15.2 billion. Again, government spending in all regions was set at a zero level.

The low levels of production (and consumption) associated

with the imposition of the equity constraints have resulted from the limited capital stock in the mining industry in New Brunswick. Since the output of this industry is needed to support consumption activities there and elsewhere, consumption was limited in New Brunswick and the other Eastern Provinces, and due to the equity constraints, the per worker income levels in all other provinces were restricted. When the capital stocks were allowed to be mobile across industries within provinces, with the labour force fixed by industry and province, the capital constraint of the mining industry in New Brunswick became nonbinding. The capital stock was shifted to that industry, thus allowing its output to increase (by about 10 per cent -- not reported) in order to satisfy higher levels of consumption demand. Total disposable income is larger by 8 per cent over the previous case (Table 5.1). This relatively small increase is due to the fixity of the labour force. The labour constraints become binding in the service industries in the four Eastern Provinces. In particular, the labour constraint of the institutions industry in Prince Edward Island carries the highest shadow prices among all the resource constraints. The output of this industry constrained the consumption activity in Prince Edward Island and, consequently, through the equity constraints constrained the income levels in other regions. Further relaxation of the capital constraints, with

labour held fixed by industry and region, did not change the value of the objective function (table 5.1). However, allowing both factors to be mobile within regions increases both the output and income levels. The next subsection describes the solution of this experiment.

5.3.2 Equity Constraints With Factors Mobile Within Regions

In this experiment we allow resources to be reallocated within regions in order to achieve the highest level of national income with the equity constraints being imposed. This assumption leads to an increase of national income by 12 per cent and of total gross output by 11 per cent over the values associated with non-mobility of resources. By comparing the value of the objective function with that of the unconstrained solution, under the same mobility configuration, one finds that the cost of interregional equity in this case amounts to about 40 per cent of total disposable income. This high cost is the result of holding down the level of income achievable by the poorest province. In particular, labour and capital in the low income regions are shifted to the industries that deliver heavily to local consumption, thus allowing consumption levels in these regions to increase as long as there are available resources. This increase will stop when the stock of either labour or capital is exhausted. In this experiment the labour forces in

TABLE 5.5

Allocation of Activities Across Provinces Associated with the Equity Constraints; Labour and Capital are Mobile Within Provinces

	YD^r	C^r	λ_{c^r}	GTR^r	DNFA	λ_{eq^r}	EMP^r	DNAG	λ_{DNAG}	G^r
Nfld.	2412.5	1867.3	-.10316	-165.1	-514.4	-0.20585	201.1			1916.3
PEI	639.8	441.4	311.30820	-0.6	-10.9	10.80801	53.3			610.4
N.S.	4426.0	3342.6	-.12285	-140.0	-329.1	-0.38217	368.9			4465.6
N.B.	3347.9	2397.1	-.08066	-517.6	-707.7	-0.27982	279.1			2414.0
Que	35001.8	26560.2	-.00845	12131.6	-4330.8	-2.78342	1772.1			0.0
Ont	51636.2	36534.3	-0.00610	-14762.3	-4341.4	-4.09766	4191.5			39152.6
Man	5773.1	4195.0	-0.00285	2158.7	-686.3	-0.45711	288.0			0.0
Sask	5197.2	3451.7	-0.00819	-691.6	-1577.7	-0.41289	433.3			3948.5
Alta	12655.7	8694.0	-0.00145	3992.8	-8947.4	--	631.7			0.0
B.C.	15023.3	11040.3	-0.00118	3007.2	-4367.9	-1.18810	738.6			0.0
Total	136113.8	98523.9		5013.1	-25813.6		8957.6	6208.5	0.0	52507.4

EMP^r is measured in thousands, all other figures except λ_{c^r}, λ_{eq^r} and λ_{DNAG} are in millions of dollars.

TABLE 5.6

Values of Gross Output by Province and Industry Associated with the Equity Constraints; Labour and Capital are Mobile Within Provinces

	Nfld	PEI	NS	NB	Que	Ont	Man	Sask	Alta	B.C.	Total
Agriculture	21.9	103.8	189.4	113.8	1633.2	3086.8	1095.1	2290.0	3583.5	976.1	13093.9
Forestry	39.6	0.1	87.2	218.6	636.7	495.9	34.8	54.5	72.2	2900.0	4539.9
Fishing	148.4	26.8	207.6	52.3	47.5	41.5	21.2	12.8	12.5	270.6	841.5
Mining	1219.3	0.2	253.2	319.7	1687.7	2382.1	615.5	1842.7	11063.0	2557.7	21941.4
Manufacturing	971.9	199.1	3038.5	3062.0	36881.3	74014.8	3817.5	1745.1	7322.6	13738.3	144791.1
Construction	866.6	76.6	590.2	1702.3	10670.1	8586.0	841.0	1346.4	5298.3	2833.2	32811.2
Utilities	591.7	101.4	1009.9	861.9	6156.9	11712.7	1850.0	1271.0	3431.5	3943.0	30930.3
Trade and Finance	687.5	192.5	1274.0	1198.6	12056.3	19077.8	2110.7	2129.7	6922.9	5462.2	51112.6
Institutions	1150.9	246.9	1560.0	1235.6	12269.2	23158.8	1660.6	2085.4	4627.8	6303.4	54298.8
Housing	149.2	53.1	327.9	222.5	1594.0	3903.0	501.5	335.1	952.9	1272.4	9212.1
Total	5847.2	1000.8	8538.4	8987.8	83641.9	146459.3	12448.2	13113.1	43287.5	40251.4	363581.6

Figures are in millions of 1979 dollars

the Eastern Provinces and Saskatchewan became the scarcest resources. In general, production increased in the services industries of those provinces (table 5.6). In other provinces resources were allocated inefficiently in order that income be kept low. Thus for the first time government spending became positive (table 5.5). The level of income in Prince Edward Island could not be increased and thus the income levels of all the other provinces were held down. This can be seen from the shadow prices of the equity constraints reported in table 5.5, which points to Prince Edward Island as the only province with a psoitive shadow price associated with its equity constraint. The income levels of the other provinces are lower than those associated with the unconstrained solution. This reduction in the level of regional incomes is fairly significant, amounting to 49 per cent in Alberta, 40 per cent in British Columbia, Saskatchewan, Ontario and New Brunswick, 38 per cent in Manitoba and Nova Scotia, and 34 per cent in Newfoundland. Prince Edward Island is the only province that experiences an increase in its income level which amounts to a modest 7 per cent.

5.3.3 Equity Constraints With Factors Mobile Across Regions

Allowing labour to cross the regional boundaries reduces the impact of the equity constraints on the system. The provinces with low income levels export labour to the provinces that can best

support an increasing labour force, thus increasing income per worker. This process increases the efficiency of the national economy by increasing the levels of economic activity in the most efficient provinces. The movement of the labour force towards the efficient provinces is limited, however, by the employment levels in the sending regions which are necessary to support the production of commodities delivered to intermediate and final demand at home, in other regions and abroad.

The cross regional mobility of labour leads to a significantly larger value of the objective function under any specification of capital mobility. As can be seen from Table 5.1, total income has increased by 70 per cent in the least constrained capital mobility case, and by 37 per cent in the most constrained capital mobility case. Table 5.1 also shows that the interregional equity is achieved at a higher level of national income the higher is the mobility of factors of production. In particular, the cross regional mobility of labour contributes the most to increasing the value of the objective function. A comparison of tables 5.1 and 4.1 reveals that the cost of interregional equity is lowest when labour is mobile across regions and capital is mobile within regions. In this case, the value of the objective function is almost the same under both the equity constrained and unconstrained solutions. The allocation of economic activities across regions is similar under

both specifications. A comparison of Tables 5.7 and 5.8 which present the results associated with the equity constraints with tables 5.9 and 5.10 where the corresponding results of the unconstrained solutions are reported confirms the above observation. The highest variations are observed in Prince Edward Island where disposable income in the unconstrained solution is 22 per cent higher than that associated with the equity solution. The other provinces show small differences in their disposable income levels. The decrease in the disposable income of Prince Edward Island that resulted from the imposition of the equity constraints is explained by labour movement out of the province in order to support a high level of income per member of the labour force. The labour remaining in Prince Edward Island was fully employed (Table 5.7) in order to support intermediate and final demand requirements at home, in other regions and abroad.

Both the employment level and gross output decreased substantially as compared to the unconstrained solution. The decrease in output is evident in every industry but most strongly in the construction industry, where output in the constrained solution was only 18 per cent of that in the unconstrained solution. This reduction occurs because investment in Prince Edward Island is reallocated away from the housing industry, where 90 per cent of the requirements are from the local construction industry, towards

TABLE 5.7

Allocation of Activities Across Provinces Associated with the Equity Constraints; Labour is Mobile Across Provinces; Capital is Mobile Within Provinces

	YD^r	C^r	λ_{c^r}	GTR^r	$DNFA^r$	λ_{eq^r}	EMP^r	LF^r	DNAG	λ_{DNAG}
Nfld.	3892.6	3013.4	0.78273	2088.2	-180.0		157.8	196.6		
PEI	614.3	423.8	1.07075	321.1	-125.7	0.00067	31.1	31.1		
N.S.	7037.8	5315.1	0.80224	4310.1	310.2	0.0	228.5	355.4		
N.B.	5482.0	3925.2	0.84616	3047.3	-101.8	0.0	180.7	276.8		
Que.	53103.3	40296.0	0.79842	26314.7	34.8	0.0	2081.9	2685.0		
Ont.	86775.8	61396.7	0.86530	34291.4	5935.9	0.0	3364.4	4388.6		
Man.	9276.7	6740.9	0.83377	4138.7	271.3	0.0	374.3	469.5		
Sask.	8359.5	5551.9	0.91223	3124.9	-515.6	0.0	352.2	418.1		
Alta.	23718.5	16293.7	0.88194	8539.1	-5484.3	0.0	845.5	1199.9		
B.C.	26186.6	19244.1	0.82443	9850.2	-1407.6	0.0	946.7	1325.5		
Total	224447.3	162200.8		96025.7	-1212.8		8563.1	11347.0	-28787.2	0.39378

EMP^r and LF^r are measured in thousands, the other figures except λ_{c^r}, λ_{eq^r} and λ_{DNAG} are in millions of 1979 dollars.

TABLE 5.8

Values of Gross Output by Province and Industry Associated with the Equity Constraints; Labour is Mobile Across Provinces; Capital is Mobile Within Provinces.

	Nfld	PEI	NS	NB	Que	Ont	Man	Sask	Alta	BC	Total
Agriculture	30.4	115.8	191.4	127.5	2114.2	4326.2	1330.6	2814.8	2899.7	691.6	14642.3
Forestry	56.3	0.1	91.7	227.9	690.0	568.7	38.6	56.8	72.6	2568.1	4370.8
Fishing	159.7	29.8	226.9	54.8	54.5	45.0	21.4	13.7	12.7	344.5	963.3
Mining	1088.4	0.4	189.6	304.0	1592.6	2228.1	418.6	1962.7	13778.8	2570.4	24133.7
Manufacturing	1045.3	223.8	3308.6	3178.0	41212.6	77744.6	4454.2	1940.6	9269.1	15540.6	157917.2
Construction	1122.4	131.8	418.2	409.4	4637.0	11516.5	1638.3	3306.3	9444.7	5550.5	38175.4
Utilities	632.2	89.4	956.9	932.2	7510.6	13521.5	2280.6	1467.3	4534.9	5040.6	36966.3
Trade and Finance	904.5	194.8	1758.5	1618.6	17161.3	27026.4	2949.4	2699.1	10266.1	8099.9	72678.7
Institutions	985.2	147.6	1338.5	1186.8	14709.4	22805.1	2216.5	2042.1	6606.9	8230.5	60268.9
Housing	240.7	76.2	521.5	364.4	2418.4	6559.1	645.3	539.1	1785.9	2217.9	15368.8
Total	6265.3	1009.8	9002.2	8403.8	92100.6	166341.2	15993.7	16842.5	58671.6	50854.9	425485.6

Figures are in millions of 1979 dollars

TABLE 5.9

Allocation of Activities Across Provinces With No Equity Constraints; Labour is Mobile Across Provinces; Capital is Mobile Within Provinces

	YD^r	C^r	$\lambda_c{}^r$	GTR^r	$DNFA^r$	LF^r	EMP^r	DNAG	λ_{DNAG}
Nfld	3901.4	3019.8	0.78301	2107.6	-178.0	157.1	196.6		
PEI	751.4	518.4	0.87846	247.1	-636.5	57.8	57.8		
N.S.	6983.0	5273.6	0.80252	4245.9	296.8	229.1	368.9		
N.B.	5424.9	3884.3	0.84646	2929.7	-117.9	181.3	279.1		
Que	53057.2	40261.1	0.79870	26244.6	23.7	2083.2	2917.9		
Ont	86671.2	61322.7	0.85660	34134.4	5905.3	3367.3	4304.6		
Man	9457.1	7872.0	0.83406	3640.9	320.6	357.9	481.2		
Sask	8357.8	5550.8	0.91256	3122.0	-516.2	352.3	433.3		
Alta	23705.9	16285.1	0.88225	8502.0	-5488.3	846.3	1055.2		
B.C.	26194.9	19250.2	0.82472	9812.4	-1405.4	946.5	1252.4		
Total	224505.1	162238.0		95086.6	-1795.9	8578.8	11347.0	-28787.2	0.39392

EMP^r and LF^r are measured in thousands, while other figures except λ_{c^r} and λ_{DNAG} are in millions of 1979 dollars.

TABLE 5.10

Values of Gross Output by Province and Industry with No Equity Constraints; Labour is Mobile Across Provinces; Capital is Mobile Within Provinces

	Nfld	PEI	NS	NB	Que	Ont	Man	Sask	Alta	BC	Total
Agriculture	30.7	124.6	192.1	127.8	2113.9	4236.2	1333.6	2816.0	2899.9	691.7	14656.7
Forestry	56.4	0.1	93.2	229.7	690.9	567.9	37.9	56.7	72.0	2561.4	4366.4
Fishing	159.9	33.1	228.9	55.5	54.5	45.1	21.4	13.7	12.7	344.7	969.7
Mining	1088.8	2.1	191.5	305.2	1592.8	2231.5	413.7	1962.4	13787.3	2571.6	24147.1
Manufacturing	1047.1	253.7	3343.8	3210.2	41290.7	77912.2	4430.0	1940.0	9262.9	15526.8	158214.6
Construction	1104.0	710.3	417.9	409.1	4636.9	11516.0	667.1	3306.3	9525.4	5550.5	37843.8
Utilities	633.1	101.0	958.0	934.6	7512.1	13524.1	2280.2	1466.5	4533.6	5039.2	36982.8
Trade and Finance	890.5	228.0	1755.9	1620.2	17163.1	27035.7	2964.4	2702.9	10267.7	8102.1	72730.9
Institutions	985.2	199.2	1340.8	1189.2	14715.0	22815.4	2177.4	2040.1	6606.9	8228.0	60297.4
Housing	241.3	62.4	517.5	360.7	2416.3	6551.2	657.8	538.9	1784.9	2218.6	15349.9
Total	6237.2	1714.6	9039.8	8442.2	92186.2	166525.3	14983.9	16843.8	58750.7	50835.3	42555.9

Figures are in millions of 1979 dollars

other sectors where more investment goods are required from outside the region. The levels of output in the other provinces and their allocation across industries are similar under both specifications. The allocation of the labour force across regions under the equity constraint differs from the historical allocation. In order to equalize the income level per member of the labour force across provinces some movement of unemployed labour is required. A comparison of the level of regional labour forces associated with the equity solution with the historical levels reveals a movement of labour towards Ontario, Alberta and British Columbia, and away from the other provinces. This labour movement, which amounts to 6 per cent of the total labour forces of the sending regions, was most noticeable in Prince Edward Island, where it was 41 per cent, followed by Quebec with 8 per cent, Nova Scotia with 4 per cent, Newfoundland, Manitoba and Saskatchewan with 2 per cent, and finally, New Brunswick with less than 1 per cent. All of the provinces except Prince Edward Island, however, show a positive unemployment level in the equity solution. The full employment of labour force remaining in Prince Edward Island constrains national income. Prince Edward Island is the only province that has a positive shadow price associated with its equity constraint (table 5.7), and thus it is holding incomes per worker in all other provinces down to its level.

Keeping the labour force mobile across regions, but changing the mobility of capital from being mobile within regions to any other mobility specification increases the cost of interregional equity. This cost, measured in terms of national disposable income, is 9 per cent when capital is fixed, 6 per cent when capital is mobile within industries, and 7 per cent when capital is fully mobile. Since there are no substantial differences among the three cases, only the case of fully mobile capital is considered in detail. The cost of interregional equity is mainly due to the altered allocation of activities across regions. A comparison of tables 5.11 and 5.12, where the results of the equity solution are presented, with tables 4.11 and 4.12, where the results of the unconstrained solution are presented, reveals these differences. While income per worker is allocated equally across provinces in the equity solution, income is concentrated totally in Alberta in the unconstrained solution. The reallocation of consumption across provinces implies that scarce resources are employed in the industries and regions that are not the most efficient. Production activities are shifted away from Alberta to other provinces in order to satisfy the requirements of local consumption. The level of output is larger in all provinces except Alberta, especially in the Eastern Provinces. As a result, total gross output is lower by 7 per cent. The increased production levels in these provinces implies relatively small movement of labour towards Alberta. As can be seen from

TABLE 5.11

Allocation of Activities Across Provinces Associated with the Equity Constraints; Labour and Capital are Mobile Across Both Provinces and Industries

	YD^r	C^r	λ_{c^r}	GTR^r	$DNFA^r$	λ_{eq^r}	EMP^r	LF^r	DNAG	λ_{DNAG}
Nfld	2224.3	1721.6	0.78488	1327.8	-557.0	--	108.9	108.9		
PEI	467.0	322.2	0.80320	296.7	-64.6	0.00051	22.8	22.8		
N.S.	3740.9	2825.2	0.60439	1777.7	-496.8	-0.00039	183.3	183.3		
N.B.	3652.6	2615.3	0.70769	1254.1	-621.3	0.00007	178.9	178.9		
Que.	35652.0	27053.6	0.82529	14051.3	-4174.0	0.00117	1746.6	1746.6		
Ont	61566.2	43560.1	0.72098	15130.7	-1437.0	0.00010	3016.2	3016.2		
Man	7581.2	5508.9	0.78500	2524.1	-192.1	0.00066	371.4	371.4		
Sask	7367.1	4892.9	0.72304	2024.0	-848.9	-0.00017	360.9	360.9		
Alta	91004.4	62516.6	0.59685	54718.1	15578.5	-0.00082	1637.8	4458.3		
B.C.	18364.9	13496.1	0.85253	3087.4	-3481.2	0.00117	899.7	899.7		
Total	231620.9	164512.5		96191.9	3705.6		8626.5	11347.0	-28787.2	0.50096

EMP^r and LF^r are measured in thousands, while other figures except λ_{c^r}, λ_{eq^r}, and λ_{DNAG} are in millions of 1979 dollars.

TABLE 5.12

Values of Gross Output by Province and Industry Associated with the Equity Constraints; Labour and Capital are Mobile Across Both Provinces and Industries

	Nfld	PEI	NS	NB	Que	Ont	Man	Sask	Alta	BC	Total
Agriculture	20.1	93.4	143.4	108.2	1681.1	3741.1	1266.2	2884.5	4650.3	736.1	15324.7
Forestry	48.0	0.1	77.3	213.3	629.0	538.1	38.8	55.8	101.7	2616.5	4318.6
Fishing	140.9	24.3	199.2	51.4	52.0	43.2	21.3	13.5	13.6	352.7	912.3
Mining	1024.9	0.2	195.9	305.2	1579.4	2215.6	439.8	1920.3	15236.2	2536.3	25453.8
Manufacturing	920.3	178.4	2843.0	2990.6	38010.3	74769.6	4418.7	2014.3	14297.8	15825.1	156268.1
Construction	237.3	65.9	930.4	1628.0	3562.6	11054.2	2088.3	3150.9	13111.3	5421.9	41250.9
Utilities	456.9	70.9	701.3	792.6	6208.9	11819.8	2229.4	1519.7	9929.3	4430.3	37659.2
Trade and Finance	621.7	145.6	1223.6	1298.1	13541.9	23138.4	2192.9	2971.8	23492.5	7464.1	76810.7
Institutions	733.9	116.5	976.3	1030.9	12100.2	19809.2	2088.0	2020.6	14539.9	7466.6	60882.4
Housing	137.6	38.8	277.2	242.8	1623.7	4653.6	527.3	475.1	6852.2	1555.5	16383.9
Total	4341.6	734.2	7567.9	8661.2	78989.1	151782.8	16031.2	17026.6	101225.1	48905.3	43526.5

Figures are in millions of 1979 dollars

table 5.11, the labour forces remaining in these provinces were fully employed. All of the unemployed labour was moved to Alberta, which could best support (supply consumption goods to) it.

The regional equity constraints carry different shadow prices, which implies that the additional costs incurred from increasing income levels are different across regions. The equity constraints presented in equation (5.3) are modified when labour is allowed to move across regions. The relative sizes of the regional labour forces are not constant in this case, but instead, are determined by the model. The equity constraints can be written as follows:[5]

$$(5.6) \qquad LF^1 \, YD^s - LF^s \, YD^1 = 0 \qquad\qquad s = 2,3,\ldots,10$$

where LF^1 and YD^1 are the labour force and income level, respectively, of province 1 (Newfoundland).

The shadow prices of the equity constraints thus satisfy the following equation:

$$(5.7) \qquad \lambda_{eq_s} = \frac{1}{LF^1} \left| 1 + \lambda_{yd^s} - \lambda_{c_s} \, c_s \right| \qquad\qquad s = 2,3,\ldots,10$$

The interpretation of equation (5.7) is similar to that of equation (5.5). They both relate the cost of equity in a given

region to the net cost (benefit) of increasing its consumption (and income) level. They differ, however, by the scale factor, $1/LF^1$, which relates the cost of equity to the cost (benefit) of consumption. Since we are interested in the relative values of the shadow prices, and not in their absolute values, this difference becomes irrelevant. The shadow prices of the equity constraints, reported in table 5.11, indicate that the cost of equity (benefit of relaxing equity) in Quebec and British Columbia is the highest among all the provinces followed by that of Manitoba, Prince Edward Island, Ontario and New Brunswick. This cost is the result of allocating higher levels of consumption to these provinces as compared to the unconstrained solution. Moreover, further outmigration of labour, which could have increased the level of income per member of the labour force in these provinces, is stopped due to the high production levels necessary to support the demand for the output of these provinces. The other provinces have a negative cost associated with their equity constraints, with that of Alberta being the most negative, followed by that of Nova Scotia and Saskatchewan. The negative shadow cost implies that the value of the objective function would have been higher had the allocation of consumption and income been in favour of these provinces, especially Alberta.

In all of the experiments in this chapter, except when

both factors were fixed, the fundamental feature of equity is the constraint imposed on other regions by the low income regions. This implies that all but the lowest income region must have income levels below their potential which suggests that an improvement (in the Pareto sense) is possible. By allowing the income level of each province to increase above (but not to fall below) the level achieved in the corresponding equity experiments, one would expect that national disposable income would increase. These experiments, referred to as Pareto-constrained, are not reported in detail, but some of their features deserve some comments. First, Pareto improvement is not possible when the national income in the equity solution is constrained by the shortage in the supply of some commodities. In the case when both labour and capital are fixed, for example, national income is constrained by the shortage in the supply of the mining industry of New Brunswick. An increase in the income (and consumption) level of any province is not possible due to the shortage of the output necessary to support the increase in consumption. Second, Pareto-improvement is possible when the national income is constrained by a low income level province. In the case of regional mobility of both labour and capital, for example, the national income is constrained by the low level of income of Prince Edward Island. By allowing for Pareto improvement, the value of the objective function increased by 64 per cent from $136.1 billion to $223.1 billion. The disposable incomes of all

provinces except Prince Edward Island increased, approaching their levels in the unconstrained solution. The disposable income of Prince Edward Island remained at the lower bound imposed by the Pareto condition. This case demonstrates that the achievement of equity requires regional incomes per worker to be brought down to the level of the poorest region.

5.4 EQUITY CONSTRAINTS AND THE SUPPLY VERSUS DEMAND SPECIFICATIONS

The supply constrained specification of the model, which features inequalities in the material balance constraints, allows output to exceed the level of demand and disposable income to exceed the sum of consumption and investment at home and abroad. In some experiments with the supply specification of the model, the value of the objective function increased significantly while in others it did not change at all, compared to the results of the demand specification. The same value of the objective function was obtained in both the supply and demand specifications when both factors were fixed at historical levels by industry and region, and also when labour was allowed to cross regional boundaries. In these cases, the increase in production and income levels came to a halt due to the full utilization of one (or both) factor(s)

under both specifications of the model. The supply specification, however, yields a higher level of income than the demand specification when capital is allowed to move within or across regions and when labour is kept within the regional boundaries. In these experiments, the increase in the level of national income is constrained by the equity constraints rather than the resource constraints. Given the similarities of the results, only one experiment, in which labour and capital are mobile within regions, with the supply specification, is discussed.

A comparison of tables 5.13 and 5.14, where the results of the supply determined model are presented, with tables 5.5 and 5.6, which present the results of the corresponding demand determined model, shows that national income is 15 per cent larger and that total output is slightly smaller (by less than one per cent) in the supply determined case. The increase in national income is due to the relaxation of the demand constraints for the output of Prince Edward Island which allows its production level and disposable income to increase and, therefore, allows the income levels of all other provinces to reach a higher level under the equity constraints. The increase in the production level of Prince Edward Island in the supply determined case, which amounts to 57 per cent, is due to the reallocation of production activities in favour of the industries that generate a higher level of value

TABLE 5.13

Allocation of Activities Across Provinces in the Supply Determined Model Associated with the Equity Constraint; Labour and Capital are Mobile Within Provinces.

	YD^r	C^r	$\lambda_c{}^r$	GTR^r	$DNFA^r$	$\lambda_{eq}{}^r$	EMP^r	DNAG	λ_{DNAG}
Nfld.	2774.5	2147.6	0.17925	1609.4	-432.6	-0.16418	122.1		
PEI	735.8	507.6	301.29967	289.2	-611.1	10.45891	53.3		
N.S.	5090.2	3844.2	0.27958	2969.9	-166.5	-0.27589	191.1		
N.B.	3850.3	2756.9	0.18779	1799.2	-565.1	-0.22897	156.9		
Que	40254.4	30545.9	0.02521	18580.1	-3064.0	-2.71278	1736.5		
Ont	59385.1	42016.9	0.01671	17714.3	-2074.9	-4.3181	2698.0		
Man	6639.4	4824.6	0.00447	3009.0	-449.5	-0.40812	293.9		
Sask	5597.1	3969.7	0.00933	2610.5	-1315.7	-0.30812	273.3		
Alta	14554.9	9998.7	0.00334	2505.9	-8352.9	--	733.1		
B.C.	17277.8	12697.1	0.00262	4255.5	-3769.4	-1.18479	784.3		
Total	156540.0	113309.2		5534.3	-20801.7		7042.5	-1894.2	0.0

EMP^r figures are measured in thousands, while the other figures except $\lambda_c{}^r$, $\lambda_{eq}{}^r$ and λ_{DNAG} are in millions of 1979 dollars.

TABLE 5.14

Values of Gross Output by Province and Industry in the Supply Determined Model Associated With the Equity Constraints; Labour and Capital Are Mobile Within Provinces

	Nfld	NS	NS	NB	Que	Ont	Man	Sask	Alta	BC	Total
Agriculture	23.7	109.3	158.3	105.7	1670.5	3195.1	1128.7	2556.9	2339.9	543.7	11831.8
Forestry	36.4	0.1	81.6	207.6	619.4	489.1	34.9	62.2	70.3	2481.7	4083.5
Fishing	144.2	29.4	204.8	50.8	48.8	41.7	21.2	12.9	12.5	275.6	842.2
Mining	1072.7	1.4	188.0	341.2	1601.3	2260.7	391.8	1797.3	12878.3	2460.6	22994.2
Manufacturing	941.5	223.8	2946.9	2919.3	36515.2	71426.9	3848.5	1718.9	7748.2	14270.2	142558.9
Construction	554.7	678.2	656.6	668.1	4411.4	7751.0	851.6	945.9	12199.9	5087.9	33805.6
Utilities	505.6	89.0	761.2	780.6	6158.9	10813.7	1806.3	1183.4	3530.8	4039.9	29669.7
Trade and Finance	673.3	202.6	1322.8	1231.3	13534.3	19782.2	2278.4	2154.5	7470.2	6133.3	55283.2
Institutions	804.4	184.1	1078.8	985.9	12248.8	18279.7	1711.6	1558.2	5370.8	6704.2	48926.9
Housing	171.6	61.1	377.2	255.9	1833.2	4488.8	461.8	385.4	1095.9	1463.4	10594.6
Total	5928.3	1579.8	7776.3	7546.7	78641.8	138528.9	12535.3	12376.1	53216.9	43460.5	360590.6

Figures are in millions of 1979 dollars

added per unit of scarce resources. For example, the output of the construction industry -- mainly residential construction -- is larger by almost 9-fold in the supply determined case, due to the small labour requirement of this industry. Prince Edward Island remains, however, the province that holds down the level of national income under the interregional equity constraints. As can be seen from table 5.13, the equity constraint of Prince Edward Island carries a high positive shadow price, while those of the rest of the provinces have negative shadow prices. The slight decrease in the value of total gross output in the supply determined case, is the result of the re-organization of production activities across industries in such a way that it is comformable with a different pattern of final demand and a higher level of national income. This re-organization has lead to a higher output levels in Alberta, British Columbia, and Manitoba and to a lower output levels in the rest of the provinces (table 5.14).

5.5 EQUITY CONSTRAINTS AND THE MIGRATION MODEL

The imposition of the interregional migration model, equation (3.21), on the equity experiments drastically reduces the value of the objective function. The achievement of interregional equity at a high level of national income was made

possible by the free mobility of labour across regions. The migration constraints, which restrict the mobility of labour to be close to the historical mobility, imposes a low but positive level of migration between all provinces so that regional labour forces cannot change in any significant way. Consequently, the level of income per member of the labour force in the poor provinces remains relatively low and constitutes an upper bound on the income levels of all other provinces. Moreover, the cost of labour migration, which includes the resource costs of transportation as well as the opportunity cost of moving people from provinces that can support a higher level of income and/or from provinces where labour is in short supply, outweighs the benefits of migraton that result from moving the labour force to where it is needed. As a result, the values of the objective function obtained in these experiments (not reported) were slightly less (on average by less than one per cent) than those associated with no cross regional mobility of labour.

In these exepriments, Prince Edward Island again holds the per worker income levels of all other provinces down to its own level. Since the mobility of labour is restricted by the migration equations, the only means of increasing this province's income per member of the labour force is by increasing its production level up to the point of full utilization of the available resources. When the cross regional mobility of capital was not allowed, the

capital constraints in Prince Edward Island were the most binding. By relaxing these constraints the labour force becomes fully employed. The migration constraints out of Prince Edward Island carry large positive shadow prices while the in-migration constraints carry negative shadow prices. This implies that the reduction (increase) of the labour force of this province increases (decreases) the value of the objective function.

5.6 CONCLUSIONS

The imposition of the equity constraints has significantly reduced the value of national disposable income under most specifications of mobility of factors of production. The cost of equalizing the income level per member of the labour force across regions amounts to 34 per cent of national disposable income in the case of no mobility of factors, to 40 per cent when factors are mobile within regions, and to 7 per cent when factors are mobile across both regions and industries. This cost is the result of two elements; first, the elimination of the benefits that result from the concentration of economic activities in the most efficient regions and industries, and second, the restriction imposed on the income level of all provinces by that of the poorest province. The mobility of labour across regions is very important in relaxing the equity constraints. The movement of the labour force out of the low

income province(s) increases the per labourer income level(s) and relaxes the most binding constraints of the system. In the case of no cross regional mobility of labour, Prince Edward Island could not support a high level of income per member of the labour force, and this has restricted the income of the other provinces. The cross-regional mobility of labour makes the inter-regional equity and the aggregate efficiency more compatible by drastically reducing the cost of equity. However, the imposition of the migration constraints that restrict the movement of labour to be close to historical levels, essentially eliminate the benefits of free mobility of labour.

The results of the "counterfactual" experiments of this chapter have some implications for regional economic policy. The results suggest that equity and efficiency may be compatible if labour was made more mobile across regions and capital more mobile within any given region. Actually, the cost of efficiency under such a configuration is less than one per cent of aggregate disposable income. Policies that facilitate the transfer of labour from low income regions to higher income regions mitigate some of the costs of equity. But the simple smoothing of the process of

transfer is not sufficient. It is also necessary that labour should move to the regions where it is most needed, i.e., where its contribution is valued most. Thus, implicit in our results is a manpower policy that greases the transfer process of labour across space coupled with manpower guidance system and labour exchanges which direct labour to the optimal destinations (designated by our model).

Equally important in the mitigation of equity costs is the restructuring of the local economies. The increased mobility of capital within regions and between sectors is synonymous with restructuring the economic base of the local economies. Our results suggest that there are attendant economic benefits to this restructuring process. In other words, present regional industrial structures are not efficient enough to transform local resources at the production possibility frontiers of these regions. These frontiers could be reached with proper industrial strategies that facilitate the restructuring process in the various regions and permit the emergence of optimal industrial mix.

To sum up, our results indicate that a combination of manpower policies and industrial strategies guided by a general equilibrium approach such as ours, despite its many limitations, may allow Canada to couple and link equity with efficiency at minimal sacrifices.

FOOTNOTES

Chapter 5

1. The equality of per capita income across provinces might have been a better measure of equity. The equality of income per member of the labour force, however, is chosen so as to avoid the problem of whether to use the participation rate at the origin or at the destination in the conversion of labour force to population, when labour is reallocated across provinces.

2. The choice of Alberta as the basis for comparison is arbitrary. Any other province may serve the same purpose, without affecting the results.

3. The dual equation takes the form of equation (5.4) for all the provinces except Alberta. The dual equation for Alberta is written as

$$- \lambda_{yd_9} + \lambda_{c_9} c_9 - \sum_{s \neq 9} \lambda_{eq_s} = 1$$

Note that this equation, together with equation (5.5a) implies the following restriction on shadow prices across regions:

$$\sum_{s \neq 9} \frac{1}{eq_s}(1 + \lambda_{yd_s} - \lambda_{c_s} c_s) = 1 + \lambda_{yd_9} - \lambda_{c_9} c_9$$

4. Since Alberta is taken as the basis for comparison it has no separate equity constraint.

5. Here again, the choice of Newfoundland as the basis for comparison is arbitrary.

CHAPTER 6

CONCLUSIONS

This chapter offers an overview of the major findings of this study and discusses the possibilities for future research. Two questions were addressed in this study: first, are there any efficiency gains from the interregional reallocation of factors of production? second, are interregional equity and aggregate efficiency compatible? and finally, if they are not, what is the cost of equity in terms of efficiency?

In order to answer these questions, a multiregional multi-industry programming model was developed. In order to reflect all the regional bottlenecks that may hamper economic growth, the model had to be of a general equilibrium nature where interregional interactions in the goods, factor and financial markets are taken into account. The structure of the programming model is chosen so as to be compatible with the 1979 interregional input-output data for Canada.

The major findings of this study can be summarized as follows:

-- Aggregate efficiency is best served when both factors of production are fully mobile across both regions and industries.

National disposable income was larger by 36 per cent compared to the case where both labour and capital are fixed at historical levels, due to the reallocation of economic activities in favour of the most efficient regions and industries.

-- Capital mobility, coupled with any degree of labour mobility, lead to significant increases in national disposable income. The contribution of labour mobility was most noticeable when coupled with cross regional mobility of capital.

-- The reallocation of economic activities across regions favoured Ontario and the Western Provinces in general, and Alberta in particular. Concentration of consumption (and income) across provinces increased when factor mobility was increased. As a result production activities were also shifted, but however, showed much less concentration. Labour and capital were moved out of the Eastern Provinces towards Ontario and the West in order to support the higher production levels.

-- The introduction of the interregional migration model and the cost of transport of migrants eliminated the efficiency gains that resulted from the free mobility of labour across regions. The migration constraints, which force the movement of labour to be close to the historical movement, coupled with the cost of migration caused the level of national disposable income to be slightly lower than that associated with no interregional mobility of labour. The

benefits of the historical migration in the right direction (i.e., to the provinces where labour is in short supply) were outweighed wy the transport cost of migration and by the opportunity cost of moving labour from the provinces where labour is needed, to the provinces where there is excess supply of labour.

-- The imposition of the interregional equity constraints significantly reduced the value of the objective function under most specification of factor mobility. This reduction was caused by two main factors: first, the loss of efficiency that results from the transfer of economic activities away from the most efficient provinces, and second, the loss of income due to the way in which interregional equity is generally achieved, that is by pulling down the incomes of other provinces to the level of the poorest province. Prince Edward Island could not support (supply necessary consumption goods) a high income level per worker; and, given that the labour force is not allowed to migrate, this resulted in low income per worker in this province.

-- Aggregate efficiency and interregional equity are not compatible under all but one specification of factor mobility. The cost of interregional equity amounts to 33.5 per cent of national income when labour and capital are fixed by industry and region at historical levels, to 40 per cent when factors are mobile within regions, and to 7 per cent when factors are mobile across both

regions and industries. Equity and efficiency are compatible only when labour is mobile across regions and capital is mobile within regions. The cost of equity in this case is only 0.02 per cent of national income. The allocation of consumption and production are similar with or without the equity constraints. The movement of unemployed labour out of the poorer provinces makes possible the achievement of interregional equity at higher than historical levels of income. The movement of labour towards Ontario, Alberta, and British Columbia from all other provinces constituted about 6 per cent of the labour force of the sending provinces. In Prince Edward Island, however, the required movement of labour represented 41 per cent of the province's labour force.

-- The imposition of the migration model along with the equity constraints, eliminates any advantage due to the mobility of labour across regions. The cost of interregional equity in this case was even higher than that associated with no cross-regional mobility of labour.

All of the results obtained are based on some simplifying assumptions pertaining to the nature of the linear programming and thus they deserve some comments. First, the programming framework used assumes all the relationships are linear. The constraints of this model should be taken, thus, as approximations to the true

relationships. Second, the fixed interregional trade and import coefficients eliminate the possibility of substitution between the locally produced goods and those imported from other regions and from abroad. Consequently, regional income levels cannot be increased by merely transferring funds from the government to the regional economies if any resource constraint is binding. Third, the full concentration of activities that may result in a linear programming framework is not a realistic representation of the possibilities for the economy. Although this feature was reduced in production activities by the fixed interregional trade and import coefficients and by the fixed level of exports abroad, it was evident (in some experiments) in the allocation of income and consumption. Note, however, that the Pareto-constrained experiments, which did not feature extreme specialization of income and consumption, leads to values of income almost as large as those in the efficiency experiments. Thus, substantial gains in income are possible without extreme specialization.

Although the results of the "counterfactual" experiments reported here are sometimes unrealistic, they do have some implications for regional policy. First, the improvement of incomes in the low-income regions requires increasing the ability of those regions to generate income and support (supply consumption goods)

consumption. These improvements may come from reorganizing economic activities within the regions or from increasing the efficiency of resource use in specific industries, without increasing the amount of capital or labour in these regions. The economic structures of these regions, as reflected in the input-output data, are geared to low income and consumption levels. Increasing income levels in these regions will require restructuring of their economies so that higher income levels can be supported. The results reported here indicate directions that this restructuring should take. Second, where the availability of local resources limits the levels of income which can be generated and supported, movement of labour across regions can lead to improvement in per capita incomes. However, historical interprovincial migration behaviour does not appear to be contributing to this goal. Third, the reallocation of labour across regions does not appear to require substantial movement of capital across regions but will require interregional capital reallocation.

Some avenues for further research that arise from this study include:

-- Allowing for substitution between locally produced goods and goods imported from other regions and/or from abroad. This can be done by aggregating the material balance constraints across regions. This would relieve the regional disposable incomes from the upper limits imposed by the availability of local resources.

The overall government budget constraints together with upper bounds on the provincial financial constraints may be used to keep imports from abroad from increasing indefinitely.

-- Allowing for government spending to be a function of the regional labour force (or population). This will put a lower limit on government spending in each region and eliminate the possibility of using government transfers as the only means of government participation in increasing the level of regional demand.

-- The assumption of free mobility of capital across regions or across industries may be dropped and the distinction between movable and nonmovable capital may be made. This specification can be better accommodated in a multiperiod model where the accumulation of capital stocks in the desired industries and regions is made through new investment.

-- Finally, the assumption of free mobility of labour across industries may also be dropped. Although some labourers may move between industries to perform similar jobs, the cost of retraining the labour force will more accurately reflect the reality of labour mobility.

BIBLIOGRAPHY

Alonso, W., "Equity and its Relation to Efficiency in Urbanization", in J.F. Kain and J.R. Meyer (eds.), Essays in Regional Economics, Harvard University Press, Cambridge, Massachusetts, 1971.

Andersson, A.E., "Integration of Transportation and Location Analysis: A General Equilibrium Approach." Papers of the Regional Science Association, Vol. 42, 1979.

Auer, L., "Regional Disparities of Productivity and Growth in Canada". A Study prepared for the Economic Council of Canada, Ottawa, 1979.

Aziz, R., D.W. Butterfield and A.A. Kubursi, "Regional Equity and Efficiency: Some Experiments for Canada". Journal of Regional Science, Volume 23, 1983, pp. 397-412.

Ballard, K.P. and R.M. Wedling, "The National-Regional Impact Evaluation System: A Spatial Model of U.S. Economy and Demographic Activity", Journal of Regional Science, Vol. 20, 1980, pp. 143-158.

Baumann, J., and U. Schubert, "Factors of Regional Labor Force Participation Rates: An Econometric Study for Austria". Paper presented at the Regional Science Association Conference, Munich, August 1980.

Boadway R. and F. Flatters, Equalization in a Federal State: An Economic Analysis. Ottawa, Economic Council of Canada, 1982.

Bolton, R., "The Development of Multiregional Economic Modelling in North America: Multiregional Models in Transition for Economies in Transition", in B. Issaev et. al., Multiregional Economic Modelling: Practice and Prospect, North-Holland, Amsterdam, 1982.

Borts, G.H. and J.L. Stein, Economic Growth in a Free Market, Columbia University Press, New York, 1964.

Brewis,T.N., Regional Economic Policies in Canada, the Macmillan Company of Canada Limited, Toronto, 1969.

_____, "Regional Development in Canada in Historical Perspective", in N.H. Lithwick (ed.), Regional Economic Policy: The Canadian Experience, McGraw-Hill Ryerson Limited, 1978.

Chenery, H.B., P.G. Clark, and V. Cao-Pinna, The Structure and Growth of The Italian Economy, U.S. Mutual Security Agency, Rome, 1953.

Courbis, R., "The REGINA Model. A Regional-National Model of the French Economy", Economics of Planning, Vol. 12, 1972, pp. 132-152.

_____, "The REGINA MODEL. A Regional-National Model for French Planning", Regional Seience and Urban Economics, Vol. 9, 1979, pp. 117-139.

_____, "Integrated Multiregional Modeling in Western Europe", in B. Issaev, P. Nijkamp, P. Rietveld, and F. Snickars (eds.), Multiregional Economic Modeling: Practice and Prospect, North-Holland, Amsterdam, 1982.

_____, "Multiregional Modeling: A General Appraisal", in M. Albegov, A.E. Anderson, and F. Snickars (eds.), Regional Development Modeling: Theory and Practice, North-Holland, Amsterdam, 1982.

_____, and G. Cornilleau, the REGIS Model. Paper presented at the 18th European Congress Meeting of the Regional Science Association, Fribourg, Switzerland, August 29-September 1, 1978.

Courchene, T.J., "Interprovincial Migration and Economic Adjustment" Canadian Journal of Economics, Vol. 3, 1970, pp. 550-576.

_____, "A Market Perspective on Regional Disparities", Canadian Public Policy, Vol. 7, 1981, pp. 506-518.

_____, and G.H. Copplestone, "Alternative Equalization Programs: Two-Tier System" in Richard Bird (ed.), Fiscal Dimensions of Canadian Federalism, Toronto, Canada Tax Foundation, (1980), pp. 8-45.

d'Amours, A., G. Fortin, and G. Simard, "Candide-R, Un Modele National Regionalise de L'economie Canadienne" in R. Courbis (ed.), Modeles Regionaux et Modeles Regionaus-Nationaux, Cujas, Paris, 1979.

Dension, E., Why Growth Rates Differ: Postwar Experience in Nine Western Countries, The Brookings Institution, Washington, 1967.

Dresch, S.P., and D.A. Updegrove, "A Disaggregate Policy-Impact Model of The U.S. Economy", in R. Haveman and K. Hollenbeck (eds.), Microeconomic Simulation Models for Public Policy Analysis, Vol. 2, Academic Press, New York, 1980.

Firestone, O.J., "Regional Economic and Social Disparity", in O.J. Firestone (ed.), Regional Economic Development, University of Ottawa Press, 1974.

Gilbert, A.G. and D.E. Goodman, "Regional Income Disparities and Economic Development: A Critique", in A.G. Gilbert (ed.), Development Planning and Spatial Structure, Wiley, New York, 1976.

Glejser, H., G. Van Davl, and M. Lambrecht, "The First Experiment With an Econometric Regional Model of the Belgium Economy", Regional Science and Urban Economics, Volume 3, 1973, pp. 301-314.

Green, A.G., "Regional Economic Disparities", in L.H. Officer and L.B. Smith (eds.), Issues in Canadian Economics, McGraw-Hill Ryerson Limited, 1974.

_____, Regional Aspects of Canada's Economic Growth, University of Toronto Press, 1971.

Greenhut, M.L., Plant Location in Theory and in Practice: The Economics of Space, Chapel Hill, University of North Carolina Press, 1956.

Greenwood, M.J., "Research on Internal Migration in the United States: A Survey", Journal of Economic Literature, Volume 13, 1975, pp. 397-433.

Harris, C.C., Jr., "New Development and Extensions of the Multiregional Multi-Industry Forecasting Model", Journal of Regional Science, Vol. 20, 1980, pp. 159-172.

Higgins, B., "Trade-Off Curves and Regional Gaps", in J. Bhagwati and R.S. Eckaus (eds.), Development and Planning: Essays in Honor of Paul Rosenstein Rodan, Allen and Unwin, London, 1973.

Hirschman, A.O., The Strategy of Economic Development, New Haven, Yale University Press, 1958.

Hudson, B.M., "The Three Faces of Equity", School of Architecture and Urban Planning, University of California at Los Angeles, DP 47, 1974.

Isard, W., Location and Space Economy, Wiley, New York, 1956.

_____, "Interregional and Regional Input-Output Analysis: A Model of a Space Economy", Review of Economics and Statistics, 33, 1951, pp. 318-28.

Karlqvist, A.R., R. Sharpe, D.F. Batten, and J.F. Brotchie, "A Regional Planning Model and Its Applications to South Eastern Australia", Regional Science and Urban Economics, Volume 8, 1978, pp. 57-86.

Kendrick, J. and R. Sato,"Factor Prices, Productivity and Economic Growth", American Economic Review, Volume 53, 1963, pp. 974-1003.

Lefeber, L., Allocation in Space: Production, Transport and Industrial Location, North-Holland, Amsterdam, 1958.

Liaw, Kao-lee and J. Ledent, "Explanation of the Spatio-Temporal Pattern of Interprovincial Migration in Canada: An Application of the Nested Logit Model." QSEP Research Report, No. 153, McMaster University, 1986.

Lithwick, N.H., Regional Economic Policy: The Canadian Experience, McGraw Hill-Ryerson Limited, 1978.

Los, M., "A Transportation-Oriented Multiregional Economic Model for Canada", Centre de Recherche sur les Transports, Universite de Montreal Publication, 1978

Losch, A., The Economics of Location (Translated from German by W.F. Stopler), New Haven, Yale University Press, 1954.

Lundqvist, L., "Applications of a Dynamic Multiregional Input-Output Model of the Swedish Economy", Papers of the Regional Science Association, Vol. 47, 1981, pp. 77-95.

Mera, K., Income Distribution and Regional Development, University of Tokyo Press, 1975.

Metwally, M.M. and R.C. Jensen, "A Note on the Measurement of Regional Income Dispersion", Economic Development and Cultural Change, Vol. 22, 1973, pp. 135-136.

Miller, E., "The Migration of Employed Persons to and from Metropolitan Areas of the United States", Journal of American Statistics Association, 1976, pp. 1418-32.

Milne, W.J., N.J. Glickman, and F.G. Adams, "A Framework for Analyzing Regional Growth and Decline: A Multiregional Econometric Model of the United States", Journal of Regional Science, Volume 20, 1980, pp. 173-189.

Moses, L., "The Stability of Interregional Trading Patterns and Input-Output Analysis", American Economic Review, Volume 45, 1955, pp. 803-832.

Myrdal, G., Economic Theory and Underdeveloped Regions, Methuen and Company Limited, London, 1957.

Parr, J.B., "Welfare Differences Within a Nation: A Comment", Papers of the Regional Science Association, Volume 32, 1976, pp. 83-91.

Perroux, F., "Note Sur la Notion de Pole de Croissance", Economie Applique, Volume 8, 1955, pp. 307-20.

Polenske, K.R., The U.S. Multiregional Input-Output Accounts and Model, Heath/Lexington Books, Lexington, Massachusetts, 1980.

Polese, M., "Regional Disparity, Migration and Economic Adjustment: A Reappraisal", Canadian Public Policy, Volume 7, 1981, pp. 519-525.

Richardson, H.W., Regional Economics. Weidenfeld and Nicolson London, 1969.

_____, Regional Growth Theory, Halsted Press, New York, 1973.

_____, "Aggregate Efficiency and Interregional Equity", in H. Folmer and J. Oosterhaven (eds.), Spatial Inequalities and Regional Development, Martinus Nijhoff Publishing, Boston, 1979.

_____, "The State of Regional Economics: A Survey Article", International Regional Science Review, Volume 3, 1978, pp. 1-48.

Rietveld, P., "A General Overview of Multiregional Economic Models", in B. Issaev et. al. Multiregional Economic Modeling: Practice and Prospect, North-Holland, Amsterdam, 1982.

Schubert, U., "The Development of Multiregional Economic Models in Western Europe", in B. Issaev et. al. Multiregional Economic Modeling: Practice and Prospect, North-Holland, Amsterdam, 1982.

Siebert, H., Regional Economic Growth: Theory and Policy, International Textbook Company, Pennsylvania, 1969.

Shaw, P.R., "Fiscal Versus Traditional Market Variables in Canadian Migration", Journal of Political Economy, Volume 94, 1986, pp. 648-666.

Snickars, F., "Interregional Linkages in Multiregional Economic Models", in B. Issaev et. al. Multiregional Economic Modeling: Practice and Prospect, North-Holland, Amsterdam, 1982.

Solow, R., "Technical Change and the Aggregate Production Function", Review of Economics and Statistics, Volume 39, 1957. pp. 312-320.

Stanley, L.W. and D. Gauthier, "Internal Migration and Fiscal Structure". A Study prepared for the Economic Council of Canada, Ottawa, 1982.

Thijs, F. and P. Van Rompuy, "RENA, Regional Model for Belgium", in R. Courbis (ed.), Modeles Regionaux et Modeles Regionaux-Nationaux, Cujas, Paris, 1979.

Treyz, G.I., "Design of a Multiregional Policy Analysis Model", Journal of Regional Science, Volume 20, 1980, pp. 191-206.

Treyz, G.I., A.F. Friedlaender, and B.H. Stevens, "The Employment Sector of a Regional Policy Simulation Model", Review of Economics and Statistics, Volume 62, 1980, pp. 63-73.

Vanhove, H. and L.H. Klaassen, Regional Policy: A European Approach, Allenheld, Osmun, Montclair, 1980.

Van Delft, A. and W. Suyker, "Regional Investment Subsidies: An Estimation of the Labour Market Effects for the Dutch Regions." Paper presented at the 21st European Congress of the Regional Science Association, Barcelona, August 1981.

Williamson, J.G., "Regional Inequalities and the Process of National Development." Economic Development and Cultural Change, Vol. 13, 1965, pp. 3-45.