THE UNIVERSITY OF MANITOBA

A STRUCTURAL MODEL FOR REGIONAL DEVELOPMENT FORECASTING AND PLANNING: INCOME, EMPLOYMENT, AND MIGRATION IN A COMPARATIVE STATICS FRAMEWORK

by

KELLY ZERING

A thesis
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ABSTRACT

The problem addressed by this thesis is the lack of a functional comprehensive model with which to forecast the complex social-economic impacts of alternative policies considered for developing rural economic regions in Manitoba.

A linked model of Manitoba's Parkland region was developed in this study based on existing data and previous studies. A linear programming model of Manitoba agriculture was used to generate simulated income, employment and output responses of the agricultural sector to price conditions of 1971 and 1974. The changes predicted by the linear programming model were used to proportionally adjust the final demand in an input-output structure.

The subsequent solution to the input-output model provided estimates of regional income and employment. These income and employment estimates, in combination with migration and population projection models were used to predict the population and available labour force. The resulting information from analysis of four different scenerios based on the linked model was used to make predictions of demand for transportation services in the Parklands Region.

The nature of the interrelationships modeled in the study may be of use to policy-makers in developing a coordinated set of programs to pursue income and employment policy objectives in a regional context.

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CHAPTER I

THE PROBLEM

The continual decline of population levels in rural areas that has accompanied industrial and urban growth in most of Canada and the United States has left regional planners facing considerable difficulty and uncertainty. The interest of regional and provincial governments in reducing planning uncertainty has been evident in the proliferation of economic and demographic models with that objective.[1] Examples of government programs indicating this concern include the Industrial Incentives Act[2] and the General Development Agreement.[3]

A considerable amount of work has been completed around the central hypothesis that the major variables influencing people's decision to migrate are income and employment.[4] This hypothesis has been supported in

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[1] J. A. MacMillan, C. F. Framingham, F. L. Tung, and S. Lyon, "Parklands Region Manpower Information Study," Department of Agricultural Economics, University of Manitoba, Winnipeg, 1975.

[2] "Industrial Incentives Act," Revised Statutes of Canada, Volume IV, Chapters 1-10, 1970.

[3] General Development Agreement, Canada/Manitoba, Canada Department of Regional Economic Expansion, Information Canada, Ottawa, 1974.

[4] Curtis C. Harris, Jr., The Urban Economies, 1985, Lexington Books, Toronto, 1973, pp. 40-42.

empirical studies.[5] Emphasis in economic models of regional growth and development has been placed on variables ranging from "gross product"[6] to income and employment differentials[7] between regions.

It is pointed out by researchers such as Brinkman and Tweeten that outmigration of young and productive residents of basically rural regions represents a major economic loss of investment or 'human capital' to those regions.[8] Planners are faced with uncertainty about future returns on community or regional investment decisions that they must make now regarding schools, other services, and industrial development. Traditionally, economic models have made speculative forecasts for regions based on assumed levels of population arrived at by various indirect methods from demographic projections.[9]

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[5] G. Mathieson, "Estimation of the Determinants of Gross Migration in Manitoba," unpublished thesis, Department of Agricultural Economics, University of Manitoba, Winnipeg, 1977.

[6] K. Ballard and N. J. Glickman, "A Multiregion Econometric Forecasting System: A Model for the Delaware Valley," Journal of Regional Science, Vol. 17, No. 2, August 1977, pp. 161-177.

[7] G. Mathieson, op. cit., pp. 42-43.

[8] L. Tweeten and G. L. Brinkman, Micropolitan Development, The Iowa State University Press, Ames, 1976, p. 139.

[9] J. A. MacMillan, C. F. Framingham, F. L. Tung and S. Lyon, op. cit.

Recently, models have been implementing demographic characteristics as endogenous to economic models.[10] This development comes as a logical extension of hypotheses relating migration to income and employment. The planners' need to recapture investment in people and to predict future population to be served have made the delineation between 'economic' and 'demographic' variables somewhat spurious.

While recent models have considered 'demographic' variables, the vital linkages between income and employment and net migration and in return the effect of net migration on future economic activity have yet to be fully incorporated. As a result, regional planners and decision-makers in all sectors related to regional economic activity continue to be faced with substantial uncertainty.

SOME RELATED STUDIES

Similar Studies Previously Completed

Studies in this problem area completed previously include The Urban Economies, 1985 by Harris.[11] It is a study using a multi-regional, multi-industry forecasting model to study regions of the United States. The model employs industrial location theory as well as population

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[10] C. C. Harris, *loc. cit.*

[11] C. C. Harris, *op. cit.*

characteristics to study investment impacts in different regions. It uses an input-output framework as a general model. The determinants of net population migration used are labour surplus or deficit, and per capita income.

Thus, the model serves as an example of economic-demographic linkage in regional modelling on a large scale. It lacks an optimization dimension relating it more closely to economic forces toward "equilibrium." It also places emphasis on forecasting impacts of defence spending as opposed to agricultural development. This may be reflected in the structure of the model's input-output basis.

More recently, Ballard and Glickman wrote, "A Multiregion Econometric Forecasting System: A Model for the Delaware Valley."[12] Their model includes equations for personal income that contain employment variables. It does not, however, make the fundamental connection between income and employment and population migration. Instead, 'Gross County Product' is used as a proxy variable for economic attractiveness in estimating net migration. This study may highlight one other limitation of the larger Urban Economies, 1985 model: data availability and collection. A relatively large amount of data on income, employment and migration is required to document the relationship between these variables. In the Harris study, previously examined, a great deal of data was collected.

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[12] K. Ballard and N. J. Glickman, *op. cit.*

Apparently, in Ballard and Glickman's study, less data was collected. In this study much of the data is already contained in the component studies.

The Component Studies

There are four major studies that form major components of this study. They are indicative of the progress to date in regional modelling in Manitoba. They are Farm Income, Employment and Manitoba Agriculture: A Linear Programming Approach to Consideration of Policy Alternatives by C. F. Framingham, L. B. B. Baker, and W. J. Craddock; "The Parklands Region Manpower Information Study" by J. A. MacMillan, C. F. Framingham, F. L. Tung, and S. Lyon; Population Projections for Manitoba by Region and Town Size - Some Alternatives 1971-1990 by W. R. Maki, C. F. Framingham, and D. J. Sandell; and Estimation of the Determinants of Gross Migration in Manitoba by G. Mathieson. The content and mechanics provided by these studies will be briefly reviewed in this section.

Farm Income, Employment and Manitoba Agriculture: A Linear Programming Approach to Consideration of Policy Alternatives[13] is the Linear Programming component. It

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[13] C. F. Framingham, L. B. B. Baker, W. J. Craddock, Farm Income, Employment, and Manitoba Agriculture: A Linear Programming Approach to Considerations of Policy Alternatives, Vols. I.1 and I.2, Research Bulletin No. 78-1, Department of Agricultural Economics, University of Manitoba, Winnipeg, 1978.

was written to provide a basis for evaluation of programs aimed at specific income and employment objectives. It optimizes agricultural production efficiency in Manitoba subject to income and employment constraints amongst others. In this way, the linear programming technique is used to take account of land, labour, and other resource constraints when selecting the combination of farm production activities that best meets the policy objectives of planners in regard to income, employment, and consumer desires.

Further breakdown into farm size and regional specifications adds flexibility and adaptability to the model. The flexibility is characterized mainly in the model's ability to reflect changes in scale of production (farm size), production mix (enterprise level of output), and location of production (regional output). These characteristics in addition to the income and employment constraints suggest that the model is adaptable to various policy analysis situations. In particular, the linear programming model may be adapted to simulate the agricultural base economy of predominantly rural regions.

Linear programming models are, however, subject to the inherent limitations of linear relationships and fixed coefficients. In this case, however, the level of disaggregation by farm size and region is sufficient to provide some necessary flexibility. The interpretation of these limitations is the assumption that production practices are unchanged by farm size over time and that external factors are held constant.

"The Parklands Region Manpower Information Study"[14] is an extensive study conducted to analyze potential developments in terms of labour force and employment in the Parklands region of Manitoba. The framework of the study includes the following sub-topics: present and projected population and work force, farm labour market analysis, private sector growth prospects, public sector expenditures, job and income creation, wage and income determination, identification of alternative job gaps, reducing the job gap, program priority determination, program implications, and migration analysis. It is apparent from this framework that the study covers much of the area discussed in the problem statement earlier. Closer inspection, however, reveals that some problem areas were left unsolved or assumed away. An example is the use of selected alternative trends in the population and work force projections as well as alternative trends in fertility, mortality, and migration.

The study does offer an input-output sectoral analysis of the Parkland region. This analysis provides a model of the economic interrelationships that exist within the region and a method of predicting the sectoral impacts

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[14] J. A. MacMillan, C. F. Framingham, F. L. Tung, and S. Lyon, op. cit.

of income and employment changes in various components of the economy. Thus, the "Parklands" study serves as the basic component of this study.

The limiting effects of the "Parklands" input-output analysis on the whole model are basically contained within the assumptions inherent in input-output analysis. The proportion of each input per unit of output is assumed constant for each sector. This results in linear relationships which, as in the linear programming model case, are assumed to remain constant over time and magnitude of output. As the original data for the "Parklands" study was collected in 1968, it proves to be a limitation to any quantitative results that this research provides. It does not, however, affect the validity of the model constructed.

Population Projections for Manitoba by Region and Town Size - Some Alternatives 1971-1990[15] describes research conducted to show the results of six sets of population, labour force, and family formation projections to the years 1975, 1980 and 1990. The basic equations of the "Projections" model account for births, deaths, and net migration as the variables affecting population change. This model is also specified by region for Manitoba

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[15] W. R. Maki, C. F. Framingham, and D. J. Sandell, Population Projections for Manitoba by Region and Town Size - Some Alternatives, 1971-1990, Research Bulletin No. 73-2, Department of Agricultural Economics, University of Manitoba, Winnipeg, 1973.

providing some flexibility in analysis of inter-regional population shifts.

While the "Projections" study contains a substantial discussion of the economic-demographic nature of regional planning and forecasting problems, it is limited by its basic assumptions. The rigidity of its birth-rate and death-rate projections appear to be justified historically in the study. The migration projections, however, are less excusable in their rigidity as mentioned in the problem statement earlier. Migration is the fundamental and least trend-predictable of the population variables.

The causes of migration are analyzed in Estimation of the Determinants of Gross Migration in Manitoba.[16] This study measures, through regression techniques, the importance of various factors in people's decision to migrate. Its results indicate that income and employment differentials between origin of the move and the place moved to are major determinants of gross migration. In addition the distance of the move is a major inhibitor or negatively correlated determinant of migration.

In the migration analysis cross-sectional regressions were broken down by region as well as by type of move; i.e., rural to small city, rural to large city,

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[16] G. Mathieson, op. cit.

small city to rural, etc. Thus, the information provided in this model not only replaces one of the assumptions of the "Projections" model but also adds to the knowledge of the residential make-up of the future labour force in rural regions. The major limitation of the 'Determinants' study is the statistical validity of the results obtained. No projection based on the relationships identified in the 'Determinants' study can be any more significant than the equations themselves.

CHAPTER II

OBJECTIVES OF THE STUDY

Given the problems faced by regional planners arising out of the uncertainty of returns on investment in human capital and capital infrastructure; and given the existing economic and demographic models pertaining to the Parklands region of Manitoba and containing a common focus on income and employment variables, the objectives of this study were defined. The general intention was to exploit the simulative and predictive potential of the models and data previously developed, demonstrate the use of that potential, and present it.

Thus, the specific objectives of this study were as follows:

1) to develop a linked economic-demographic model for Manitoba's Parkland region based on existing data and previous studies,
2) to apply the model to estimation of the product and passenger demands for transportation within and linking the Parkland region to the rest of Manitoba, and
3) to present the model in such a fashion that the theoretical framework may be taken from the study and applied to other regions in Manitoba or elsewhere.

CHAPTER III

THEORETICAL BASIS AND SPECIFICATION OF THE MODEL

Theoretical Basis of the Model

The first portion of this chapter presents the theoretical basis of the model starting with a look at the general theories underlying the models and narrowing down to a discussion of the specific theory related to the model as presented in the final section of the chapter.

Some Regional Development Background

This section will provide a brief review of theories employed in regional development forecasting and planning models. The objective here will be to point out particular characteristics employed (or not included) in the theory used in the 'component models' and in the combined model. This section, therefore, is not intended to be all-inclusive but rather a selected overview. The procedure will be a discussion of general theory followed by a discussion of general types of regional models generated out of general theory.

The discussion of general theory is based on a more complete discussion provided by Brinkman and Tweeten.[17] They differentiate between three general

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[17] L. Tweeten, *op. cit.*

bodies of theory when looking at the basis of regional planning models. The general bodies of theory include several subsections of Neoclassical Theory, some Keynesian-based Income-Employment Growth Theory, and a cross-classification called Theory of Public Involvement.

Neoclassical Theory is seen to stress comparative advantage with profit maximization being achieved through substitution of inputs and outputs in response to price variations. Subsectors include Natural Resource Theory which emphasizes the exploitation of natural resources to produce profit as a form of comparative advantage. Location theory is a second subsector. It emphasizes that firms will locate where production costs are least given homogenous demand or that firms will locate where market demand for their product is the greatest, given homogenous production costs. Transportation costs of inputs and outputs become important in establishing site-prices of input supplies and demand for output. A further factor introduced here is the role of agglomeration economies and diseconomies in determining site-prices. In conjunction with this, Central Place Theory emphasizes a "hierarchy of interdependence among cities."[18] The relationship of numerous small outlet services to larger few-outlet services is depicted here. The dynamic characteristics of growth as well as agglomeration economies are captured in

[18]Ibid., p. 68.

theories regarding Growth Poles, Growth Centers and Growth Points. Gravity Models are the last subsector considered by Brinkman and Tweeten. Gravity Models emphasize the economic ties between various cities in an area as the basis for further development.

In summary, the contribution of Neoclassical Theory and its various offspring attempt to predict economic response to given stimuli by analyzing the actions of profit maximizing firms in a generally competitive market.

The general body of theory described by Brinkman and Tweeten as Income and Employment Growth Theory "stress aggregate savings, investment, exports, and 'engineering' interdependencies."[19] Export Base Theory is a subsector that suggests that net area income is the sum of expenditures within the region and exogenously determined export returns minus expenditures on imports. On this extensive basis, multipliers are calculated to predict the effect of external-sourced expenditures on regional income. The specific internal reactions of the region to the expenditures are left unexplained. This has been seen as a limitation in some cases.[20]

The Harrod-Domar Model is a similar type of framework which shifts emphasis to growth of savings and

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[19] Ibid., p. 70.

[20] Ibid., p. 72.

investment within the region from external demand for regional exports.

The third general body of theory described by Brinkman and Tweeten is The Theory of Public Involvement. (See page 22 for justification of the inclusion of this discussion.) Basically this proposes a basis for defining when government intervention is necessary and to what degree. It generally mends some of the weaknesses created by the Neoclassical theoretical base's assumptions about generally competitive markets. "Public action can be justified to reallocate goods to increase 'social' efficiency and total welfare whenever the net marginal benefit (cost) of a particular action differs from the net marginal 'private' benefit (cost) that is generated through the market system."[21]

Externalities are one factor in determining public involvement. Tweeten and Brinkman suggest that the government might intervene on equity grounds where 'pecuniary' externalities occur, and on efficiency grounds where 'real' externalities occur.

"Collective or public goods are goods and services that meet two criteria: (1) they must be supplied jointly to a group of people rather than provided on an individual basis, and (2) their benefits cannot be withheld from anyone who refuses to pay for them once the goods are

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[21] Ibid., p. 76.

produced." Thus governments may have to step in where private entrepreneurs would have no incentive to produce such goods.

Natural monopolies on the other hand may give private firms incentive to operate at profit-maximizing levels that do not coincide with the social optimum. In order to achieve efficiency within the constraints of the social optimum, government intervention may be required.

Nonmarket goods are goods without prices that cannot be allocated through the market system. All of the above statements generally outline theoretical considerations to be dealt with in regional development models. A more specific description of their use in regional models is provided by a review of types of models below.

This discussion is based on the in-depth review provided by Norman J. Glickman.[22] He looks at three major types of models; Economic Base Models, Regional and Interregional Input-Output Models, and Econometric Models. This overview is intended to bring out highlights and contrasts of the different types of models.

Economic Base Models generally interpret the economic base theory outlined above by identifying some proxy for regional economic activity such as net regional income or total employment and allocating that to the base (export) sector or to the service sector. The multiplier

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[22] K. Ballard and N. J. Glickman, op. cit.

of the exogenously determined export levels is determined by regional propensities to consume and invest locally. Economic base models are useful in that they require little data accumulation and are relatively inexpensive. These models are limited by "the use of improper units of measurement, imprecise identification of sectors, weak assumptions concerning the stability of the basic/service ratio, and the problems of lags."[23]

A second type of regional forecasting model is the econometric model. These generally consist of one or a series of regression analyses to establish the relationship between various economic and/or socio-economic variables. Glickman provides an especially large review of this type of model.[24] He seems to favour them in that they provide considerably more information than economic-base models but without the large and expensive data requirements of the input-output models. He also stresses flexibility of the econometric model over the rigid assumptions of the input-output model.

The third type is the Regional and Interregional Input-Output model. An example of such a model is described in the following section. The study is

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[23] Ibid., p. 20.

[24] Ibid.

entitled "The Parklands Region Manpower Information Study."[25]

Generally the transactions between all sectors of the economy are collected as data and used to form a matrix of coefficients depicting sectoral interdependencies. As a result, multiplier effects may be studied by sector which represents considerably more detail than is available from the simple econometric model. The 'inflexibility' inferred earlier regarding the input-output model comes from the assumption of fixed coefficients representing sector transactions; i.e., no economies of scale or externalities such as agglomeration economies are apparent in the estimates of multiplier effects.

The Theoretical Framework

This section attempts to highligh those specific theoretical characteristics of the component models that are directly involved in the linkage along with the theoretical assumptions and implications involved in facilitating the linkages.

The linear programming model presented in Farm Income, Employment, and Manitoba Agriculture: A Linear Programming Approach to Consideration of Policy Alternatives[26] provides an optimization process with which to

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[25] J. A. MacMillan, et al, op. cit.

[26] C. F. Framingham, L. B. B. Baker and W. J. Craddock, op. cit.

study the agricultural sectors in the Parklands region. The relationship between each output or enterprise and the inputs required for its production are expressed in a series of linear equations. In this case, the restrictions imposed by the linear relationships are somewhat relieved by the existence of different equations for each of three farm sizes in each of the regions in Manitoba for each of the agricultural sectors. The title of the linear programming model points out that income and employment are major considerations in this model. Thus, while maximum net income may be represented in the objective function, high minimum acceptable employment and/or income constraints may be used to simulate various alternatives.

The theory of optimal allocation of resources to various enterprises suggests that the marginal value product of a given input should be equal to the price of that input for each of the enterprises in which it is employed. Using three basic inputs; land, labour, and capital, the 'optimum' combination of enterprises is obtained. The above marginal value product equilibrium yields the profit maximization optimum.

It has appeared, in some cases, that profit maximization or loss minimization does not necessarily coincide with income and/or employment maximization (the importance of these latter two characteristics to regional planners was outlined earlier). This is especially true in the case of small farms with marginal profitability, substantial under-employment of farm labour in the form of the operator and his family, and given positive wages as a characteristic of the linear programming model.

As a result, the linear programming model is structured according to farm size. The output appears as specific rates of use of land, labour, and capital along with a specific set of returns. This also is interpreted as a specific set of incomes and levels of employment for the three farm sizes and the region as a whole.

It is conceivable that the profit maximizing solution of the linear programming model does not coincide with the income or employment objectives specified for the agricultural sector in the region. Income and employment are seen as important determinants of migration. Regional planners are concerned with net out-migration as a loss of investment and as a source of uncertainty in planning. As a consequence, regional planners may wish to maintain per capita income and employment at levels which will discourage net out-migration. In the model discussed here these levels are represented in the agricultural sector by the linear programming model in a potentially "constrained" optimum as opposed to a profit-maximizing solution. An example of a constrained optimum would be the maximum regional net income subject to a minimum employment of "X" man-years where X is some constant.

This income and employment flexibility of the linear programming model underlies its potential use as a means of policy simulation in order to evaluate various alternative policy goals. Where policy objectives include a high and stable level of regional employment and perhaps a stable regional population size or population growth rate, the overall model being presented in this study can be used to simulate the regional impacts on the objective variables of various programs in the agricultural sectors in the region. This can be achieved through simulating the direct level of output income to employment impacts of the programs on the agricultural sectors through the linear programming model.

A short digression is included here to justify the earlier general review of the Theory of Public Involvement. Justification for public involvement includes the ability to increase total welfare where net marginal benefit (or cost) differs from net marginal 'private' benefit (or cost). If we consider the provision of public services and infrastructure such as schools, local recreational facilities, and centralized services facilities, we may find that the 'market' (or 'private') decision to provide such services in light of income, employment, and population instability differs considerably from the decision reached under conditions of policy stabilized income, employment, and population. In this sense, we may consider the Theory of Public Intervention as part of the motivation for initiating simulation of income, employment, and particularly population impacts of various programming alternatives.

While this is by no means the only motivation for initiating such simulation, it may be considered as a possible use of the overall model. This model provides very limited ability to evaluate the difference between the 'private' and 'public' decisions regarding provision of regional public services, but it may provide data useful in the evaluation of that difference such as projected population and potential tax base via income and employment data. To end the digression; the agricultural sector programs direct income and employment impacts as generated by the linear programming model can then be used to generate regional impacts via the input-output model.

The impact of a particular set of agricultural production enterprise out-put levels on the rest of the region are calculated through the input-output component of the overall model. The proportional change in "grain for sale" and "total livestock production" (both in dollar terms) in the linear programming model are used to estimate the proportional change in final demand for the agricultural crops and agricultural livestock sectors respectively, in the input-output model. In addition, the proportional change in the share of those measures of output, produced by each farm size is used to estimate the proportional change in farm numbers for each farm size in the input-output model. (See Linkage 'a' in Figure 1.) These mechanical linkages imply the theoretical assumptions that: "grain for sale" and "total livestock

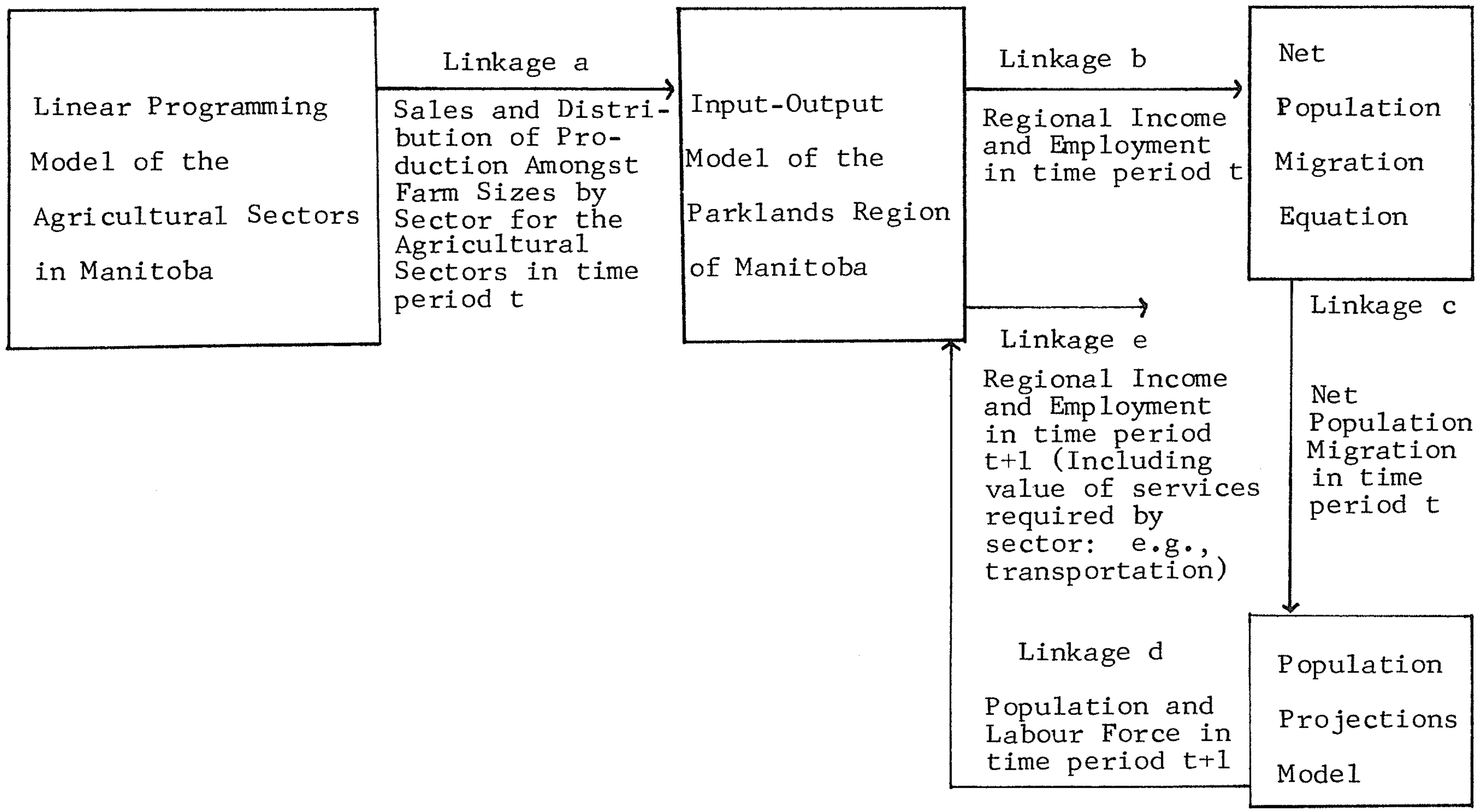

FIGURE 1

The Framework of the Overall Model:
The Component Models and the Linkages

production" in the linear programming model along with the adjustments in share of production by farm size are an accurate estimator of final demand in the input-output model.

This assumption is fairly realistic in the case of "grain for sale" which is a measure of the output not held back for intermediate use in other production processes. In the case of "total livestock production", a figure more comparable to gross output in the input-output model, the rationality of the assumption rests on the extent to which final demand remains a constant proportion of gross output given the changed level of production and the changed production function resulting from changed shares of total output by farm size. Other than intermediate uses within the Agricultural livestock sector, which will grow in fixed proportion with total output (given the sectoral production function), the proportion of final demand to total output in the agricultural livestock sector depends on two things.

The first is the increase in demand for agricultural livestock production by other intermediate sectors arising from the agricultural livestock sector's increased demand for the products of the other intermediate (endogenous) sectors as inputs. Since this relationship is also defined by fixed coefficients it will not cause results contrary to the assumption.

The second factor may be a source of potential change in the proportion of final demand to total output. It is the rate at which gross output grows in other sectors relative to the rate at which gross output is growing in the agricultural livestock sector. If gross outputs in the other sectors are growing less rapidly, for example, than gross output in the agricultural livestock sector (particularly, the final demand portion of gross output in the other sectors), the intermediate demand for agricultural livestock production will grow at a slower rate than the final demand (note: final demand defined as non-intermediate or non-input demand) in accordance with the fixed coefficients relating the other sectors' gross output to demand for agricultural livestock production. The extent of the change in proportion of final demand to gross output in the livestock sector will depend, at least, on the extent of the differences in growth rates of gross output between the other sectors and the agricultural livestock sector, and on the strength of the dependence of the livestock level of production on the intermediate demand from other sectors as defined by the fixed coefficients.

In order to indicate the extent to which the assumption is violated by the theoretical inconsistency discussed above, the proportion of final demand to gross output for the agricultural sectors appears in Appendix D.

The above discussion gives some reference to the input-output model but is incomplete in that respect.

The input-output model presented in "The Parklands Regional Manpower Information Study"[27] provides inter-sectoral relationships for the Parkland region. Included in its tableau format are linear equations representing the combinations of inputs required by each sector in the output of its product(s). Similarly, the distribution of one sector's output amongst all sectors is represented. This model provides representation of the interdependencies within the region's economy. These 'engineering' inter-dependencies are described as characteristic of Income and Employment Growth Theory by Brinkman and Tweeten.[28]

There are two agricultural sectors amongst eighteen endogenous sectors in the Parklands input-output model, twenty-six sectors overall. The two agricultural sectors have the added flexibility of being calculated as the average of the three farm size specific production functions weighted by their respective shares of gross output. In addition, the regional output is constrained by available labour and available land. This permits calculation of average income and unemployment on the basis of historical share of the labour force by sector and

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[27] J. A. MacMillan, C. F. Framingham, F. L. Tung, and S. Lyon, _op. cit._

[28] L. Tweeten, _op. cit._, p. 70.

trends for employment and income per dollar of gross output by sector (and by farm size for the agricultural sectors). This implies the assumption that labour is relatively immobile between sectors and will be either unemployed or migrate out of the region (or that the net exchange of labour between any two sectors is zero). Particularly in the case of the agricultural sectors, this assumption may be rationalized as reflecting the underemployment of agricultural owner-operators (especially given the fixed positive wage assumed in the linear programming model) in the face of the available land constraint and perhaps in keeping with tradition or other cultural constraints.

As a result of having the above capabilities, the impacts of given policy adjustments in the agricultural sectors on the whole regional economy may be observed. In addition, the impacts on specific sectors may be analyzed. In this case, an objective is to observe impacts on the transportation sector.

Furthermore, it is possible to observe the effects on the 'household' sector of the region. That is, personal income and employment totals for all sectors in the region may be generated to study the employment and income impacts of changes in the agricultural sectors. The input-output model thus translates sectoral changes into regional impacts.

The input-output solution then provides the average level of wage income per worker and the percent of available labour left unemployed in the region, given the levels of production in the agricultural sectors. These income and employment characteristics then (via Linkage 'b' in Figure 1) determine the rate of net out-migration in the subsequent time period through their introduction into the net migration equation. Since the income and employment characteristics used in the migration equation are relative to the corresponding income and employment characteristics in neighbouring regions, assumptions are made concerning economic activity in the neighbouring regions. The assumptions are in the form of holding those income and employment characteristics constant. A larger multi-region model would be able to provide information on interregional impacts of different policies and hence provide a better data base for the migration equation. Such a model, however, would require much more data and is outside the scope of the research conducted here.

The study entitled Estimation of the Determinants of Gross Migration in Manitoba[29] provides an empirically derived relationship between gross migration and several economic variables. The distance of the move, the income and employment differentials between origin and destination of the move, and ethnic background of two locales proved statistically significant in a cross sectional regression analysis of migration in Manitoba.

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[29] G. Mathieson, op. cit.

The distance of the move may be seen as representative of the cost of moving and is negatively correlated with migration. The income and employment differentials are the main economic variables seen as determinants of migration. In accordance with basic economic theory, where a large surplus of labour exists in one market but not in another with similar wages prevailing, migration should take place. Similarly, where large per capita income differences exist between regions with similar employment opportunities, migration should occur. The distance aspect or moving cost indicates imperfect mobility between markets. The ethnic background variable may be seen as a further indicator of imperfect mobility representing a non-economic factor. By reviewing the particular migration data from Estimation of Determinants,[30] it was possible to derive an average distance of migrations out of the region. This distance was inserted as a constant into the migration equation on the assumption that the relative distribution of distances of moves will remain the same irrespective of absolute number of moves. Similarly, the ethnic background characteristic was given an average value where necessary.

Given the estimated income and employment characteristics and the subsequent migration rate forecast for the region (via Linkage 'c' in Figure 1), the population

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[30] Ibid.

projections model provides base-line population and available labour force predictions for the next time period. The net migration rate is assumed constant for all age groups for lack of age specific regression analyses.

The theory of population projections and the relevant data are provided in Population Projections for Manitoba by Region and Town Size - Some Alternatives 1971-1990.[31] Population projections made in the study named above are based on implicit assumptions concerning the relationship between economic and social factors and population behaviour.

Three major variables are considered in "Population Projections." They are birth rates, survival rate, and net migration. Trends are developed from historical data and then used to predict future population levels. Trend analysis may be fairly misleading and in this case, migration is seen to be the least trend oriented of the variables being considered. While trends may be gradually changing in fertility rates, survival rates change little. Migration, on the other hand, may be seen to be more dependent on exogenous variable. The dependent net migration equation reviewed above thus replaces the trend migration rates in the overall model being presented here.

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[31] W. R. Maki, C. F. Framingham, and D. J. Sandell, op. cit.

The overall population growth rate arising from births, deaths, and migration is then used to adjust the Parklands population forecast for the following year. While the migration rate is assumed constant for all age groups, the birth and death rates cause some adjustment in the distribution of population across age-groups of the Parklands region. The population is then multiplied by age-specific labour force participation rates to generate the available labour force for the following time period. The labour force participation rates arise from historical data and are assumed to be constant over the forecast time periods for lack of better readily available data. These relationships are represented as Linkage 'd' in Figure 1.

The forecast labour force acts as a constraint in the following year's forecast of regional economic activity via the input-output model. In a more fully dynamic model, the forecast labour force might also act as a constraint in the linear programming model for the agricultural sectors. The overall model being presented here, however, employs a comparative statics approach to examine the single period reactions to price change stimuli.

The iterative process developed in the overall model arises from the assumption that adjustments in the agricultural sectors from the 'current' or 'historical' levels of production to the 'constrained optimum' levels of production calculated in the linear programming model will occur at a constant rate over a five-year period.

Recalling Linkage 'a' in Figure 1, this implies that the level of total production and the share of production by farm size will approach the 'constrained optimum' at a constant rate that adopts the 'constrained optimum' levels in five years. Further discussion of the specific alternatives selected for demonstration of the model appear in Chapter IV of this study under "Alternatives Analyzed."

Thus, with the introduction of the endogenous forecast of available labour on a year to year basis and with the introduction of change in final demand and share of production by farm size for the agricultural sectors along the trends arising from the linear programming 'constrained optimum' solution, an iterative process of regional income, employment, and population forecasting is generated through the input-output model. The beginning of the second iteration is represented by Linkage 'e' in Figure 1.

The 'second iteration' would be comprised of the solution of the input-output model with the newly introduced data described above (as well as trend-based annual changes in final demand data in the non-agricultural endogenous sectors already contained in the Parklands input-output model), the subsequent forecast of the new net migration rate (dependent on regional income and employment characteristics), and the resulting forecast of population levels and available labour force for a third year. This iterative process can be maintained for five years to achieve the 'constrained optimum' solution of the linear programming model and its associated regional impacts. Extrapolation of the linear programming solution trends may allow forecasts beyond five years although the theoretical justification for such extensions is unclear.

Specific formulation of the relationships expressed in the 'Linkages' discussed above appear in the following section. Additional information about the relationships included in the component models appears in Appendix A.

SPECIFICATION OF THE MODEL

This section outlines the relationships used in the analysis.

a) The Linear Programming to Input-Output Linkage was made through use of proportional change in final demand and distribution of production amongst farm sizes for the Agricultural Crops and Agricultural Livestock sectors. The variables identified as representative of final demand in the Linear Programming results were 'Total Grain for Sale' and 'Total Livestock Production'. Due to data restrictions, this linkage also required the assumption that final demand remained a constant proportion of gross output for the agricultural sector. This assumption allows the linear programming 'Total Livestock Production' figure which is actually representative of gross output, to be used as an indicator of final demand in the input-output model. The validity of this assumption is considered in Appendix D.

The distribution of production amongst farm sizes was measured by the portion of 'Total Production' (in dollars) by farm size for both agricultural sectors. The corresponding numbers in the input-output analysis were the number of farms by farm size. Given a single input-output or production function for each farm size and an initial distribution of production levels by farm size within the input-output historical data for 1971, and assuming a similar distribution of production amongst farm sizes in the Linear Programming Historical data for 1971: this model uses the proportional annual change in share of total production by farm size in the Linear Programming Analysis to calculate the annual change in share of total production (as represented by farm numbers by farm size and sector) by farm size in the input-output data. The equations for calculating input-output final demand and distribution of total production amongst farm sizes from linear programming solution follow:

1. $$FD_{i,t} = \frac{P_{i,t}}{P_{i,t-1}} \times FD_{i,t-1} \qquad i = 1,\ 2$$

The assumption described above for the Agricultural Livestock sector actually implies the following:

1a. $$FD_{1,t} = \frac{\dfrac{FD'_{1,t}}{GP'_{1,t}} \times GP'_{1,t}}{\dfrac{FD'_{1,t-1}}{GP'_{1,t-1}} \times GP'_{1,t-1}} \times FD_{1,t-1}$$

where:

$FD'_{1,t}$ = output for 'final demand' in the agricultural livestock sector of the linear programming model in time period 't'.

$GP'_{1,t}$ = 'gross output' in the agricultural livestock sector of the linear programming model in time period 't'.

With the assumption that $\frac{FD'_{1,t}}{GP'_{1,t}}$ is a constant over time, equation 1a. reduces to equation 1. above.

2. $$FN_{i,j,t} = \frac{SP_{i,j,t}}{SP_{i,j,t-1}} \times FN_{i,j,t-1} \qquad i = 1, 2 \qquad j = 1, 2, 3$$

where:

$FD_{i,t}$ = Final Demand in sector 'i' (1 = Agricultural Livestock, 2 = Agricultural Crops) in time period 't' in the input-output data.

$P_{i,t}$ = 'Total Livestock Production' where i = 1 or 'Total Grain for Sale' where i = 2, in time period 't' in the Linear Programming results.

$FN_{i,j,t}$ = Farm numbers in sector 'i', farm size 'j' (1 = small farms, 2 = medium farms, and 3 = large farms), in time period 't' in the input-output data.

$SP_{i,j,t}$ = Share of Total Production in sector 'i' by farm size 'j', in time period 't' in the linear programming solution.

b) The Input-Output to Population Projection linkage was made through the net migration equation. Two major variables in the net migration equation make the net migration rate dependent on the input-output solution. The ratio of unemployment in the 'rest of Manitoba' (assumed constant) to unemployment in the Parklands was calculated in each iteration of the input-output model. The ratio of average wage income in the 'rest of Manitoba' (assumed constant) to the average wage income in the Parklands was the second variable calculated in each iteration of the input-output model. The Net Migration Equation may be written as follows:

$$NPM_t = K_1 + K_2D + K_3I_{it} + K_4U_{it} - K_5D' - K_6\left(\frac{1}{I_{it}}\right) - K_7\left(\frac{1}{U_{it}}\right) + e$$

where:

$$I_{it} = K_8 / TO_{18t} / ALAB_t$$

and:

$$U_{it} = K_9 / \left[(ALAB_t - TOE_t) / ALAB_t\right]$$

where:

NPM_t = the net population migration rate out of the Parklands in time period 't'.

K_1 = constant comprised of the intercept and any other independent variables assumed constant (see section on the Input-Output to Population Projection Linkage in Chapter IV).

K_2, K_3, K_4, K_5, K_6, K_7 = constant coefficients of the determinants of migration.

D = average distance of migration out of Parklands.

D' = average distance of migration into Parklands.

I_{it} = ratio of average wage income in 'the rest of Manitoba' to the average wage income in the Parklands.

U_{it} = ratio of percent of labour force unemployed in 'the rest of Manitoba' to the percent of the labour for unemployed in the Parklands.

K_8 = assumed constant average wage income in 'the rest of Manitoba'.

TO_{18t} = total payments to (or purchases from) the households sector from endogenous sectors in the input-output model in time period 't'.

$ALAB_t$ = available labour force in time period 't' in the Parklands region.

TOE_t = total employment demanded in the Parklands region in time period 't'.

e = the error term.

c) The population Projection to the Input-Output Linkage was made through two variables. The 'available labour' variable was calculated in each iteration of the population projection model. Available labour then served as a constraint to Gross Output in the Parklands input-output solution. The sales to the "Households" sector by each of the other endogenous sectors and hence the total endogenous sales to the households sector was varied in direct proportion to population change in each iteration. The equation representing the calculation of 'available labour' follows:

$$ALAB_t = (XALAB_t / XALAB_{t-1}) \times ALAB_{t-1}$$

where:

$$XALAB_t = \sum_i POP_{it} \times LFP_i$$

where:

$ALAB_t$ = available labour force in the Parklands input-output data in time period 't'.

$XALAB_t$ = available labour force in the Parklands population projection data in time period 't'.

POP_{it} = population projected in age group 'i' in time period 't' in the Parklands Population Projection results.

LFP_i = labour force participation rates in age group 'i' in the Parklands Population Projection data.

This completes the linkage required to create the larger model. The component models are able to carry out further calculations internally that are not discussed here. An overview of the component models appears in Appendix A. The demonstration of the forecast of the level of demand for transportation services in post-1971 time periods is carried out by reading the input-output solution of gross output by the 'Transportation' sector. The equations representing the internal relationships reflecting transportation demand comprise the input-output model, i.e., transportation demand is interdependent with the demand in other sectors through the inter-sectoral production functions representing each sector.

CHAPTER IV

ALTERNATIVES ANALYZED AND SUPPORTING DATA

Alternatives Analyzed

Four alternative sets of economic conditions were analyzed based on existing solutions of the Linear Programming model. The first alternative considered used 1971 Historic Conditions as described in the Linear Programming Analysis[32] and the growth trends developed in the input-output model for distribution of farm numbers amongst farm sizes and for final demand.[33] The second alternative adopts the 1974 Constrained Optimum Solution from the Linear Programming Analysis[34] and starting from the 1974 levels of farm numbers and final demand found in the Historic trend (Alternative Number 1) uses a five year straight-line trend to adopt the 1974 solution levels. The third alternative considered was the 1971 Constrained

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[32] L. B. B. Baker, "The Effects of Changing Prices and Cost on the Level and Distribution of Agricultural Production in Manitoba: A Linear Programming Analysis," an unpublished Master's Thesis, Department of Agricultural Economics, The University of Manitoba, Winnipeg, Manitoba, February 1977, p. 369.

[33] J. A. MacMillan et al, *op. cit.*

[34] C. F. Framingham, L. B. B. Baker and W. J. Craddock, *op. cit.*

Optimum Solution from the Linear Programming Analysis[35] with farm numbers and final demand levels moving from the 1971 Historic levels along a straight-line trend that attained the 1971 Constrained Optimum solution levels in five years and was extended through to 1979. The fourth alternative considered followed the 1971 solution trend established in Alternative Number 3 through 1974 and moved from there to the 1974 Constrained Optimum solution of the Linear Programming Analysis[36] over a straight-line trend covering five years.

Thus, there were four alternative sets of distribution of production and growth rates of final demand considered. The different linear programming solutions basically arise from different sets of input and output prices. The four sets of conditions simulated by the alternatives presented here represent a sample of the possible series of price conditions that could have existed in agriculture and the simulated direct income and employment response brought about by each of them. See Figure 2 for a schematic illustration of the alternatives analyzed.

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[35] L. B. B. Baker, *op. cit.*, p. 341.

[36] C. F. Framingham, L. B. B. Baker, and W. J. Craddock, *op. cit.*

FIGURE 2

Alternatives Analyzed as Defined by the Linear Programming Solutions Used as Data in the Input-Output Analyses

Alternative Number	Time Period	1971 - 1974	1975 - 1979
1.		1971 Historic Conditions with Trends Developed in Parklands Input-Output Model	1971 Historic Conditions with Trends Developed in Parklands Input-Output Study Continued
2.		1971 Historic Conditions with Trends Developed in Parklands Input-Output Model	1974 Constrained Optimum Solution of Linear Programming Model Attained over a 5 Year Straight-Line Trend
3.		*1971 Constrained Optimum Solution of the Linear Programming Model Attained over a 5 Year Straight-Line Trend	1971 Constrained Optimum Solution of the Linear Programming Model Extended Along the 5 Year Straight-Line Trend
4.		*1971 Constrained Optimum Solution of the Linear Programming Model Attained over a 5 Year Straight-Line Trend	1974 Constrained Optimum Solution of the Linear Programming Model Attained over a 5 Year Straight-Line Trend

*Note: In Alternative Number 3, the 1971 Constrained Optimum Solution of the Linear Programming Model is not actually attained until 1976, i.e., 5 Years from the 1971 Historical Conditions. In Alternative Number 4, the 1971 Constrained Optimum Solution is never actually attained, although it is pursued along the same 5-Year Trend as in Alternative Number 3, the trend changes after 1974.

<u>The Linear Programming Results to Input-Output Data Conversion of Each Alternative</u>

The linkages are the distribution of production amongst farm sizes and the level of output in each of the agricultural livestock and agricultural crops sectors. The distinct characteristics of the existing linear programming analysis and the input-output analysis were taken into account in this linkage by making all changes in the input-output data proportional to the 1971 data previously contained in the Parklands study.[37]

The proportion of change in farm numbers by farm size in the input-output model was determined by the proportion of change in the share of total output by farm size in the linear programming model. For example, if Farm Size 1 produced 14.5 percent of Total Livestock Production (in dollars) in the Parklands in 1971 as defined in the Linear Programming Analysis 'Historic Levels' and 15.3 percent of Total Livestock Production in the 1971 Constrained Optimum Solution of the Linear Programming Analysis, the 1,765 farms of Size 1 identified in the Livestock sector of the 1971 input-output data would have to grow to 15.3%/14.5% x 1,765 = 1,862 farms in order to meet the 1971 Constrained Optimum Solution. This adjustment was assumed to occur over a five year period and hence there were 1,862 farms of Size 1 in the livestock sector of the input-output

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[37] J. A. MacMillan et al, <u>op</u>. <u>cit</u>.

data in 1976 for this particular alternative, namely, Alternative Number 3.

Tables 1 through 4 show the calculations of the farm numbers by farm size and final demand in the agricultural sector for each alternative as described in the first section of this chapter.

The Input-Output to Population Projections Linkage: The Net Migration Equation, Data and Calculation

a) The Linkage

The net migration equation forms the linkage between the input-output model and the population projections model. The calculation of the net migration equation itself, is described and illustrated in the following section. This section focuses on the nature of the linked data. The net migration equation makes the net migration rate per capita dependent on average wage income and the unemployment rate. The 'income' variable is calculated as the average wage income per worker in the Parklands (total intermediate income to the households sector divided by the available labour force) divided into the comparable figure for the rest of Manitoba which is assumed to be constant over the forecast period. The unemployment variable is calculated as the unemployment rate for the rest of Manitoba (assumed at 5 percent throughout the forecast period) divided by the Parklands unemployment rate (calculated as available labour minus total employment

TABLE 1

Alternative 1

Input-Output Farm Numbers by Farm Size as Calculated From Linear Programming 1971 Historic Conditions And the Input-Output Historic Trends

Year	Sector	Farm Size 1	Farm Size 2	Farm Size 3	Final Demand ($1,000)[c]
1971[a]	Ag. Livestock	1,765	1,075	365	26,712.7
	Ag. Crops	1,878	1,390	216	33,077.2
1972	Ag. Livestock	1,732	1,093	399	27,950.9
	Ag. Crops	1,791	1,365	225	34,199.3
1973	Ag. Livestock	1,699	1,110	433	29,258.2
	Ag. Crops	1,703	1,340	234	35,360.8
1974	Ag. Livestock	1,667	1,128	467	30,634.2
	Ag. Crops	1,616	1,315	243	36,562.5
1975	Ag. Livestock	1,635	1,145	500	32,084.5
	Ag. Crops	1,528	1,290	253	37,806.1
1976	Ag. Livestock	1,602	1,163	534	33,610.5
	Ag. Crops	1,441	1,264	262	39,092.6
1977[b]	Ag. Livestock	1,570	1,180	568	35,223.5
	Ag. Crops	1,353	1,239	271	40,424.9
1978	Ag. Livestock	1,537	1,198	602	36,922.8
	Ag. Crops	1,266	1,214	280	41,803.5
1979	Ag. Livestock	1,505	1,215	636	38,709.6
	Ag. Crops	1,178	1,189	289	43,229.6

[a]The 1971 Parklands Farm Numbers were calculated from Interlake data and Parklands data as follows:

$$\text{Number of farms in Parklands in Sector 'X' of Size 'Y'} = \left[\frac{\text{Parklands Proportion of Total Farms in Sector 'X'}}{\text{Interlake Proportion of Total Farms in Sector 'X'}}\right] \times \left[\frac{\text{Parklands Proportion of Total Farms of Size 'Y'}}{\text{Interlake Proportion of Total Farms of Size 'Y'}}\right]$$

$$\times \left[\frac{\text{Parklands Total Number of Farms}}{\text{Interlake Total Number of Farms}}\right] \times \text{Number of Farms in Interlake in Sector 'X' of Size 'Y'}$$

The resulting numbers were then adjusted to sum to the totals by farm size and by enterprise (sector) shown in Parklands data. The Interlake farm numbers and Parklands totals are listed below.

(Continued)

TABLE 1 (Continued)

1971 Interlake Farm Numbers by Farm Size and Sector

	Size 1	Size 2	Size 3
Ag. Livestock	1,700	1,337	746
Ag. Crops	916	876	224

1971 Parklands Farm Number Totals by Farm Size and by Sector

(from "Parklands Information Study," Volume 1, p. 21)

Ag. Livestock	Ag. Crops	Size 1	Size 2	Size 3
3,205	3,484	3,643	2,465	581

[b]The growth trends in Parkland farm numbers by size and sector were developed from the growth trends in Interlake farm numbers by size and sector. The calculation formula and 1977 Interlake farm numbers appear below:

$$\text{1977 Parklands farm Numbers of Size 'X' and Sector 'Y'} = \left[\frac{\text{1977 Interlake farm Numbers of Size 'X' and Sector 'Y'}}{\text{1971 Interlake farm Numbers of Size 'X' and Sector 'Y'}}\right] \times \text{1971 Parklands farm numbers of Size 'X' and Sector 'Y'}$$

1977 Interlake Farm Numbers by Size and Sector

	Size 1	Size 2	Size 3
Ag. Livestock	1,512	1,468	1,161
Ag. Crops	660	781	281

[c]Final demand figures are those developed in the "Parklands Information Study."

TABLE 2

Alternative 2

Input-Output Farm Numbers by Farm Size as Calculated From the Linear Programming 1974 Constrained Optimum Solution and the 1974 Data From Alternative 1

Year	Sector	Farm Size 1	Farm Size 2	Farm Size 3	Final Demand ($1,000)[a]
1974	No. of Livestock Farms[b]	1,667	1,128	467	30,634.2
1974	No. of Crop Farms[b]	1,616	1,315	243	36,562.5
1975	Ag. Livestock	1,655	1,119	448	33,188.7
	Ag. Crops	1,798	1,266	242	57,613.8
1976	Ag. Livestock	1,643	1,110	430	35,743.2
	Ag. Crops	1,980	1,217	242	78,665.1
1977	Ag. Livestock	1,630	1,101	411	38,297.7
	Ag. Crops	2,163	1,168	241	99,716.4
1978	Ag. Livestock	1,618	1,092	392	40,852.3
	Ag. Crops	2,345	1,120	241	120,767.7
1979	No. of Livestock Farms[b]	1,606	1,082	374	43,406.8
1979	No. of Crop Farms[b]	2,527	1,071	240	141,819

[a]Final Demand was calculated as follows:

$$\text{1979 Final Demand in Sector 'X'} = \frac{\text{1974 LP Solution Total Sales by Sector 'X'}}{\left[\dfrac{\text{1974 Final Demand in Sector 'X' from Alternative 1}}{\text{1971 Final Demand in Sector 'X' from Alternative 1}}\right] \times \text{1971 LP Historical Conditions Total Sales by Sector 'X'}} \times \text{1974 Final Demand in Sector 'X'}$$

The Linear Programming "Total Sales" Data by Sector

Sector	1971 Historic Conditions	1974 Constrained Optimum Solution
Ag. Livestock	31,732,176	51,563,163
Ag. Crops	15,378,991	65,937,668

(Continued)

TABLE 2 (Continued)

[b]Farm Numbers were calculated by sector using a straight-line trend between 1974 and 1979. The 1979 Farm Numbers were calculated as follows:

$$\text{1979 Farm Numbers in Sector 'X' and Farm Size 'Y'} = \frac{\text{1974 LP Solution Percent of Total Sales of Sector 'X' by Farm Size 'Y'}}{\text{1971 LP Historic Conditions Percent of Total Sales by Sector 'X' by Farm Size 'Y' as adjusted to 1974 in Alternative 1}} \times \text{1974 Farm Numbers in Sector 'X' and Farm Size 'Y' from Alternative 1}$$

The initial farm numbers by farm size and sector appear in the table above.

The 1974 Linear Programming Solution Percent(s) of Total Sales were calculated as: (for example)

$$\text{1974 LP Solution Percent of Total Sales of Sector 'X' by farm Size 'Y'} = \frac{\text{1974 LP Solution Total Sales of Sector 'X' by Farm Size 'Y'}}{\text{1974 LP Solution Total Sales of Sector 'X'}}$$

where 1974 Linear Programming Solution Total Sales data were taken from L. B. B. Baker, *op. cit.*, p. 314, and 1971 Historic data were taken from p. 369 of the same source.

TABLE 3

Alternative 3

Input-Output Farm Numbers by Farm Size as Calculated From the 1974 Linear Programming Constrained Optimum Solution and the 1971 Linear Programming Constrained Optimum Solution Trend from Alternative 3

Year	Sector	Farm Size 1	Farm Size 2	Farm Size 3	Final Demand ($1,000)[a]
1971[b]	No. of Livestock Farms	1,765	1,075	365	26,712.7
1971[b]	No. of Crop Farms	1,878	1,390	216	33,077.2
1972	Ag. Livestock	1,784	1,076	363	26,228.37
	Ag. Crops	1,806	1,392	221	34,309.1
1973	Ag. Livestock	1,804	1,077	361	25,744.04
	Ag. Crops	1,733	1,395	225	35,540.99
1974	Ag. Livestock	1,823	1,079	360	25,259.7
	Ag. Crops	1,661	1,397	229	36,772.9
1975	Ag. Livestock	1,843	1,080	358	24,775.4
	Ag. Crops	1,589	1,399	232	38,004.8
1976[b]	No. of Livestock Farms	1,862	1,081	356	24,291.04
1976[b]	No. of Crop Farms	1,516	1,402	236	39,236.67
1977	Ag. Livestock	1,882	1,082	354	23,806.6
	Ag. Crops	1,444	1,404	240	40,468.6
1978	Ag. Livestock	1,901	1,083	352	23,322.3
	Ag. Crops	1,371	1,407	244	41,700.5
1979	Ag. Livestock	1,920	1,085	351	22,838.0
	Ag. Crops	1,299	1,409	248	42,932.4

[a]Final Demand was calculated as follows:

$$\text{1976 Final Demand in Sector 'X'} = \frac{\text{1971 Linear Programming Constrained Optimum Solution Total Sales for Sector 'X'}}{\text{1971 Linear Programming Historic Conditions Total Sales for Sector 'X'}} \times \text{1971 Final Demand in Sector 'X' from Historic Input-Output Data}$$

(Continued)

TABLE 3 (Continued)

1971 LP Constrained Optimum Solution "Total Sales" by sector were:

Ag. Livestock = 30,259,661 Ag. Crops = 18,242,200

1971 LP Historic Conditions "Total Sales" appear in Table 2.

[b]1976 Farm Numbers were calculated as follows:

$$\text{1976 Farm Numbers in Sector 'X' and Farm Size 'Y'} = \frac{\text{1971 LP Constrained Optimum Solution Percentage of Production by Farm Size 'Y' in Sector 'X'}}{\text{1971 LP Historic Conditions Percentage of Production by Farm Size 'Y' in Sector 'X'}} \times \text{1971 Farm Numbers in Sector 'X' and Farm Size 'Y' as calculated in Alternative 1}$$

where 1971 LP Constrained Optimum Solution and LP Historic Conditions Percentages of Production are calculated from data taken from Unpublished data and L. B. B. Baker, *op. cit.*, p. 369, respectively.

TABLE 4

Alternative 4

Input-Output Farm Numbers by Farm Size as Calculated From the 1974 Linear Programming Constrained Optimum Solution and the 1971 Linear Programming Constrained Optimum Solution Trend from Alternative 3

Year	Sector	Farm Size 1	Farm Size 2	Farm Size 3	Final Demand ($1,000)[d]
1974[a]	No. of Livestock Farms	1,823	1,079	360	25,259.71
1974[a]	No. of Crop Farms	1,661	1,397	229	36,772.89
1975	Ag. Livestock	1,779	1,080	363	28,652.03
	Ag. Crops	1,835	1,332	231	57,783.04
1976	Ag. Livestock	1,735	1,081	366	32,044.34
	Ag. Crops	2,009	1,267	232	78,793.19
1977	Ag. Livestock	1,692	1,082	369	35,436.66
	Ag. Crops	2,183	1,201	234	99,803.34
1978	Ag. Livestock	1,648	1,083	371	38,838.97
	Ag. Crops	2,356	1,136	235	120,813.49
1979[b]	No. of Livestock Farms	1,604	1,084	374	42,221.29
1979[b]	No. of Crop Farms	2,530	1,071	237	141,823.64

[a]1974 Farm Numbers and Final Demand were taken from the 1974 levels calculated in Alternative 3. 1974 percentages of production by sector and farm size were calculated as follows:

$$\text{1974 Percent of Production in Sector 'X' by Farm Size 'Y'} = \frac{\text{1974 Farm Numbers in Sector 'X' of Farm Size 'Y' from Alternative 3}}{\text{1971 Farm Numbers in Sector 'X' of Farm Size 'Y' from Alternative 3}} \times \text{1971 Percent of Production in Sector 'X' by Farm Size 'Y'}$$

(Continued)

TABLE 4 (Continued)

[b]The 1979 Farm Numbers were calculated as follows:

$$\text{1979 Farm Numbers in Sector 'X' of Farm Size 'Y'} = \frac{\text{1974 LP Constrained Optimum Solution Percentage of Production of Sector 'X' by Farm Size 'Y'}}{\text{1974 Percent of Production in Sector 'X' by Farm Size 'Y' as calculated above}} \times \text{1974 Farm Numbers in Sector 'X' of Farm Size 'Y' from Alternative 3}$$

[c]L. B. B. Baker, *op. cit.*, p. 314.

[d]Final demand was calculated by sector as a straight-line trend from the 1974 levels calculated in alternative 3 to the 1979 levels calculated as follows:

$$\text{1979 Final Demand in Sector 'X'} = \frac{\text{1974 LP Constrained Optimum Solution Total Sales by Sector 'X'}}{\left[\frac{\text{1974 Final Demand in Sector 'X' from Alternative 3}}{\text{1971 Final Demand in Sector 'X'}}\right] \times \text{1971 LP Historic Conditions Total Sales by Sector 'X'}} \times \text{1974 Final Demand in Sector 'X' from Alternative 3}$$

where the Linear Programming "Total Sales" data are as follows:

	1971	1974
Ag. Livestock	31,732,176	51,563,163
Ag. Crops	15,378,991	65,937,668

demanded divided by the available labour force). The calculation of the available labour force is described in the last section of this chapter.

Total employment demanded is calculated using fixed labour per dollar of output coefficients by sector in the input-output model. The labour coefficients for the agricultural sectors are farm size specific and hence the distribution of output amongst farm sizes determines to some extent the employment in agriculture. The labour coefficients are listed in Tables 5 to 8 for the four alternatives considered in this study. The labour coefficients for the seventeen endogenous sectors in 1971, 1975 and 1979 are listed to illustrate the changes in the 'agriculture sectors' coefficients as well as the impacts of the productivity growth factor built into the input-output analysis.

The Net Migration Equation

The net migration equation used follows:

$$\hat{NMR} = .0184369 - .0999484\ U + .0484363\ U' + .0230598\ I - .0092725\ I'$$

where:

$\hat{NMR}$ = estimated net migration rate for the Parklands where $NMR > 0$ indicates outmigration.

U = the average unemployment rate in the area of destination divided by the average unemployment rate in the Parklands.

TABLE 5

Labour Coefficients: Alternative 1

Sector \ Year	1971	1975	1979
	(Man Years Per $1,000 of Gross Output)		
Ag. Livestock	0.14650	0.13083	0.12468
Ag. Crops	0.20127	0.18325	0.16565
Mining	0.23928	0.23928	0.23928
Food and Beverage Manufacturing	0.08106	0.07823	0.07551
Other Manufacturing	0.01635	0.01618	0.01601
Transportation	0.85365	0.72690	0.61898
Construction	0.15067	0.12737	0.10767
Petroleum Wholesale Farm Equipment and Buildings	0.06061	0.05364	0.04748
Food Stores	0.09298	0.08985	0.08682
Other Retail	0.13100	0.12659	0.12232
Automobile Products	0.06341	0.06128	0.05922
Apparel and Shoes	0.20448	0.19759	0.19094
Furniture	0.58437	0.56469	0.54568
Insurance	0.63861	0.56410	0.49829
Personal Service	0.01445	0.01410	0.01376
Other Services	0.83764	0.81719	0.79723
Households	0.0	0.0	0.0

SOURCE: Data and growth rates found in J. A. MacMillan et al, *op. cit.*

TABLE 6

Labour Coefficients: Alternative 2

Sector \ Year	1971	1975	1979
	(Man Years Per $1,000 of Gross Output)		
Ag. Livestock	0.14650	0.13214	0.13108
Ag. Crops	0.20137	0.19363	0.21627
Sectors 3-18	........(See Table 5).........		

TABLE 7

Labour Coefficients: Alternative 3

Sector \ Year	1971	1975	1979
	(Man Years Per $1,000 of Gross Output)		
Ag. Livestock	0.14650	0.13511	0.13271
Ag. Crops	0.20127	0.18507	0.17018
Sectors 3-18	........(See Table 5).........		

SOURCE for Tables 6 and 7: Basic growth rates and calculations developed in J. A. MacMillan et al, op. cit.

TABLE 8

Labour Coefficients: Alternative 4

Sector \ Year	1971	1975	1979
	(Man Years Per $1,000 of Gross Output)		
Ag. Livestock	0.14650	0.13477	0.13109
Ag. Crops	0.20127	0.19432	0.21672
Sectors 3-18	........(See Table 5).........		

SOURCE: As in Tables 6 and 7.

U' = the inverse of U.

I = the average income in the area of destination divided by the average income in the Parklands.

I' = the inverse of I.

The derivation of the Net Migration Equation appears in Appendix A. The net migration equation shown above was inserted into the population projection program in place of the trend or historic migration rates formerly used. The migration rate calculated by this equation was assumed constant for all age groups.[38] The impact of net migration out of Manitoba on the Parklands population level was assumed to be equal to zero. In addition, the accuracy of the Net Migration equation depends on the statistical significance of the gross migration equations and the methods used in combining them. Population forecasts were calculated annually using fertility, mortality, and base population data contained in the Population Projections study.[39]

<u>The Population Projection as a Constraint to the Input-Output Model: Available Labour Force</u>

Given the forecast population described above, the available labour force was calculated using fixed historical

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[38] See the Limitations section of this thesis.

[39] W. R. Maki et al, *op. cit.*

labour force participation rates.[40, 41] The available labour force then appeared as a constraint to gross output by sector where labour requirements were estimated using labour/output coefficients described in the 'Input-Output to Population Projection Linkage' section above. The final estimate of constrained gross output by sector then permitted an additional forecast of 'average income' and unemployment as earlier defined, beginning an additional iteration of the forecast.

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40 Ibid., pp. 88-89.

41 See the Limitations section of this thesis.

CHAPTER V

RESULTS AND CONCLUSIONS

Projected Parklands Region Population and Gross Output for the Transportation Sector for Each Alternative

Table 9 displays the projected population and labour force for each of the four alternatives considered. Table 10 displays the projected gross output for the Transportation sector for each of the four alternatives.

The 1971 'Historic Conditions' alternative was extended through 1979 to establish a baseline. The projected population for 1975 under this alternative was 57,956 compared to 55,617 in 1971. After a rapid adjustment in 1972 to 60,882, projected population fell steadily to 57,720 in 1976 and recovered to 57,791 by 1980.

Gross output was constrained by labour in all but six sectors from 1972 through 1979 while the agricultural sectors were constrained by land over the same period. The transportation sector projected gross output grew to \$3,038,200 in 1975 and \$3,633,800 by 1979. The projected potential gross output constrained by land only for the transportation sector was \$11,652,407 in 1975 and \$13,994,922 in 1979.

The second alternative had 1971 historic trends giving way to the 1974 linear programming solution in the

TABLE 9

Unemployment, Income, Net Migration for the Previous Year, and Projected Total Population of the Parklands Region Under the Four Alternatives for 1972, 1975, 1976 and 1980

Alternative and Year	Unemployment (% of Available Labour)	Income ($1,000/ Man-Year)	Net Migration (% of Total Population)	Projected Total Population
			(+ = outmigration)	
Alternative 1				
1971	3.081	3.4685	-8.562	60,882
1975	5.764	3.2964	1.796	58,085
1976	5.701	3.2837	1.656	57,720
1980	5.442	3.2776	0.996	57,791
Alternative 2				
1972	3.081	3.4685	-8.562	60,882
1975	5.764	3.2964	1.796	58,085
1976	4.468	3.2842	-1.958	59,840
1980	4.518	3.1310	-1.581	66,430
Alternative 3				
1972	3.081	3.4685	-8.562	60,882
1975	5.383	3.2716	0.846	59,857
1976	5.225	3.2468	0.444	60,224
1980	5.105	3.1903	0.177	62,593

(Continued)

TABLE 9 (Continued)

Alternative and Year	Unemployment (% of Available Labour)	Income ($1,000/ Man-Year)	Net Migration (% of Total Population)	Projected Total Population
			(+ = outmigration)	
Alternative 4				
1972	3.081	3.4685	-8.562	60,882
1975	5.383	3.2716	0.846	59,857
1976	4,752	3,2456	-0.965	61,073
1980	4.748	3.1209	-0.808	66,467

TABLE 10

Projected Constrained Gross Output for the Transportation Sector and the Potential Unconstrained Gross Output For the Transportation Sector for 1971, 1974, 1975 and 1979

Alternative and Year	Projected Potential Unconstrained Gross Output for the Transportation Sector ($1,000)	Projected Gross[a] Output Constrained By Land Only for the Transportation Sector ($1,000)	Projected Gross Output Constrained By Land and Labour for the Transportation Sector ($1,000)
Alternative 1			
1971	10,032.857	10,032.857	2,341.1
1974	11,534.895	11,139.345	2,906.4
1975	12,089.907	11,652.407	3,038.2
1979	14,630.922	13,994.922	3,633.8
Alternative 2			
1971	10,032.857	10,032.857	2,341.1
1974	11,534.895	11,139.345	2,906.4
1975	12,512.981	11,685.221	3,004.3
1979	16,638.012	14,206.302	3,848.1
Alternative 3			
1971	10,032.857	10,032.857	2,341.1
1974	11,454.193	11,130.353	2,945.6
1975	11,979.339	11,635.899	3,101.6
1979	14,378.026	13,952.596	3,827.9

(Continued)

TABLE 10 (Continued)

Alternative and Year	Projected Potential Unconstrained Gross Output for the Transportation Sector ($1,000)	Projected Gross Output Constrainted By Land Only for the Transportation Sector ($1,000)	Projected Gross Output Constrained By Land and Labour for the Transportation Sector ($1,000)
Alternative 4			
1971	10,032.857	10,032.857	2,341.1
1974	11,454.193	11,130.353	2,945.6
1975	12,452.691	11,701.881	3,078.4
1979	16,624.188	14,200.088	3,879.6

[a] See Appendix E for calculation of Projected Gross Output Constrained by Land only for the Transportation Sector.

1975 iteration through 1979. This alternative produced identical results to the first alternative through 1974 including the 1975 projected population. The projected population drops to 58,085 in 1976 before recovering to 66,430 by 1980.

Gross output under this alternative was constrained by labour in all but six sectors throughout. The agricultural sectors were both constrained by land throughout. Gross output was projected at $3,004,270 in the transportation sector in 1975 and $3,848,100 in 1979. The projected potential gross output constrained by land only for the transportation sector was $11,685,221 by 1975 and $14,206,302 in 1979.

The third alternative had the 1971 linear programming solution trend extended through 1979. The projected population grew to 62,593 by 1980 from 55,617 in 1971. After the initial jump to 60,882 in 1972, the projected population dropped to 59,647 in 1973 and then grew steadily to the 1980 level.

Gross output under this alternative was constrained by labour in all but four sectors in 1971 with the initial labour force of 21,830. As labour force grew to 25,272 by 1979, seven sectors were unconstrained by labour including the Agricultural Crops sector which was constrained by land. Gross output in the Transportation sector grew from $2,341,100 in 1971 to $3,827,900 in 1979 under the labour constraint although estimated potential gross output constrained by land only grew from $11,635,899 in 1971 to $13,952,596 in 1979.

The final alternative combined the 1971 linear programming solution trend, through 1974, with the 1974 linear programming solution trend, from 1975 through 1979. Under this alternative, identical results to the third alternative were produced through 1974 including the 1975 projected population. The 1976 projected population climbed to 61,073 in this alternative as compared to 60,224 in the third alternative. The 1980 projected population rises to 66,467.

Gross output is constrained by labour in all but six sectors in 1975 through 1979 in this alternative. Both agricultural sectors are constrained by land after 1974. The transportation sector gross output had grown to $3,078,400 by 1975 and $3,879,600 by 1979 with potential gross output constrained by land only having grown to $11,701,881 in 1975 and $14,200,088 by 1979.

CONCLUSIONS

The first conclusion, illustrated by the results, is that the model described in this study is stable within the range of income and unemployment differences considered. While the result of outmigration follows from high local unemployment, the stability of the model also depends on the growth of final demand amongst sectors compared with the initial (1971) allocation of labour amongst sectors, and the income effects of that growth. The variety of results achieved arise from different paths and rates of growth of final demand for the agricultural sectors in addition to different rates of input use in the agricultural sectors due to different shares of production by farm size. Alternatives two and four were expected to produce the most 'realistic' results in that they combine two different sets of observations under different agricultural output price conditions, as opposed to the single data set trends simulated in alternatives one and three. Alternative 1 produces a slight decrease in projected population while Alternatives 2-4 produce projected population increases along different paths. In all 4 cases, however, the projected population is apparently stabilizing.

A conclusion on the reality of the causes of income and unemployment variation depicted in this model is difficult to reach on the basis of this research. Unemployment is mainly structural in nature in this model. The labour constraint was shown to have substantial limiting effects on the gross output of the Transportation sector in the results above; not only in the projected years but in the base year (1971) as well. A number of conclusions are possible including:

a) a sudden increase in demand for transportation services just prior to compilation of the data in 1971,

b) a historical lack of labour employed in the Parklands Transportation sector reflecting a dependency on imported transportation services, perhaps from larger urban centres such as Winnipeg, or

c) the Parklands labour force has experienced a lack of inter-sectoral mobility for some time and has become accustomed to importing certain types of services.

Alternative a) above seems unlikely and the distinction between b) and c) is a fine one. Alternative b) suggests that the location of transportation services outside the Parklands region is an intentional one, perhaps to take advantage of economies of scale or agglomeration economies, or perhaps in response to a cyclical demand for services from the Parklands. Alternative c) on the other hand, implies a mobility problem which, if it exists, may be of concern to regional policy makers. A fourth alternative would be a modelling failure to allocate labour to appropriate sectors.

Income and unemployment variations are generally caused by varying growth ratios in final demand by sector as mentioned above. Substantial variations in growth rates such as the large growth in potential gross output projected for the Agricultural Crops sector through 1979 in Alternatives two and four appear to have sufficient impact on the labour force (as depicted in this model) to increase employment to the point where it encourages population growth. It may be noted that both Alternatives two and four show a substantial increase in the share of agricultural production by the smaller farm size, possibly indicating that smaller (and possibly more marginal) farms are taking the brunt of the production cycling. This would result in high unemployment (and/or underemployment) in times of low prices for agricultural outputs and low unemployment in times of high prices.

The failure of the labour force to adjust to the sustained trends of growth of final demand in Alternatives one and three may once again be tied to the accompanying shift towards large farm sizes having a larger share of agricultural production. As mentioned in an earlier chapter, there is no logical basis for extending the trends beyond the assumed five year period. Alternatives one and three may assist in exaggerating the effects of sustained low prices for agricultural commodities, including stagnant or shrinking population levels resulting from high unemployment and/or underemployment in the agricultural sectors and the interdependent effects on the rest of the economy. The predictive accuracy of the model is difficult to measure due to limitations including the age of the input-output and demographic data. With such limitations in mind, a cursory glance at the population growth trends developed gives some indication (see Figure 3). In spite of the historic population of 55,617 in 1971, a starting point for comparison may be the 1972 projected population of 60,882 which arises from the 1971 economic data and the migration equation. This adjustment occurs in each of the four alternatives and may arise from the remaining

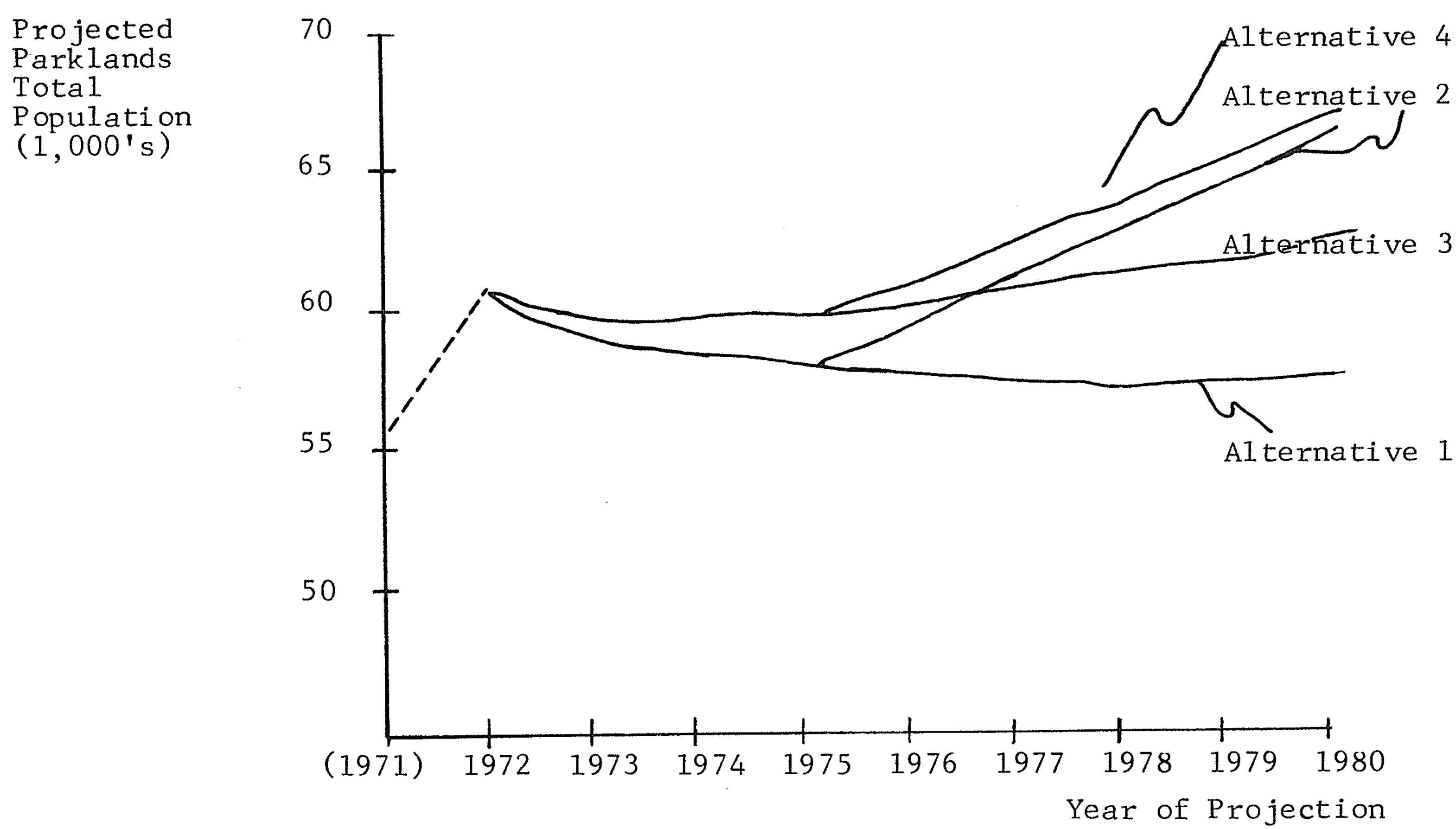

FIGURE 3

Projected Population Growth Trends:
The Four Alternatives

incompatibility of the component models (specifically, the initial allocation of labour to sectors in the input-output model and any differences between the size of the Parklands labour force implied by that allocation and the actual labour force that coincided with the economic data). With 60,882 serving as the initial population projection, the alternatives provide projections of decreased, in one case, and increased population over a range of approximately 9,000 people.

Finally, it may be concluded that the transportation sector's gross output is dependent on the final demand in the agricultural sectors both through intermediate demand and availability of labour. The breakdown of the demand for transportation services depicted in this model is also affected by the nature of production in the agricultural sectors. The conditions which were seen to generate high employment and growing population also project a proportional growth in 'passenger' and 'household' demand for transportation services. On the other hand, conditions which generate less employment and less population growth may suggest a stagnant demand by 'households' for transportation services. Similarly, increased gross output in sectors such as the agricultural sectors suggests proportionately higher demand from those sectors for commercial transportation services.

IMPLICATIONS

Thus, the implications of the results are as follows:

a) Given the rationality of the assumptions of this model, the demand for goods and services, such as transportation will be dependent on the volume of output and the population. While population is linked to the value of output via the production process in this model, it is not clear that increased value of output will guarantee the maximum increasing demand for transportation. That is, a low employment/output ratio for the major product of the area might result in lower demand for transportation than the same level of regional output with higher employment of labour.

b) While the limitations are thought to preclude quantitative forecasting, it is safe to say that different price conditions will generate cycling pressures on income, employment, regional population growth rates, and hence, demand for goods and services. The cost of such cycling effects to regional planning efforts remains to be quantified. The worthiness of any stabilization policies might be evaluated on a cost-benefit basis once the cost quantification has been completed.

c) Given, once again, the implicit structure of the model, it is apparent that total regional employment will depend on the growth of final demand by sector relative to historic distribution of employment by sector. Thus, the relatively rapid cycling of demand for output from the agricultural sectors implies sustained unemployment (probably including underemployment) in a cycle similar to the output demand cycle. This study projected a cycling in population growth rates in Alternatives 2 and 4. The cycling nature of these results may be exaggerated by the fact that constant unemployment and income rates were maintained in the 'rest of Manitoba'. The implicit limited mobility of labour between sectors within the region arises out of the assumption of the model but it should be a factor of concern to regional planners.

d) If the apparent relationship between regional income and unemployment and prices for agricultural output via the share of agricultural production held by small farms holds true, policy aimed at reducing regional unemployment would logically have to deal with price cycles for agricultural products or with adjusting the structure of agricultural production. Possible programming options might include some form of demand stabilization for agricultural products, at least at the small farm level. A second programming option may take the form of a concentrated effort to employ small farm occupants in other sectors, either to supplement their farm work or as a substitute with an attempt to reduce the number of small farms. This research sheds little light on which of the policy alternatives might be most appropriate or achievable. A positive implication however, is that this model is suitable for analyzing the relative nature of the regional income, employment, and migration impacts of alternative policies in the Parklands region. In particular, the analysis of policies with alternative income and employment goals in the agricultural sectors is facilitated by the ability of the linear programming model to handle such objectives (and/or constraints) and by the ability of the overall model presented here to demonstrate relative impacts of such policies on the regional economy.

CHAPTER VI

LIMITATIONS OF THE STUDY AND SUGGESTIONS FOR FURTHER RESEARCH

The limitations arise from the component models and the linkages developed in this study. The linear programming model provides trends of production response to particular price conditions. The quantitative aspect of the solution is limited by an assumed maximum level of adjustment of twenty percent: increase or decrease. This limit is intended to reflect various short-run barriers to adoption of the 'optimal' solution such as cultural tradition and limited capital mobility. A further limitation is imposed in the linkage involving the linear programming model when it is assumed to reach this solution over a five year period. The fact that the data is limited to two sets of price conditions and that no better information on speed of adjustment was readily available contributed to this assumption.

The major limitation arising from the input-output analysis is due to the rigid production function implied in the input-output model and the age of the data used. The input-output data was collected in 1968 in the Interlake region of Manitoba and adjusted to reflect the Parklands region economy of 1970-71. Perhaps, the most restrictive assumption of static behaviour was implied by the initial allocation of labour amongst the various sectors of the input-output analysis. This assumption plays an important role in determining unemployment; the primary link to the migration equation. The actual restrictiveness of this assumption could be determined in an empirical study in which the dependence of migration from one sector to another, within the region or between regions, on sustained unemployment in the originating sector was determined.

The population projection segment of this study is limited mainly by the data used, including fixed labour force participation rates and fertility rates. It is indeed possible to overcome this problem but not within the scope of this study.

The population migration equation is a limitation in that the original gross migration equations are of limited statistical significance. In addition, the combination of equations into a migration equation further reduced the statistical significance of the final expression. The procedure for removing inconsistent variables, as discussed in earlier sections, was an unavoidable source of error. Another limitation arises from the fact that a single migration rate is used for all ages of the population while only a portion of migrations may, in fact, be dependent on income and unemployment. An example might be that the determinants of migration for retired individuals differ from non-retired individuals. The extent of the difference in migration rates could be determined in a future study. Further research might also include estimation of inter-sectoral and intra-regional migrations in response to unemployment.

Finally, the comparative static nature of the model imposed by the two sets of linear programming data is a limitation in that there is no annual adjustment. As a result, the trends generated may be less than realistic. It was pointed out earlier that the model might be made more fully dynamic by introducing new price data annually and having the labour constraint reintroduced to the linear programming model annually. Additional research might study the speeds of adjustment (response) by the agricultural sectors in response to price fluctuations. The linear programming data is currently being updated. It would be interesting to note the impact of petroleum price increases on the structure of agricultural production in Manitoba.

Finally, an additional application of the model presented here might be the study of the effects of constraining production by the various farm sizes under a constant price set. Such a study might verify the apparent dependence of population size on the share of agricultural production by small farms.

BIBLIOGRAPHY

Baker, L. B. B. "The Effects of Changing Prices and Cost on the Level and Distribution of Agricultural Production in Manitoba: A Linear Programming Analysis." An unpublished Master's Thesis, Department of Agricultural Economics, The University of Manitoba, Winnipeg, Manitoba, February 1977.

Ballard, K. and N. J. Glickman. "A Multiregion Econometric Forecasting System: A Model For the Delaware Valley," Journal of Regional Science. Vol. 17, No. 2, August 1977.

Framingham, C. F., L. B. B. Baker, and W. J. Craddock. Farm Income, Employment, and Manitoba Agriculture: A Linear Programming Approach to Considerations of Policy Alternatives. Vols. I.1 and I.2, Research Bulletin No. 78-1, Department of Agricultural Economics.

Harris, Curtis C. Jr. The Urban Economies, 1985. Toronto: Lexington Books, 1973.

Information Canada. General Development Agreement, Canada/Manitoba. Ottawa: Canada Department of Regional Economic Expansion, 1974.

Queen's Printer. 1971 Census of Canada. Catalogue number 92-707, Vol. I - Part 1, Ottawa, October 1972.

MacMillan, J. A., C. F. Framingham, F. L. Tung, and S. Lyon. "Parklands Region Manpower Information Study." Department of Agricultural Economics, University of Manitoba, Winnipeg, 1975.

MacMillan, J. A. Chang-mei Lu, and C. F. Framingham. Manitoba Interlake Area, A Regional Development Evaluation. Center for Agricultural and Rural Development, Iowa State University, Ames, Iowa, 1975.

Maki, W. R., C. F. Framingham, and D. J. Sandell. Population Projections For Manitoba By Region and Town Size--Some Alternatives, 1971-1990. Research Bulletin No. 73-2, Department of Agricultural Economics, University of Manitoba, Winnipeg, 1973.

Mathieson, G. "Estimation of the Determinants of Gross Migration in Manitoba." Unpublished thesis, Department of Agricultural Economics, University of Manitoba, Winnipeg, 1977.

Revised Statutes of Canada, "Industrial Incentives Act." Vol. IV, Chapters 1-10, 1970.

Tweeten, L., and G. L. Brinkman. Micropolitan Development. Ames, Iowa: The Iowa State University Press, 1976.

A P P E N D I C E S

APPENDIX A

THE LINEAR PROGRAMMING MODEL*

Maximize the objective function

$$Y = \sum_{i=1}^{14} \sum_{j=1}^{3} \sum_{k=1}^{3} \sum_{p=1}^{40} r_{ijkp} X_{kjkp} - \sum_{i=1}^{14} \sum_{v=1}^{14} \sum_{p=14}^{16} t_{vip} T_{vip}$$

$$- \sum_{i=1}^{14} \sum_{v=1}^{14} \sum_{p=17}^{41} c_{vip} A_{vip}$$

subject to the following constraints:

Land Availability

$$\sum_{j=1}^{3} \sum_{p=1}^{40} a_{ijkp} X_{ijkp} \leq L_{ik} \text{ for all } i \text{ and } k$$

Livestock Feed Supplies

$$\sum_{j=1}^{3} \sum_{k=1}^{2} \sum_{p=11}^{13} m_p b_{ijkp} X_{ijkp} - \sum_{j=1}^{3} \sum_{p=17}^{40} f_p X_{ij3p}$$

$$+ \sum_{p=14}^{16} m_p \sum_{v=1}^{14} T_{vip} - \sum_{p=14}^{16} m_p \sum_{v=1}^{14} T_{ivp} = 0 \text{ for all } i$$

Intermediate Livestock Commodity Supplies

$$\sum_{j=1}^{3} s_{ij3pq} X_{ij3p} - \sum_{j=1}^{3} s'_{ij3pq} X_{ij3p} + \sum_{v=1}^{14} A_{vip}$$

$$- \sum_{v=1}^{14} A_{ivp} = 0 \text{ for all } i \text{ and } q \text{ and for } p = 17\text{-}41$$

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*C. F. Framingham, L. B. B. Baker, and W. J. Craddock, op. cit., pp. 12-16.

Supplies of Feed Grain for Sale

$$\sum_{j=1}^{3} \sum_{k=1}^{2} b_{ijkp} X_{ijkp} - \sum_{v=1}^{14} T_{ivp} = 0 \text{ for all i and for}$$

p = 14, 14, 16

Minimum Oats in Livestock Rations

$$\sum_{j=1}^{3} \sum_{k=1}^{2} m_{12}\, b_{ijk12} X_{ijk12} - \sum_{p=17}^{40} f'_{1p} X_{ij3p} + m_{15} \sum T_{iv15}$$

$$- m_{15} \sum T_{vi15} \geq 0 \text{ for all i and v}$$

Minimum Barley in Livestock Rations

$$\sum_{j=1}^{3} \sum_{k=1}^{2} m_{13}\, b_{ijk13} X_{ijk13} - \sum_{17}^{40} f'_{2p} X_{ij3p} + m_{16} \sum T_{iv16}$$

$$-m_{16} \sum T_{vi16} \geq 0 \text{ for all i and v}$$

Hay Supplies

$$\sum_{j=1}^{3} b_{ij3,10} X_{ij3,10} - h_p X_{ij3p} = 0 \text{ for all i and for}$$

p = 17-32, 36, 37

Regional and Provincial Commodity Maximums and Minimums

$$\sum_{k=1}^{3} b_{ijkp} X_{ijkp} \geq R_{ijp} \text{ for all i and j and for}$$

p = 1-9, 18-20, 26-28, 33, 34, 36-40

$$\sum_{k=1}^{3} b_{ijkp} X_{ijkp} \leq R'_{ijp}$$ for all i and j and for

p = 1-9, 18-20, 26-28, 33, 34, 36-40

$$\sum_{i=1}^{14} \sum_{j=1}^{3} \sum_{k=1}^{3} b_{ijkp} X_{ijkp} \geq P_p$$ for p = 1-9, 17, 20, 25,

34, 36-40

$$\sum_{i=1}^{14} \sum_{j=1}^{3} \sum_{k=1}^{3} b_{ijkp} X_{ijkp} \leq P'_p$$ for p = 1-9, 17, 20, 25,

34, 36-40

Income Constraints

$$\sum_{k=1}^{3} \sum_{p=1}^{40} y_{ijkp} X_{ijkp} \geq Y_{ij}$$ for all i and j

Labor Constraints

$$\sum_{k=1}^{3} \sum_{p=1}^{40} l_{ijkp} X_{ijkp} \geq LH_{ij}$$ for all i and j

with the subscripts identified as follows:

i and v = regions 1-14;

j = farm and enterprise sizes 1-3;

k = soil types; 1-2 are crop land; 3 is pasture land;

p = commodity produced; p = 1-9 are crops produced for sale to final provincial demand or for export; p = 10 is hay; p = 11-13 are cereals produced for feed within a region; p = 14-16 are cereals produced for sale as feed in other regions; and p = 17-41 are livestock commodities;

q = intermediate livestock commodities 1-6;

r = cereal feed types 1-2;

and with the variables identified as follows:

Y = net revenue; that is, return to management after deducting:
(1) operator and hired labor at the minimum wage,
(2) interest and depreciation, and
(3) operating costs;

r_{ijkp} = net revenue from the production of one unit of commodity p in region i on farm size j and soil quality k;

X_{ijkp} = the quantity of commodity p produced in region i on farm size j and soil quality k;

t_{vip} = transportation cost per unit of crop commodity p transported from region v to region i;

T_{vip} = quantity of crop commodity p transported from region v to region i and allowed only where region v is adjacent to region i;

c_{vip} = transportation cost per unit of livestock of commodity type p produced on farms in region v transported to farms in region i;

A_{vip} = number of livestock animals of commodity type p produced on farms in region v transported to farms in region i and allowed only where region v is adjacent to region i;

L_{ik} = land with soil quality k available in region i;

a_{ijkp} = the commodity p per unit requirement for land in region i on farm size j and soil quality k;

R_{ijp} = the minimum level of production of commodity p allowed in region i on farms with enterprise size j;

R'_{ijp} = the maximum level of production of commodity p allowed in region i on farms with enterprise size j;

b_{ijkp} = per unit yield of commodity p in region i on farms of size j and soil quality k;

P_p = minimum provincial consumption plus export demand for commodity p;

P'_p = maximum provincial consumption plus export demand for commodity p;

Y_{ij} = minimum income requirement for farms of size j in region i;

Y_{ijkp} = net revenue from commodity p produced in region i on farms of size j and soil quality k;

LH_{ij} = minimum labor hours required on farms of size j in region i;

l_{ijkp} = labor hours required per unit of commodity p produced on soil of quality k on farms of size j in region i;

m_p = metabolizable energy provided per unit of commodity p produced;

f_p = metabolizable energy required per unit of commodity p produced;

s_{ijkpq} = supply of intermediate livestock inputs of type q produced per unit of commodity p produced on soil quality k on farms of size j in region i;

s'_{ijkpq} = amount of intermediate livestock inputs of type q required per unit of commodity p produced on soil quality k on farms of size j in region i;

f'_{rp} = minimum requirement for feed of type r per unit of commodity p produced; and

h_p = hay requirement per unit of commodity p produced.

THE INPUT-OUTPUT MODEL

The following pages display the Input-Output and Interdependence Coefficients tables for the Parklands region of Manitoba. The input-output table for the Parklands region is constructed from the Interlake input-output table by adjusting total output to reflect sales in the Parklands region by sector and assuming input coefficients remain constant. The Parkland Input-Output and Interdependence Coefficients tables serve to illustrate the sectors considered and the input proportions by sector.

INTERDEPENDENCE COEFFICIENTS 1971

SECTOR FROM 1 TO 10										
(1) AG-LIVESTOCK	1.0491	0.0247	0.0080	0.6100	0.0078	0.0123	0.0077	0.0022	0.0352	0.0223
(2) AG- CROP	0.0299	1.0234	0.0033	0.0865	0.0031	0.0050	0.0043	0.0009	0.0351	0.0101
(3) MINING	0.0000	0.0000	1.0000	0.0000	0.0057	0.0000	0.0000	0.0000	0.0000	0.0000
(4) FOOD BEV MFG	0.0050	0.0030	0.0018	1.0387	0.0018	0.0029	0.0014	0.0005	0.0010	0.0291
(5) OTHER MFG	0.0018	0.0020	0.0013	0.0016	1.0017	0.0026	0.0068	0.0006	0.0022	0.0005
(6)TRANSPOTATION	0.0118	0.0195	0.0115	0.0164	0.0092	1.0057	0.0124	0.0008	0.0224	0.0028
(7)CONSTRUCTION	0.1114	0.1204	0.0935	0.0791	0.0190	0.0466	1.0710	0.0093	0.0176	0.0115
(8)PET.WHOLESALE	0.1298	0.1029	0.0375	0.1041	0.0258	0.1267	0.0218	1.0086	0.0217	0.0134
(9)FARM EQ. BLD	0.1196	0.0955	0.0082	0.0780	0.0048	0.0073	0.0608	0.0014	1.0084	0.0045
(10) FOOD STORE	0.0311	0.0328	0.0244	0.0319	0.0240	0.0378	0.0182	0.0068	0.0117	1.0089
(11)OTHER RETAIL	0.0615	0.0619	0.0453	0.0624	0.0456	0.0790	0.0375	0.0129	0.0233	0.0170
(12)AUTO PRODUCT	0.1758	0.2332	0.0858	0.1528	0.0638	0.2434	0.1207	0.0254	0.0514	0.0307
(13)APPAREL SHOE	0.0063	0.0068	0.0051	0.0065	0.0050	0.0078	0.0038	0.0014	0.0024	0.0018
(14) FURNITURE	0.0026	0.0028	0.0021	0.0027	0.0019	0.0032	0.0017	0.0006	0.0010	0.0007
(15) INSURANCE	0.0025	0.0033	0.0009	0.0022	0.0008	0.0049	0.0018	0.0003	0.0011	0.0011
(16)PERS SERVICE	0.0268	0.0287	0.0214	0.0277	0.0210	0.0332	0.0162	0.0059	0.0102	0.0078
(17)OTHER SERVIC	0.0087	0.0102	0.0056	0.0085	0.0052	0.0092	0.0114	0.0030	0.0030	0.0029
(18) HOUSEHOLD	0.4169	0.4460	0.3336	0.4312	0.3277	0.5164	0.2479	0.0922	0.1594	0.1212
TOTAL	2.1906	2.2170	1.6893	2.7403	1.5739	2.1440	1.6454	1.1726	1.4071	1.2862
SECTOR FROM 11 TO 18										
(1) AG-LIVESTOCK	0.0064	0.0036	0.0038	0.0056	0.0188	0.0339	0.0108	0.0262		
(2) AG- CROP	0.0019	0.0017	0.0016	0.0022	0.0077	0.0134	0.0043	0.0104		
(3) MINING	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000		
(4) FOOD BEV MFG	0.0055	0.0008	0.0009	0.0013	0.0043	0.0438	0.0029	0.0061		
(5) OTHER MFG	0.0016	0.0023	0.0080	0.0014	0.0098	0.0026	0.0086	0.0021		
(6)TRANSPOTATION	0.0162	0.0045	0.0086	0.0072	0.0801	0.0076	0.0225	0.0076		
(7)CONSTRUCTION	0.0138	0.0079	0.0113	0.0154	0.1588	0.0289	0.0486	0.0336		
(8)PET.WHOLESALE	0.0147	0.0123	0.0141	0.0227	0.0661	0.0295	0.0330	0.0730		
(9)FARM EQ. BLD	0.0025	0.0018	0.0042	0.0030	0.0159	0.0081	0.0068	0.0121		
(10) FOOD STORE	0.0114	0.0110	0.0115	0.0173	0.0574	0.0235	0.0325	0.0814		
(11)OTHER RETAIL	1.0231	0.0224	0.0223	0.0327	0.1167	0.0484	0.1024	0.1493		
(12)AUTO PRODUCT	0.0376	1.0339	0.0383	0.0539	0.3245	0.0756	0.1099	0.2007		
(13)APPAREL SHOE	0.0024	0.0023	1.0024	0.0036	0.0119	0.0048	0.0067	0.0168		
(14) FURNITURE	0.0014	0.0009	0.0009	1.0014	0.0053	0.0019	0.0027	0.0065		
(15) INSURANCE	0.0013	0.0008	0.0011	0.0018	1.0066	0.0019	0.0021	0.0026		
(16)PERS SERVICE	0.0107	0.0097	0.0101	0.0152	0.0505	1.0215	0.0356	0.0713		
(17)OTHER SERVIC	0.0041	0.0045	0.0040	0.0146	0.0332	0.0090	1.0178	0.0164		
(18) HOUSEHOLD	0.1562	0.1503	0.1569	0.2358	0.7835	0.3200	0.4442	1.1111		
TOTAL	1.3108	1.2705	1.2999	1.4350	2.7512	1.6744	1.8917	1.8273		

INPUT-OUTPUT COEFFICIENTS 1971

SECTOR FROM 1 TO 10										
(1) AG-LIVESTOCK	0.0327	0.0105	0.0	0.5568	0.0	0.0	0.0	0.0	0.0298	0.0027
(2) AG- CROP	0.0209	0.0156	0.0	0.0639	0.0	0.0	0.0	0.0	0.0321	0.0065
(3) MINING	0.0	0.0	0.0	0.0	0.0056	0.0	0.0	0.0	0.0	0.0
(4) FOOD BEV MFG	0.0025	0.0005	0.0	0.0336	0.0	0.0	0.0	0.0	0.0	0.0275
(5) OTHER MFG	0.0	0.0001	0.0001	0.0001	0.0010	0.0011	0.0057	0.0003	0.0018	0.0002
(6)TRANSPOTATION	0.0047	0.0126	0.0083	0.0069	0.0068	0.0009	0.0084	0.0001	0.0203	0.0013
(7)CONSTRUCTION	0.0	0.0003	0.0552	0.0	0.0062	0.0	0.0276	0.0043	0.0007	0.0019
(8)PET.WHOLESALE	0.0948	0.0682	0.0143	0.0107	0.0034	0.0918	0.0035	0.0024	0.0039	0.0024
(9)FARM EQ. BLD	0.0639	0.0692	0.0	0.0008	0.0007	0.0	0.0538	0.0	0.0	0.0
(10) FOOD STORE	0.0006	0.0001	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
(11)OTHER RETAIL	0.0042	0.0007	0.0	0.0010	0.0014	0.0090	0.0032	0.0004	0.0014	0.0004
(12)AUTO PRODUCT	0.0538	0.1041	0.0	0.0008	0.0003	0.1094	0.0075	0.0058	0.0052	0.0012
(13)APPAREL SHOE	0.0	0.0	0.0	0.0	0.0000	0.0	0.0	0.0	0.0	0.0
(14) FURNITURE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
(15) INSURANCE	0.0011	0.0020	0.0	0.0002	0.0000	0.0036	0.0010	0.0001	0.0005	0.0007
(16)PERS SERVICE	0.0	0.0	0.0	0.0	0.0	0.0	0.0002	0.0	0.0	0.0
(17)OTHER SERVIC	0.0013	0.0022	0.0	0.0003	0.0003	0.0008	0.0070	0.0015	0.0003	0.0009
(18) HOUSEHOLD	0.2965	0.3256	0.2754	0.1347	0.2870	0.4265	0.1832	0.0795	0.1057	0.0914
TOTAL	0.5770	0.6117	0.3532	0.8100	0.3128	0.6431	0.3012	0.0943	0.2018	0.1371
(21)DEPRECIATION	0.1083	0.1617	0.3343	0.0963	0.1160	0.1329	0.0574	0.0113	0.0298	0.0249
(19)GOVERNMENT	0.0249	0.0434	0.0598	0.0026	0.1737	0.0439	0.0090	0.0051	0.0216	0.0110
(20)INVTRY DEPL.	0.0783	0.0674	0.0	0.0015	0.0	0.0	0.0012	0.0	0.0	0.0003
(22) RENT	0.0127	0.0062	0.0002	0.0	0.0013	0.0013	0.0018	0.0	0.0	0.0
(23) INTEREST	0.0062	0.0099	0.0	0.0004	0.0010	0.0146	0.0071	0.0112	0.0049	0.0024
(24)UNALLOCATED	0.0051	0.0101	0.0141	0.0025	0.0006	0.0270	0.0109	0.0024	0.0042	0.0046
(25) IMPORT(ROM)	0.2658	0.1526	0.2385	0.0875	0.3310	0.1345	0.4731	0.6808	0.7377	0.8196
(26) IMPORT(ROC)	0.0	0.0045	0.0	0.0007	0.0636	0.0026	0.1395	0.1949	0.0	0.0003
TOTAL	1.0783	1.0674	1.0000	1.0015	1.0000	1.0000	1.0012	1.0000	1.0000	1.0003
SECTOR FROM 11 TO 18										
(1) AG-LIVESTOCK	0.0	0.0	0.0	0.0	0.0	0.0019	0.0	0.0191		
(2) AG- CROP	0.0	0.0002	0.0	0.0	0.0	0.0068	0.0	0.0071		
(3) MINING	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
(4) FOOD BEV MFG	0.0045	0.0	0.0	0.0	0.0	0.0405	0.0	0.0		
(5) OTHER MFG	0.0012	0.0020	0.0076	0.0008	0.0070	0.0017	0.0073	0.0007		
(6)TRANSPOTATION	0.0148	0.0033	0.0073	0.0052	0.0718	0.0043	0.0180	0.0025		
(7)CONSTRUCTION	0.0032	0.0007	0.0005	0.0052	0.0	0.0074	0.0167	0.0213		
(8)PET.WHOLESALE	0.0026	0.0020	0.0030	0.0065	0.0066	0.0041	0.0016	0.0606		
(9)FARM EQ. BLD	0.0	0.0	0.0021	0.0	0.0	0.0	0.0	0.0060		
(10) FOOD STORE	0.0	0.0	0.0	0.0	0.0	0.0001	0.0	0.0732		
(11)OTHER RETAIL	0.0018	0.0020	0.0010	0.0004	0.0086	0.0048	0.0417	0.1324		
(12)AUTO PRODUCT	0.0006	0.0031	0.0018	0.0077	0.0	0.0030	0.0045	0.1699		
(13)APPAREL SHOE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0151		
(14) FURNITURE	0.0004	0.0	0.0	0.0	0.0	0.0	0.0	0.0058		
(15) INSURANCE	0.0008	0.0004	0.0006	0.0012	0.0043	0.0010	0.0009	0.0019		
(16)PERS SERVICE	0.0006	0.0	0.0	0.0	0.0	0.0009	0.0070	0.0640		
(17)OTHER SERVIC	0.0016	0.0022	0.0016	0.0109	0.0199	0.0039	0.0107	0.0132		
(18) HOUSEHOLD	0.1271	0.1300	0.1315	0.2010	0.6077	0.2580	0.3661	0.0		
TOTAL	0.1594	0.1459	0.1569	0.2388	0.7259	0.3386	0.4745	0.5927		
(21)DEPRECIATION	0.0395	0.0194	0.0417	0.0153	0.0232	0.0323	0.0236	0.0587		
(19)GOVERNMENT	0.0208	0.0206	0.0345	0.0339	0.0169	0.0265	0.0178	0.1516		
(20)INVTRY DEPL.	0.0042	0.0025	0.0161	0.0054	0.0	0.0	0.0	0.0		
(22) RENT	0.0035	0.0022	0.0139	0.0244	0.0268	0.0054	0.0362	0.0128		
(23) INTEREST	0.0068	0.0041	0.0050	0.0057	0.0096	0.0073	0.0112	0.0		
(24)UNALLOCATED	0.0069	0.0036	0.0054	0.0123	0.0463	0.0111	0.0522	0.0528		
(25) IMPORT(ROM)	0.7630	0.8039	0.7426	0.6696	0.1493	0.5748	0.3702	0.1314		
(26) IMPORT(ROC)	0.0001	0.0003	0.0	0.0	0.0020	0.0040	0.0143	0.0		
TOTAL	1.0042	1.0025	1.0161	1.0054	1.0000	1.0000	1.0000	1.0000		

THE POPULATION PROJECTIONS MODEL

$$P_{m,o,t} = \sum_{n=15}^{49} \left[(P_{1,n,t-1}) \right] + (P_{1,n,t-1}) \cdot (M_{1,n,t-1}) - (P_{1,n,t-1}) \cdot (1-S_{1,n,t}) \cdot \tfrac{1}{2} \Big] F_{n,t} \, (a_m) \qquad (1)$$

for m = 1 (female), m = 2 (male), n = 15,...,49

$$P_{m,n,t} = (P_{m,n-1,t-1}) \cdot (S_{m,n-1,t}) + (P_{m,n-1,t-1}) \cdot (M_{m,n,t-1}) \qquad (2)$$

for m = 1, 2 and n = 1,...,80+

$$M_{m,n,t} = \left[P_{m,n,t} / (P_{m,j,t-1} \cdot SR_{m,j,t}) \right]^{1/5} - 1 \qquad (3)$$

for m = 1, 2 and j = 1,...,17

where:

$P_{m,o,t}$ = population of sex m and age o at time t (births);

$P_{m,n,t}$ = population of sex m and age n at time t;

$M_{m,n,t}$ = the net migration rate of sex m and age n at time t;

$S_{m,n,t}$ = the survival rate of sex m and age n at time t;

$F_{n,t}$ = the fertility rate of females at age n at time t where n = 15,...,49;

a_m = proportion of births of sex m;

$P_{m,j,t}$ = population of sex m and age cohort j at time t;

and

$SR_{m,j,t}$ = survival rate of sex m and age cohort j at time t.

Equation (1) indicates that the number of births in period t is derived by:

1. adjusting the number of females in each of the child-bearing ages (15 to 49) for changes due to death and migration; and

2. multiplying the resulting female population by individual ages by the fertility rates for each age.

In equation (2) adjustments are made in the population data by individual ages and sex to account for changes due to death and migration in the previous period, t-1. The total population is obtained by summing births from equation (1) and the adjusted population from equation (2). Equation (3) calculates the migration rate for age based on the ratio of the population in each age cohort in period t to the surviving population in the cohort from period t-1. In this model, equation (3) is replaced by a Net Migration equation dependent on regional income and unemployment differentials.

THE NET MIGRATION EQUATION

The net migration equation is a combination of gross migration equations estimated in <u>Determinants of Gross Migration</u>.[1] The gross migration equations that were incorporated are:[2]

1. Rural to Urban 3

$$\hat{MR} = .048 - .00014D + .013I - .014U + .0079E - .029A - .0088ED + .0015S_j \qquad (R^2 = .39)$$

2. Urban 3 to Urban 3

$$\hat{MR} = .0137 - .000031D - .01711 - .011U + .00006E - .0059A + .021ED - .0037S_i \qquad (R^2 = .63)$$

3. Urban 1 to Urban 3

$$\hat{MR} = .0066 - .000067D + .031I - .00088U - .00076E - .011A - .0065ED - .00038S_j \qquad (R^2 = .42)$$

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[1] G. Mathieson, *op. cit.*

[2] Ibid., pp. 51, 54 and 59.

Where:[3]

Migration ($\frac{Mij}{Pi}$) - sum of outmigrants from each element of a classification divided by the total population of the element.

Distance (D) - distance between point of origin and destination of migration.

Income (I) - the average income in the area of destination divided by the average income in the area of origin, (I_j/I_i).

Unemployment Rate (U) - the average unemployment rate in the area of destination divided by the average unemployment rate in the area of origin.

Ethnic Background (E) - the proportion of the total population of the dominant ethnic group in the area of origin divided by the proportion of the total population of that ethnic group in the area of destination (assume = 1).

Age (A) - the proportion of the population in the area of origin between 16 and 29 divided by the proportion of the population in the area of destination between the ages of 16 and 29 (assume = 1.0).

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[3] Ibid., pp. 41-46.

Education (ED) - the proportion of population in the area of destination with a high school education or more divided by the proportion of the population in the area of origin with a high school or better education (assume = 1).

Primary and Secondary Employment (S_j) - the proportion of total employment made up by secondary industries in area j (of destination) (assumed = 1.0).

When adjusted to reflect only statistically significant coefficients (at 15 percent level or better), the equations appear as follows:

1. Rural to Urban 3

$$\hat{MR} = .048 - .00014D - .014U + .0079E - .029A$$

2. Urban 3 to Urban 3

$$\hat{MR} = .0137 - .000031D - .047I - .011U + .021ED + .00037S_i$$

3. Urban 1 to Urban 3

$$\hat{MR} = -.000067D + .031I - .011A$$

Those variables which display a coefficient with a sign incompatible with the results generally supported in

<u>Determinants of Gross Migration</u>[4] were then removed,[5] leaving:

1. Rural to Urban 3

$$\hat{MR} = .048 - .00014D - .014U + .0079E - .029A$$

2. Urban 3 to Urban 3

$$\hat{MR} = .0137 - .000031D - .011U + .021ED$$

3. Urban 1 to Urban 3

$$\hat{MR} = -.000067D + .031I - .011A$$

Constants were inserted for variables assumed to be unchanged by inclusion in the aggregate model;[6] the resulting equations appear as:

1. Rural to Urban 3 (Out of Parklands)

$$\hat{MR} = .048 - .00014\ (192.61) - .014U + .0079\ (1) - .029\ (1)$$

2. Urban 3 to Urban 3 (Out of Parklands)

$$\hat{MR} = .0137 - .000031\ (175.75) - .011U + .021\ (1)$$

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[4] Ibid., p. 71.

[5] The removal of theoretically inconsistent variables without re-estimating the gross migration equations was done when the original data could not be located.

[6] See Appendix B for distance calculations and data.

3. Urban 1 to Urban 3 (Out of Parklands)

$$\hat{MR} = -.000067\ (190.97) + .031I - .011\ (1)$$

4. Rural to Urban 3 (into Parklands)

$$\hat{MR} = .048 - .00014\ (244.54) - .014U' + .0079\ (1) - .029\ (1)$$

5. Urban 3 to Urban 3 (into Parklands)

$$\hat{MR} = .0137 - .000031\ (186.4) - .011U' + .021\ (1)$$

6. Urban 1 to Urban 3 (into Parklands)

$$\hat{MR} = .000067\ (234.67) + .031I' - .011\ (1)$$

Next the equations were multiplied by the proportion of the total population represented by the three equations (three into and three out of: the Parklands) that dwells in their respective originating classifications (e.g., rural, urban 3, urban 1):[6]

1. Rural to Urban 3 (out of Parklands)

$$\hat{MR} = \left(\frac{32,538}{46,876}\right) \times \left[-.0000654 - .014U\right] = -.0000453 - .0097178U$$

2. Urban 3 to Urban 3 (out of Parklands)

$$\hat{MR} = \left(\frac{9,392}{46,876}\right) \times \left[.02925 - .011U\right] = .00586 - .002204U$$

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[6] See Appendix C for population data and calculations.

3. Urban 1 to Urban 3 (out of Parklands)

$$\hat{MR} = (\frac{4,946}{46,876}) \times \left[-.023795 + .031I\right] = -.00251 + .0032708I$$

4. Rural to Urban 3 (into Parklands)

$$\hat{MR} = (\frac{198,989}{278,268}) \times \left[-.007336 - .014U'\right] = -.0052459$$

$$- .010011U'$$

5. Urban 3 to Urban 3 (into Parklands)

$$\hat{MR} = (\frac{58,127}{278,268}) \times \left[-.02892 - .011U'\right] = .006041$$

$$- .0022977U'$$

6. Urban 1 to Urban 3 (into Parklands)

$$\hat{MR} = (\frac{21,152}{278,268}) \times \left[-.026723 + .031I'\right] = -.0020312$$

$$+ .0023564$$

The equations were added to produce a weighted average outmigration equation and a weighted average in-migration equation:

A. Rural, Urban 1 and Urban 3 to Urban 3 (out of Parklands)

$$\hat{MR} = -.003305 - .0119218U + .0032708I$$

B. Rural, Urban 1, and Urban 3 to Urban 3 (into Parklands)

$$\hat{MR} = -.0012361 - .012309U' + .0023564I'$$

The two equations were then multiplied by the total number of migrations divided by the number of migrations from Rural, Urban 1 and Urban 3 to Urban 3 classifications 'out-of' and 'into' the Parklands, respectively to produce Total Migration per base population equations.

A. Total Migrations per Rural, Urban 1 and Urban 3 Population (out of Parklands)

$$\left(\frac{4,108^{*}}{227+65+198^{**}}\right) \times \left[.003305 - .011928U + .0032708I\right]$$

$$= .027708 - .0999484U + .0274213I$$

B. Total Migrations per Rural, Urban 1, and Urban 3 Population (into Parklands)

$$\left(\frac{3,452^{*}}{141+6+122^{**}}\right) \times \left[-.0012361 - .012309U' + .0023564I'\right]$$

$$= -.0158625 - .1579578U' + .030239I'$$

Finally, the equations were multiplied by the Population of Rural, Urban 1 and Urban 3 classifications divided by the total population for the Parklands and the rest of Manitoba, respectively, to generate Total Migration per Total Population equations:

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*G. Mathieson, op. cit., p. 96.

**G. Mathieson, op. cit., p. 95.

A. Total Migrations per Total Population (out of Parklands)

$$\left(\frac{46,876}{55,742}\right)^{***} \times \left[.027708 - .0999484U + .0274213I\right]$$

$$= .0233009 - .084051U + .0230598I$$

B. Total Migrations per Total Population (into Parklands)

$$\left(\frac{278,268}{907,472}\right)^{***} \times \left[-.0158625 - .1579578U' + .030239I'\right]$$

$$= -.004864 - .0484363U' + .0092725I'$$

Subtraction of equation B from equation A generated the Estimated Net Migration Equation for the Parklands (where NMR $>$ 0 indicates outmigration):

$$\widehat{NMR} = .0184369 - .0999484U + .0484363U' + .0230598I - .0092725I'$$

This net migration equation was then inserted into the population projection program in place of the trend or historic migration rates formerly used.

***See Appendix C for tabulation.

APPENDIX B

DISTANCE CONSTANTS FOR INDIVIDUALS VARIABLES
IN THE GROSS MIGRATION EQUATIONS

The distance constants for each equation were calculated as the weighted average of distances migrated by the migrants observed in _Determinants_.[7] The migrations out of the Parklands region were weighted by the number of migrants moving from the origin to the destination by urbanization specified in the equation to the various regions in the 'rest of Manitoba' times the highway distance from Dauphin to the largest town in the region of destination. The migrations into the Parklands region are similarly weighted by the number of migrants from each originating region times the distance from the largest town in that region to Dauphin. The number of migrants, distances, and weighted average distances appear in Table B-1.

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[7] G. Mathieson, _op_. _cit_., p.

TABLE B-1

Data and Calculations of Distance Constants Used in the Gross Migration Equations

1 Gross Migration Equation Origin	2 Destination	3 Distance (miles)	4 Number of Migrations	5 Total Migrant Miles (Column 3 x Column 4)	6* Average Distance of Migration (Miles)
Rural to Urban 3					
	Interlake	414	11	4,554	
Parklands	North Central	233	61	14,213	192.61
	Southwest	161	155	24,955	
Urban 3 to Urban 3					
	Interlake	414	5	2,070	
Parklands	North Central	233	23	5,359	175.75
	Southwest	161	170	27,370	
Urban 1 to Urban 3					
	Southeast	432	4	1,728	
Parklands	North Central	233	12	2,796	190.97
	Southwest	161	49	7,889	

(Continued)

TABLE B-1 (Continued)

1 Gross Migration Equation Origin	Destination	3 Distance (miles)	4 Number of Migrations	5 Total Migrant Miles (Column 3 x Column 4)	6* Average Distance of Migration (Miles)
Rural to Urban 3					
Southeast		432	26	11,232	
Interlake		414	8	3,312	
North Central	Parklands	233	14	3,262	244.54
South Central		350	9	3,150	
Southwest		161	84	13,524	
Urban 3 to Urban 3					
Southeast		432	2	864	
Interlake	Parklands	414	1	414	186.4
North Central		233	32	7,456	
Southwest		161	87	14,007	
Urban 1 to Urban 3					
Interlake		414	1	414	
South Central	Parklands	350	1	350	234.67
Southwest		161	4	644	

*The average distance of migration is calculated as the sum of total migrant miles (Column 5) for a given gross migration equation divided by the total number of migrations for that equation.

APPENDIX C

POPULATIONS USED AS WEIGHTS BY URBANIZATION

The populations used to weight the various gross migration equations are based on data contained in the "Parklands Information Study"[8] and the 1971 Census of Canada. The "Parklands Study" data was used to represent Parklands region population by level of urbanization. In one case, the Parklands data was not specified to the level of disaggregation required by the gross migration equations. The population data provided in the "Parklands Study" had a listing for towns of 500 to 5,000 people. The migration equations are specified for towns of 500 to 1,000 (Urban 1) and towns of 1,000 to 5,000 (Urban 2). Thus, the "Parklands Study" data for towns of 500 to 5,000 people were allocated to Urban 1 and Urban 2 classifications by proportions derived from Census data for the Parklands. The raw data and calculations of populations used as weights appear in Table C-1.

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[8] J. A. MacMillan et al, <u>op</u>. <u>cit</u>., p.

TABLE C-1

Population Data and Calculations by Urbanization For as Weights on the Gross Migration Equations

Level of Urbanization / Region	Parklands[a]	Manitoba	Manitoba-Parklands ("Rest of Manitoba")
Rural and Urban 500	32,538	231,527 (252,351)[b]	198,989
Urban 1 (500- 1,000)	4,946[c] (4,333)[d]	26,098	21,152
Urban 2 (1,000- 5,000)	8,866[c] (7,768)[e]	43,048	34,182
Urban 3 (5,000-30,000)	9,392	67,519 (101,455)[b]	58,127
Indian Reserves	1,200	25,204	24,004
Winnipeg	-	540,262	540,262
Total	56,942	988,418	931,476
Total excluding Indian Reserves	55,742	963,214	907,472
Subtotal of Rural, Urban 1 and Urban 3 (excluding North)	46,876	325,144	278,268

[a] *op. cit.*, p. vii, Vol. II.

[b] including North.

(Continued)

TABLE C-1 (Continued)

[c]The total population of towns between 500 and 5,000 residents in the Parklands, as reported in the "Parklands Information Study" (see a above), was distributed to the Urban 1 and Urban 2 classifications in proportion to the population in those classifications in the Parklands as reported in the 1971 Census of Canada (see d and e below). The Census populations appear in brackets in the Urban 1 and Urban 2 rows.

[d]Sum of populations of towns with 500 to 1,000 residents from 1971 Census of Canada, catalogue no. 92-707, Vol. 1--Part 1, Queen's Printer, Ottawa, October, 1972.

[e]Sum of the populations of towns with 1,000 to 5,000 residents from loc. cit., d above.

APPENDIX D

The Ratio of the Agricultural Livestock Sector's Final Demand to Unconstrained Potential Gross Output for the Years 1971, 1974, 1975 and 1979 from the Input-Output Model for the Four Alternatives Considered

Alternative and Year	Final Demand (1,000's)	Unconstrained Potential Gross Output ($1,000's)	Final Demand / Potential Gross Output %
Alternative 1			
1971	26,712.7	33,645.016	79.396
1974	30,634.2	38,280.831	80.025
1975	32,084.5	40,000.202	80.211
1979	38,709.6	47,807.07	80.970
Alternative 2			
1971	26,712.7	33,645.016	79.396
1974	30,634.2	38,280.831	80.025
1975	33,188.7	41,786.289	79.425
1979	43,406.8	55,686.218	77.950
Alternative 3			
1971	26,712.7	33,645.016	79.396
1974	25,259.7	32,574.114	77,545
1975	24,775.4	32,234.763	76.859
1979	22,838.0	30,893.36	73.925
Alternative 4			
1971	26,712.7	33,645.016	79.396
1974	25,259.7	32,574.114	77.545
1975	28,652.0	36,956.475	77.529
1979	42,221.3	54,416.904	77.589

APPENDIX E

CALCULATION OF PROJECTED GROSS PRODUCT FOR THE TRANSPORTATION SECTOR CONSTRAINED BY LAND ONLY

Projected Gross Product for the Transportation Sector constrained by land only was calculated as follows:

Projected GP Constrained by Land Only = Projected GP Unconstrained of Transportation - Change in Projected GP of Transportation due to Land Constraint

where:

Change in Projected GP of Transportation Sector due to Land Constraint = [Change in Projected GP of Agric. Crops Sector due to Land Constraint x Interdependence Coefficient of Transportation /Agric. Crops]

+ [Change in Projected GP of Agric. Livestock Sector due to Land Constraint x Interdependence Coefficient of Transportation /Agric. Livestock]

The data taken from the input-output program's results to perform the calculations are listed by the selected Alternatives and years in Table E.1 below.

TABLE E.1

Data Used in Calculating Reduction in Gross Product of the Transportation Sector Due to the Land Constraint

Alternative and Year	Change in GP of Agric. Livestock Sector Due to Land Constraints	Interdependence Coefficient Transportation/Agric. Livestock	Change in GP of Agric. Crops Sector due to Land Constraint	Interdependence Coefficient Transportation/Agric. Crops
Alternative 1				
1971	no change	-	no change	-
1974	- 3,533.93	.0127	-18,264.26	.0192
1975	- 4,465.24	.0128	-19,809.82	.0192
1979	- 8,870.89	.0132	-26,625.14	.0195
Alternative 2				
1971	no change	-	no change	-
1974	- 3,533.93	.0127	-18,264.26	.0192
1975	- 6,643.33	.0126	-39,577.42	.0188
1979	-19,175.91	.0125	-124,546.0	.0176
Alternative 3				
1971	no change	-	no change	-
1974	no change	-	-16,779.18	.0193
1975	no change	-	-17,703.31	.0194
1979	no change	-	-21,486.17	.0198

(Continued)

TABLE E.1 (Continued)

Alternative and Year	Change in GP of Agric. Livestock Sector Due to Land Constraints	Interdependence Coefficient Transportation/Agric. Livestock	Change in GP of Agric. Crops Sector due to Land Constraint	Interdependence Coefficient Transportation/Agric. Crops
Alternative 4				
1971	no change	-	no change	-
1974	no change	-	-16,779.18	.0193
1975	- 1,823.09	.0123	-38,336.03	.0190
1979	-17,794.98	.0125	-124,387.68	.0177