AN ECONOMIC IMPACT ASSESSMENT OF THE CHILLIWACK REGION USING AN INPUT-OUTPUT MODEL

by

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ABSTRACT

Input-output (I-O) analysis is a technique to model the structure and inter-sectoral flows of an economy. The I-O model can further be used to estimate the magnitude of backward-linked economic activity (indirect and induced effects), and the effect of an increase or decrease in final demand. As well, the model can assess the effect of certain government policies on the output, income, and resource use of regions. In this study, the conceptual and mathematical frameworks of I-O analysis are explained in detail. Technical considerations relating to the construction and operation of regional I-O models are also reviewed. An I-O model of the Chilliwack region is constructed. The structure of the Chilliwack regional economy is evaluated; multiplier estimates of regional sectors are derived; and the response of the Chilliwack economy to specific changes in final demand is simulated.

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DEDICATION

To all with whom

I have exchanged

glances of the heart

1.0 INTRODUCTION

1.1 Problem Statement

Primary industries, agriculture and forestry, have been the mainstay of the Chilliwack regional economy throughout its history. In recent times, secondary and tertiary sectors have also grown in importance. As these sectors have increased in importance and the region evolved a more urbanized structure, the contribution of agriculture to the local economy has become less apparent; the urban population has become less cognizant of the importance of agricultural sectors.

Pressures to divert land away from agricultural uses threaten to significantly reduce the agricultural productivity of the region. A decrease in primary agricultural activities would lead to further economic losses throughout the local economy through the loss of secondary expenditures. While a well-managed diversion of agricultural lands to other productive uses could lead to greater regional income, poorly managed diversion to non-productive land uses could result in lost opportunities for regional income generation. Local economic planners need to develop a broad understanding of the structure and dynamics of the local economy to facilitate development decisions which maximize regional income generation capabilities.

1.2 Study Purpose and Objectives

The purpose of this project is to illustrate the impact agricultural sectors have on the Chilliwack regional economy and to heighten local awareness of the importance of the agricultural sector. The objectives of the study are thus to construct a regional input-output model for the

Chilliwack region, and to provide an impact assessment of local economic sectors. In broad terms, the study will describe, in detail, the structure of the regional economy with particular emphasis on the various sub-sectors of agriculture, and will demonstrate how each sector contributes to the overall regional economy in terms of output, income, and employment.

Input-output analysis is a complex and broad subject. The first stage of the project is to provide an indepth but easily followed explanation of its conceptual and mathematical frameworks, particularly as it relates to regional studies. As well, a detailed review of technical considerations relating to the construction and operation of regional I-O models will be provided. An emphasis will be with regard to 'short-cut' approaches to model construction.

In the second stage of the project, the objective is to develop an input-output model which lays out the chief structural features of the regional economy. That is, the model will show how money flows through the local economy; how it first enters the local economy from the 'outside world' via revenue generated by the export of local goods and services or through the inflow of funds from senior levels of government, how it then circulates locally for a time, and how it eventually leaks away as money spent on goods and services produced beyond the regional boundary. This information alone will be useful to a broad range of community, provincial, and federal organizations.

In the third stage, the objective is to illustrate quantifiably rather than with general descriptions the impact each sector has on the local economy. Three sets of multiplier estimates will be described; output, income, and employment. Briefly, multiplier estimates are indications of the overall impact of each dollar of exports from the local area. These estimates provide an indication of the relative importance of different types of economic activity.

In the fourth stage, the objective is to simulate how the local economy would react to specific changes either in the composition of local economic sectors or in the level of demand for local products or services from outside the region. For example, the model will be used to estimate total gains/losses to the local economy in terms of both income and employment due to some event, such as the expansion or closure of an existing food processing plant, the addition of a new industry not currently represented locally, an increase/decrease in the demand for local goods and services, or an increase/decrease in federal spending within the region. Although this simulation process is far from perfect - its limitations are reviewed in detail in later sections - it will provide further insight into characteristics of the local economy. Interested organizations will have additional information with which to address issues of economic growth.

In summary, the specific objectives of this project are:

1. to describe the structure of the Chilliwack economy;
2. to determine the economic linkages in the region, particularly inter-industry linkages;
3. to estimate output multipliers - changes in total regional output resulting from a change in output in a specific economic sector due to increased demand by final users;
4. to estimate income multipliers - changes in total regional household income resulting from a change in output in a specific economic sector due to increased demand by final users;

5. to estimate employment multipliers - the regional employment effects resulting from a change in output in a specific economic sector due to increased demand by final users;
6. to assess the direct and indirect consequences of alternate scenarios of economic growth.

Ancilliary objectives are:

1. to provide an indepth explanation of the conceptual and mathematical frameworks of regional I-O analysis;
2. to provide an detailed review of technical considerations relating to the construction and operation of regional I-O models.

1.3 Background

1.3.1 Regional Economic Planning

Economic growth in recent years has been an area of great concern. The upheavals of the 1970s and the early 1980s have illustrated all too starkly how vulnerable regional economies are to national and international events and trends. Technological advances, shifting trade patterns, fluctuating world prices, and intense competition have a tremendous impact on the structure of the Canadian economy.

While national and provincial statistics provide valuable insight as to the overall state of the economy and the quality of life, they obscure the details of how individual communities respond to an economy in constant flux. It is the role of regional planning to highlight these details.

At the broadest level, regional planning is the comprehensive analysis of the social, economic, and bio-physical characteristics of a distinct geographical area. Regional planning can also have a more narrow perspective. Examples include land use suitability assessments, transportation analyses, social housing studies, or economic strategies. This study concentrates on the economic characteristics of the Chilliwack area. In particular, the structure of the regional economy is described in detail and the spin-off effects of economic activity are simulated.

The administrative framework of a region defines, to a large extent, how a regional planning project is formulated and how it is applied. The most common type of planning exercises are those undertaken by government at either the municipal, provincial, or federal levels of administration. In many cases, the government agency is responsible for all stages of the planning exercise; project initiation, goal formation, selection of the methodology, research, plan/policy formulation, plan approval, and implementation. In other instances, either the public or non-government institutions contribute to the planning exercise. For instance, community organizations concerned with a particular issue may request that the appropriate level of government undertake a study into the problem. Or, a government agency, having initiated a project and set the project goals and terms of references, may enlist an outside organization to conduct the research and to recommend a plan.

This regional planning project is different from most in that it has been conducted to a large extent outside the realm of government. The project was initiated by a community organization, the Agriscope Society. Once the general goals were established, a university consultant was contracted to undertake the study with the final report presented to the Agriscope Society in November, 1987: this thesis is an expansion of that work. Nevertheless, government still has several key roles in the project. First, the project was entirely funded by government - federal, provincial, and local - with other valuable assistance provided by Agriscope Society members and the Department of Agricultural Economics at U.B.C. Second, government departments and agencies were a major source of data key to the successful completion of the project. In addition, one of the goals of the project was to provide different levels of government with information to be used in the assessment and refinement of existing agricultural programs and policies.

1.3.2 Economic Impact Methodologies

Regional development is a concern at all levels of government. Wilson (1968, p. 376) observed that a key question of policy-makers is, "How far can regional disparities be reduced by modifying the regional pattern of gross domestic monetary expenditure through taxation, transfers, or monetary policy." Several methodologies have been developed to examine this issue through the analysis of economic structure and dynamics. At the regional level of analysis, economic base, income-expenditure, and input-output methodologies are most commonly used.

1.3.3 Economic Base Studies

Economic base studies usually attempt to determine an overall economic multiplier for a region. Lewis (1976) identified four stages in the development of an economic base model; (a) identify the appropriate regional unit, (b) specify the equation system, (c) measure the export base, and (d) estimate the parameters of the model. Employment is most often used as the measure of export base since employment statistics are most readily available. A single ratio is the most simple equation form:

$$k = \frac{T}{X} \tag{1}$$

where k is the estimated multiplier , T is total employment, and X is export employment. The assumption is that export related employment is a fixed ratio of total employment. Therefore, if export related activity increases, total economic activity is expected to increase by this set ratio which is referred to as the multiplier. This relationship is described by a straight line through the origin of the plot (linearly homogeneous).

There have been many adaptations of this simple formula with varying degrees of complexity. Isserman (1977) reports that three main estimation procedures are used with secondary data for a single time period; the location quotient method, the minimum requirements approach, and the assignment approach. As well, various procedures use time-series data to estimate economic base model employment multipliers (Weiss and Gooding, 1968; Mather and Rosen, 1974). Though a considerable amount of discussion and assessment has been directed toward these different methods, the "...superiority of any one technique has not been demonstrated..." (Isserman, 1977, p. 1004) In view of this, Isserman proposed a bracketing approach which estimates upper and lower bounds based on the location quotient and the Mather-Rosen techniques respectively.

Although very easy to carry out, economic base studies provide very little information about a regional economy. These models usually produce a single, aggregate multiplier of a regional economy, though some studies have produced separate employment multipliers for the largest three or four economic sectors (Weiss and Gooding, 1968). More importantly, the many techniques used to derive economic base multipliers have all been subject to a great deal of criticism with regard to their theoretical justification and level of accuracy.

1.3.4 Income-Expenditure Accounts

Another common method used to describe the economic impact of a sector on a regional economy is to develop an income-expenditure account for that specific sector. An income-expenditure account is a partial rather than a general equilibrium economic model because it examines or concentrates on only a portion of the regional economy. The main attribute of this methodology is that it describes in detail the backward and forward linkages of the sector. For instance, a flow chart could be developed for the agricultural sector to show how farms buy a certain proportion of their inputs from local trade and service establishments, how they sell a portion of their output to local food processors, and how these processors, in turn, sell products with a higher value-added outside the region.

By making some very broad assumptions and economic estimates, a general multiplier for the agricultural sector could be estimated. However, the usefulness or value of this estimate would be limited for a number of reasons. First, many of the underlying estimates are based on a very limited knowledge of the regional economy. Second, a multiplier is obtained for only one economic sector, or, at best, two or three related sectors. In isolation, the multiplier estimate is not very meaningful, especially since differences in techniques between studies prevent valid comparisons.

1.3.5 Input-Output Studies

Input-output analysis is an extension of the income-expenditure account in that an income-expenditure account is derived for a mutually exclusive and exhaustive list of regional economic sectors. In other words, with input-output studies, the regional economy is first organized into a complete list of distinct economic sectors and then an income-expenditure account is derived for each sector. As in any accounting procedure, care must be taken to ensure that the accounts for the individual sectors are mutually consistent. A more detailed explanation of input-output (I-O) analysis is provided in section 2.

I-O analysis has several advantages over the two previous methodologies. First, a complete set of economic accounts is provided within a matrix. This matrix describes the structure of the entire regional economy. Second, data are derived or estimated for all aspects of inter- and intra-regional trade. This enables the estimation of economic multipliers for each economic sector. Thus, while "the basic-service model tends to be a single-degree freedom model, defining a single multiplier with respect to total input in a single reduced form equation, ...input-output is an n-degree freedom model, defining as many industrial multipliers as there are endogenous activities and requiring as many equations for their solution." (Garniek, 1970, p. 35) While this is a very time-consuming task, the resulting economic multipliers are generally more reliable than those derived from the previous two methodologies. Third, several types of multipliers can be derived for each local economic sector using the same methodology (definitions, estimation techniques, etc.). This permits the comparison of impacts across sectors.

The disadvantages of the I-O methodology in comparison to the previous two are (a) that it requires a tremendous amount of data which are not readily available and (b) that it is, therefore, a time-consuming approach. It was decided, however, that these disadvantages were not overly critical in the context of this study. The study area is relatively small with a limited number of economic sectors, and a limited number of enterprises in each sector. The survey process would therefore be manageable. Also, the study area corresponds with the boundaries of a Regional District; consequently, a considerable amount of census data are available. In view of these considerations, the I-O methodology was selected for this economic impact assessment of the Chilliwack area.

1.4 Policy Implications

Input-output modelling was developed to serve as an analytical tool in the assessment of economies, national and regional. The primary use of I-O models is therefore with positive economic analysis. The models can be used to described the structure of the local economy. As well, the I-O model can be used to describe the effect an industry has on a regional economy in terms of spin-off benefits. This information can then be used to assist in the design of economic development plans.

In a limited sense, I-O analysis can be used for normative analysis: that is, to assess what course of action is best. An common objective of development planners is often to maximize local economic activity. Economic activity means jobs and income for area residents. I-O analysis can be used to assist in decisions involving investment options. If two or more investment options are available to local planners each of similar magnitude, then the project that has the largest economic multipliers is the best option from a local context. However, if the development options involve substantially different initial investments, then a simple comparison of multipliers becomes irrevelant.

Input-output analysis is also frequently used to determine who benefits from government expenditures. For example, government investments into irrigation works increase economic activity locally, within other parts of the province, and across the nation. The distribution of these economic benfits can serve as a guide to the formulation of cost sharing schemes between the direct beneficiaries and the two or three levels of government involved in the project. In addition, I-O models can be used to rate development plans in terms of optimal use of resources or contributions to environmental pollution. When combined with other modelling processes, such as regression based general equilibrium or dynamic linear programming models, the normative potential of I-O models expands greatly; however, the review of combined models is beyond the scope of this study.

I-O analysis is often over-extended in policy analysis. In other words, it is often improperly used as a basis for normative analysis. This study should assist those involved in policy formultion to understand the proper uses of I-O analysis.

1.5 Organization of Thesis

A major concern throughout the development of this study was that the material and content be readily understandable to non-economists. Economic impact assessments are prepared for the benefit of a very diverse group of community interests that range from decision-makers, such as city officials, to the public at large, those who are affected by the complex myraid of community development efforts. Therefore, the style and organization of the report are geared as much as possible towards individuals that have limited training in economics. Economic terminology, or jargon, is avoided as much as possible. For instance, use of the term 'marginal', a cornerstone of economic analysis (marginal costs, marginal revenue, marginal rate of transformation, marginal gains), is limited to the sections dealing with advanced technical issues. In the majority of the text, the concepts are described in more common language.

The audience of the study has a substantial effect on the organization of the thesis. This is most evident in the ordering of sections dealing with literature review, model assumptions, and model development. Acedemic treatices usually begin with a literature review, and then outline the assumptions/limitations of the methodology. Only then is the methodology outlined in detail. Since the audience of the report will generally be unfamiliar with economic impact analysis, a different organization was preferred. The economic methodology is first clearly described, initially with words, and then mathematically. Once the reader has a basic understanding of the methodology, its general assumptions and limitations are reviewed. Finally, technical details of input-output analysis are reviewed.

2.0 INPUT-OUTPUT ANALYSIS - AN OVERVIEW

A regional economy comprises many different sectors each involved in a different aspect of business, commerce, or community service. Each sector is dependent upon the economic activities of other sectors, which include households and government, both within and beyond regional boundaries. The amount of economic interdependence among sectors and the amount of demand by final consumers, including exports, determines the overall level of economic activity, and, therefore, the levels of regional employment and income. As the size of the region decreases, the importance of exports, or trade between regions, grows in relation to the economic activity between sectors within the region. "In a national economy with a high degree of regional specialization, the income level or growth of a particular region is dependent on its ability to export goods and services to other regions." (Weiss and Gooding, 1968, p. 235)

Since the 1940s, I-O analysis has been used extensively to describe the structure of national and regional economies, and to estimate the impact of alternate economic sectors. Section 2.1 provides a brief review of the development of I-O analysis. A more comprehensive examination of the issues, techniques, and developments of I-O analysis is provided in section 3.0 The two main steps of I-O analysis are examined in sections 2.2 and 2.3.

The first step is to construct a set of regional accounts. These accounts are a detailed flow chart of regional economic transactions. It shows how money first enters the region and how it is then exchanged between local economic sectors for a time before it eventually leaks out of the region. Thus, the accounts are a snapshot of the structure of the regional economy, not at a particular instant in time, but over the course of a particular year. This step is described in section 2.2.1.

The second step of I-O analysis is to predict how the overall regional economy would change in response to a specific change in the final demand of one local sector. The various stages in this step are described with words in sections 2.2.2 through 2.2.5 and mathematically in section 2.3.

In order to make these predictions, I-O analysis makes a number of strong assumptions. The main assumption is that all economic sectors have a fixed pattern of expenditures on inputs as described by the regional accounts in the given base year. Stated differently, each economic sector is assumed to have a fixed production function - a fixed method of production - and is assumed to buy and sell goods and services in a set pattern described by the base year of the model. As an illustration of this assumption, if industry A, in the base period, purchased $1000 worth of product X from industry B to use in its own production processes, and its total sales for that particular year were $10,000, then its input/sales ratio for that particular year was 0.1.

To make its prediction of regional economic activity, I-O analysis assumes that this industry (A) will continue to have the same fixed set of input ratios at any level of production. Thus, if next year's sales are predicted to increase to $15,000, then it is assumed that the purchases of industry A from industry B will likewise increase to $1500 maintaining the input ratio for this product at 0.1. The assumptions and limitations of I-O analysis are discussed in more detail in section 2.3 after the basic framework of I-O analysis is fully described.

2.1 The Evolution of Input-Output Analysis

Input-output analysis was first formalized by Wassily Leontief in the late 1930s as an economic analytical tool (Leontief, 1936, 1941). Accordingly, it is also referred to as the Leontief model. The fundamental purpose of the Leontief model is to analyse the interdependence of industries in an economy (Miller and Blair, 1895, p. 1). Each industry, or economic sector, is described through two interdependent, equivalent linear equations representing the sector's sources of revenue and expenditures. A national or regional economy is represented through the combination of a 'system of linear equations' comprising all economic sectors into a 'transactions table'. The reasoning and mechanics of this I-O system are addressed in sections 2.2 and 2.3.

The transactions table can be viewed simply as an accounting framework of inter-industry activity. This concept was first developed by the French economist, Francois Quesnay, in the mid 1700s. Quesnay developed a "Tableau Economique" which described diametrically "how expenditures can be traced through an economy in a systematic way." (Miller and Blair, 1985, p. 1) Much later, the U.S.S.R. developed a similar economic account described as a "chessboard" table (U.S.S.R. Central Statisitics Board, 1926). Leontief (1941) has described his I-O model "as an attempt to construct a Tableau Economique of the United States."

Another important precursor of Leontief's I-O model was the work of Leon Walrus (1874) in developing a theory of general equilibrium in economics based on the notion of economic interdependence. In the general equilibrium model, a series of production coeffiecients were established which represented the total quantity of factor inputs required to produce a single unit of output. The Leontief I-O model uses similar production coefficients. It has thus been described as an approximation of the Walrusian model, with several important simplifications which allowed the general equilibrium theory to be applied in a working model.

Just prior to Leontief's initial development of the I-O model, John Maynard Keynes set out a new framework of macroeconomics. A fundamental component of the framework is the general equilibrium model of a national economy expressed as a system of two linear equations, the first representing gross national expenditures and the second gross national product. In section 2.3, the I-O model is shown to be a direct extension of Keynes' general equilibrium model. While the Keynesian model represents gross national product, the I-O model represents total product. Total product is simply gross national product (payments to factors of production) plus intermediate production (goods used to produce final consumption goods). By including intermediate production, "I-O analysis explicitly recognizes the magnitude of the impact of an economic stimulus on a regional economy depends on the sector(s) of the economy in which the stimulus originates...The input-output model (thus) allows for the construction of sectoral multipliers..." (Davis, 1976, p. 18) Suprisingly, this connection between the two most applied general equilibrium models is rarely explicitely examined. A notable exception is MacMillan, Lu, and Framingham (1975).

Polenske (1980, p. 94) reports that fifteen years passed after Leontief's first I-O article before 'space' was explicitely introduced to this method of economic analysis; that is, before regional I-O analysis was developed. Activity in this area surged forth in the 1950s. Polenske further identifies four ways in which space is dealt with in I-O analysis; regional, intra-national, multi-regional, and inter-regional.

This thesis presents a regional I-O analysis. The earliest such models were developed by Isard (1951), Cumberland (1954), and Moore and Peterson (1955) for Maryland, New England, and Utah respectively.

2.2 Theoretical Framework

In this section, I-O analysis is explained in non-mathematical terms. A hypothetical example is used to illustrate the various steps. For further illustrations, see Miernyk (1965).

2.2.1 Transactions Matrix

The first stage of input-output analysis involves the construction of a transactions matrix. The matrix is a record of the total annual trade between economic sectors. Within the matrix, details of revenues and expenditures are listed separately for each sector. Thus, the transactions matrix is simply a collection of double-entry regional accounts: revenues for one sector are simultaneously recorded as expeditures in some other sector.

Before we introduce the entire transactions matrix, an illustration of financial accounting will be worthwhile. Table 2.1 outlines the revenues and expenditures of a hypothetical average firm.

To make the accounts easier to read, the various economic sectors have been grouped into five main categories. The first category includes all local businesses, firms, and community organizations. The sub-total indicates the firm's total sales to local businesses and the total amount of purchases of supplies and services made from local businesses. The second category provides the total amount of sales to local consumers and the total wages paid to local labour. Consumers and labour refer, of

TABLE 2.1 FINANCIAL ACCOUNTS OF A HYPOTHETICAL FIRM

Economic Activity		Revenue ($)	Expenditures ($)
Firms	b	12	67
	c		84
	d	114	
	e		97
	f	104	
	Sub-total	230	248
Consumers/Labour		422	424
Government		17	26
Exports/Imports		585	369
All Other	rent	31	23
	interest	67	63
	depreciation		47
	profit		132
	other	36	56
	Sub-total	134	321
Total		1,388	1,388

course, to the same group - households. The third category represents all revenues received from the payments of government; federal, provincial, regional, and local. Examples include research grants paid to the firm and taxes collected from the firm. The fourth category, exports and imports, accounts for all trade in goods and services with individuals, firms, and businesses (excluding government) beyond the regional boundary. For example, sales to tourists from outside the region would be recorded in the revenue column as an export. The final category - all other revenue and expenditures - includes items which cannot be regarded as either a good or a service. Note that the two sides of the account are balanced by including profits in the expenditures column - e.g. payments to shareholders.

In I-O analysis, we are concerned with economic sectors rather than individual firms. Thus, all establishments are assigned to an appropriate economic sector. The accounts for each sector are simply the sum of all of the individual firm accounts which comprise that economic sector. For illustrative purposes, suppose the above firm is assigned to economic sector A, feed manufacturers, and there are nine other identical firms within that sector. Then the sector accounts would be ten times the magnitude of the individual firm's accounts. If each of the other firms listed in the accounts represent different economic sectors, then the industry accounts would be as in Table 2.2.

A transactions matrix is a collection of industry accounts with the revenues read across rows and expenditures read down columns. An example of a hypothetical I-O transactions matrix is shown in Table 2.3. The accounts for the above sector are listed in the first row (revenue) and the first column (expenditures).

The transactions matrix is grouped into quadrants (after Jensen, Mandeville, and Karunartne, 1979). Quadrant I represents inter-industry trade; the amount of goods and services local industries purchased from other local industries for use in their own production processes. These intermediate goods are used to make goods which are sold to final consumers.

Quadrant II represents sales to final users. This quadrant is the 'driving force' of the regional economy. Final demand usually includes

TABLE 2.2 FINANCIAL ACCOUNTS OF A HYPOTHETICAL ECONOMIC SECTOR

Economic Sector		Revenue ($)	Expenditures ($)
Inter-mediate Sectors	B	120	670
	C		840
	D	1,140	
	E		970
	F	1,040	
	Sub-total	2,300	2,480
Consumers/Labour		4,220	4,240
Government		170	260
Exports/Imports		5,850	3,690
All Other	rent	310	230
	interest	670	630
	depreciation		470
	profit		1,320
	other	360	560
	Sub-total	1,340	3,210
Total		13,880	13,880

net inventory change, capital formulation (sales to investment), government purchases, exports, and purchases by households. Quadrant III represents industry value-added. It includes the primary inputs of labour and government (subsidies), and other final payments such as those for imported goods and services, rent, interest, and depreciation.

The last group, quadrant IV, represents direct inputs of final demand which are not produced by industries in the intermediate

TABLE 2.3 HYPOTHETICAL INPUT-OUTPUT TRANSACTIONS TABLE

		Purchasing Sector							Final Demand					Total
		a	b	c	d	e	f	Total Inter-mediate	House-holds	Govern-ment	Exports	Other Final Demand	Total Final Demand	
		I							II					
Producing Sector	a	0	120	0	1,140	0	1,040	2,300	4,220	170	5,850	1,340	11,580	13,880
	b	670	110	5,570	650	840	5,430	13,270	27,680	1,120	9,210	4,590	42,600	55,870
	c	840	0	0	0	0	430	1,270	4,180	80	4,860	4,210	13,330	14,600
	d	0	2,560	1,450	180	1,320	3,240	8,750	8,770	230	1,390	2,430	13,820	21,570
	e	970	0	0	0	0	2,350	3,320	11,850	480	3,950	3,280	19,560	22,880
	f	0	12,620	0	5,310	2,280	1,300	21,510	10,390	2,400	5,720	8,650	27,160	48,670
	Total Inter-mediate	2,480	15,410	7,020	7,280	4,440	13,790	50,420	67,090	4,480	30,980	24,500	127,050	177,470
		III							IV					
Primary Inputs	House-holds	4,240	16,390	5,260	3,590	12,230	20,470	62,180	9,610	27,780	109,900	47,160	194,450	256,630
	Gov't	260	2,140	120	30	340	3,200	6,090	32,930				32,930	39,020
	Imports	3,690	16,310	1,990	9,230	5,080	4,560	40,860	115,360				115,360	156,220
	Other Value Added	3,210	5,620	210	1,440	790	6,650	17,920	31,640				31,640	49,560
	Total Primary Inputs	11,440	40,460	7,580	14,290	18,440	34,880	127,050	189,540	27,780	109,900	47,160	374,380	501,430
Total		13,880	55,870	14,600	21,570	22,880	48,670	177,470	256,630	32,260	140,880	71,660	501,430	678,900

processing sector. For regional studies, portions of this quadrant may be blank because the transactions take place outside of the region. That is, these accounts are 'balanced' either at a national or worldwide level.

2.2.2 Economic Spin-off Effects

A primary objective of I-O analysis is to estimate the total change in regional production resulting from an increase in the final demand of the output of one local industry. Every regional industry is dependent on other local industries for some proportion of their inputs. As this one local industry increases its sales to final consumers, such as households or exports, it must purchase additional inputs from its local suppliers. These local suppliers must, in turn, purchase additional inputs from other local industries. This is refered to as the ripple effect. Economic multipliers are a measure of how large this ripple effect is in relation to the original increase in sales to final consumers.

The ripple effect is essentially the spin-off growth in regional production over and above the initial growth in sales to final consumers. It is derived from three stages of economic activity. These stages are termed the direct effect, the indirect effect, and the induced effect.

The direct effect refers to the first round of the spin-off growth. For example, suppose the regional farm sector arranges a new contract to supply $1000 worth of unprocessed vegetables to a wholesale firm located outside of the region. This represents the initial increase in sales to final consumers, i.e. this is final demand as far as the regional economy is concerned. To meet this order, farmers will have to purchase additional goods and services from other local industries. This first round of the ripple effect is refered to as the direct effect: the growth of local production directly needed by the farm sector to meet its increased export demand.

The second round is represented by increased purchases made by the suppliers of the farm to meet their own increased production demands. For example, feed and fertilizer manufacturers, to meet increased demand for their products, would need to increase their own purchases of supplies such as packaging materials and chemicals from other local establishments. Theoretically, this ripple effect continues for an infinite number of rounds. However, the leakage of revenue from the 'active' regional economy quickly reduces the magnitude of the ripple effect. This leakage occurs through many sources. The largest source of monetary leakage is the purchase of 'imports' from outside the region. Other important sources of leakage are savings and taxes. For large areas, most of the ripple effect is captured after about seven rounds, but for small regions this can happen after only two or three rounds as the percentage of purchases from outside the local economy are typically much higher. Together, the infinite number of rounds of spin-off growth beyond the first round make up the indirect effect of total regional growth.

Lastly, the induced effect is the increase in regional output as the result of new income to households. With the initial export order and at each stage of the ripple effect, households earn more income. A percentage of this new income will in turn be spent on local goods and services, thereby amplifying the ripple, or multiplier, effect.

I-O studies typically produce two sets of multiplier estimates. The first includes only the direct and indirect effects of increased regional output. These multipliers illustrate the interdependence of local industries: how an increase in the final demand of one sector results in an increase of output in other sectors solely through the trade of intermediate goods and services. The second set of multipliers represent direct, indirect, and induced effects. They include the increased spending by households and are, as such, a more representative view of what actually takes place within an economy. The second set of multipliers are usually considerably larger than the first because: (a) the second set of multipliers include the additional ripple effect of household spending; (b) the household sector is usually the largest economic sector, i.e. represents the largest category of revenue; and (c) in small regional economies, the household sector usually has one of the highest propensities to consume locally, i.e. has the lowest tendency to purchase goods and services directly from outside the local economy.

The first set of multipliers are referred to as Type I multipliers. The associated I-O model is said to be open in that the household sector is not included in the ripple effect. The second set are Type II multipliers and they are derived from a closed I-O model - households are included in the ripple effect.

2.2.3 Direct Requirements Matrix

Two main steps are required to derive either the direct and indirect effects of the Type I output multiplier or the direct, indirect, and induced effects of the Type II output multiplier. The first step is to produce a direct requirements matrix as described below. The second step is to derive an inverse matrix as described in the next section.

2.4 HYPOTHETICAL INPUT-OUTPUT DIRECT REQUIRMENTS MATRIX

	A	B	C	D	E	F	House-holds
	Quad. I						Quad. II
A	0.000	0.002	0.000	0.053	0.000	0.021	0.016
B	0.048	0.002	0.382	0.030	0.037	0.112	0.108
C	0.061	0.000	0.000	0.000	0.000	0.009	0.016
D	0.000	0.046	0.099	0.008	0.058	0.067	0.034
E	0.070	0.000	0.000	0.000	0.000	0.048	0.046
F	0.000	0.226	0.000	0.246	0.100	0.027	0.040
	Quad. III						Quad. IV
House-holds	0.305	0.293	0.360	0.166	0.535	0.421	0.037
Gov't	0.019	0.038	0.008	0.001	0.014	0.066	0.128
Other Value Added	0.497	0.392	0.151	0.495	0.257	0.230	0.573
Total	1.000	1.000	1.000	1.000	1.000	1.000	1.000

A direct requirements matrix is derived simply by dividing each entry in the transactions matrix by its column total (Table 2.4). Since the spin-off effects are generated solely through the interaction of local groups, the columns representing non-local sectors (e.g. exports, federal government) are dropped from the table.

The direct requirements matrix has two parts comprising technical coefficients and primary input coefficients respectively. For the open I-O model where households are viewed as 'outside' final demand, the portion represented by quadrant I is refered to as the technical coefficients matrix. These coefficients (reading down any given column) represent how much a given processing sector must purchase from other processing sectors in order to produce one dollar's worth of output. These values are determined by the technology used by the sector in its production or service activities.

By processing sector, we refer to all local industrial, business, and community service organizations. In other words, technical coefficients represent the magnitude of inter-industry trade among local businesses of tangible goods and services. Consequently, they are also refered to as trading coefficients.

The entries in quadrant III similarly represent the proportion of payments to each of the primary inputs by a given sector in order to produce one dollar's worth of output. Which expense items are considered to be 'primary inputs' is actually a somewhat arbitrary decision. In the open model, labour (households) is considered a primary input. Examples of other primary inputs are land rentals, imports, interest payments, depreciation, subsidies, and profit. Thus, primary inputs generally represent fiscal payments and accounting procedures rather than trade in tangible goods and services. Together, the column totals of the direct requirements coefficients in quadrants I and II should add to 1.

As an example, let sector C represent the farm crop sector. The expenditures of this sector are determined from column 3. In order to produce one dollar's worth of output, the sector as a whole must purchase 38.2¢ worth of goods from sector B, e.g. fertilizer manufacturers and dealers, and 9.9¢ worth of goods from sector D, e.g. farm equipment dealers. The sum of the technical coefficients, i.e. the direct requirement coefficients in quadrant I, provides the magnitude of the direct effect, the first round of the spin-off growth. So for every dollar's worth of output in sector C, first round spin-off production in the regional economy amounts to about 48¢. This figure is the direct effect component of regional economic expansion resulting from an increase in the final demand for the production of sector C.

The zero in the third row and column indicates that this particular sector does not have any intra-industry trade; that is, crop farmers do not make purchases from other crop farms. However, this is not always the case. For instance, firms in sector D must purchase 0.8¢ worth of goods from other local firms within sector D in order to produce one dollar's worth of goods.

2.2.4 Inverse Matrix

The next step in the process of deriving output multipliers is to compute an inverse matrix. A separate inverse matrix is calculated for the open and the closed I-O models based on the direct requirements matrix.

Inverse refers to a mathematical operation performed on matrices which corresponds to the ordinary numerical operation of division. Furthermore, an inverse matrix can only be calculated from a square matrix, i.e. a matrix with an identical number of rows and columns. As a simple example, suppose we have a square matrix, one with an identical number of rows as columns, which we label G. The inverse of G, which we will label IG, can be represented as:

$$IG = \frac{1}{G} \tag{2}$$

where 1 is defined as a diagonal matrix of ones.

Since Type I multipliers are derived from inter-industry spin-off trade, the first inverse matrix (Table 2.5) is based solely on the inter-industry component of the direct requirements matrix (quadrant I). In our hypothetical example, this includes the first six rows and columns of the matrix in Table 2.4. If we label this sub-matrix D_{6x6} and the

TABLE 2.5 INVERSE MATRIX OF A HYPOTHETICAL OPEN INPUT-OUTPUT MODEL: TYPE I MULTIPLIERS

	A	B	C	D	E	F
	Quad. I					
A	1.002	0.011	0.010	0.061	0.007	0.028
B	0.078	1.035	0.402	0.068	0.055	0.131
C	0.061	0.003	1.002	0.006	0.002	0.011
D	0.016	0.066	0.128	1.032	0.070	0.083
E	0.071	0.013	0.007	0.018	1.007	0.054
F	0.029	0.258	0.126	0.279	0.134	1.085
Total	1.257	1.387	1.675	1.463	1.274	1.393

Type I inverse matrix I_{6x6}, then the mathematical relationship between the two matrices is expressed as:

$$I_{6x6} = \frac{1}{(1 - D_{6x6})} \tag{3}$$

with 1 again defined as a diagonal matrix of ones.

The Type II multipliers, on the other hand, include both inter-industry spin-off trade as well as household spin-off trade. Consequently, the Type II inverse matrix (Table 2.6) is based on the inter-industry component of the direct requirements matrix as well as the household row and column, the first seven rows and columns of our hypothetical example (Table 2.4). If we label this sub-matrix D_{7x7} and the Type II inverse matrix I_{7x7}, then the mathematical relationship is expressed as:

$$I_{7x7} = \frac{1}{(1 - D_{7x7})} \tag{4}$$

A more involved explanation of the mathematical 'mechanics' of the I-O model is provided in section 2.3. However, a general understanding of I-O analysis does not require an understanding of the detailed mathematical framework.

2.2.5 Multipliers

Several kinds of multipliers can be developed using I-O analysis. In this study, three forms will be derived; output multipliers, income multipliers, and employment multipliers.

TABLE 2.6 INVERSE MATRIX OF A HYPOTHETICAL CLOSED INPUT-OUTPUT MODEL: TYPE II MULTIPLIERS

	A	B	C	D	E	F	House-holds
	Quad. I						Quad. II
A	1.012	0.022	0.026	0.069	0.023	0.042	0.026
B	0.141	1.102	0.488	0.121	0.152	0.217	0.155
C	0.070	0.013	1.014	0.014	0.015	0.023	0.022
D	0.041	0.093	0.162	1.053	0.109	0.117	0.061
E	0.096	0.040	0.042	0.039	1.046	0.088	0.062
F	0.073	0.305	0.186	0.315	0.201	1.144	0.108
	Quad. III						Quad. IV
House-holds	0.485	0.520	0.669	0.405	0.746	0.657	1.195
Total	1.917	2.095	2.586	2.015	2.291	2.288	1.628

Output Multiplier

The output multiplier is a measure of how total regional output changes in response to a change in the final demand of a given sector. An output multiplier can be expressed as either a Type I or a Type II multiplier. This means that the output multiplier can measure total output expansion either in terms of local inter-industry spin-off production (Type I) or in terms of local inter-industry and household spin-off trade. The value of the Type I and Type II output multipliers is determined simply by calculating the column totals of the respective inverse matrices.

For example, suppose the final demand for vegetables from the local farm crop sector increases by \$1000 through an increase in export demand. Then the Type I output multiplier for this sector, as shown in column 3 of Table 2.5, is 1.675. This indicates that total regional output will increase by \$1675, \$1000 due to the original export order and \$675 due to economic spin-offs amongst community industries. Similarly, the Type II output multiplier for this sector, as shown in Table 2.6, is 2.586. This indicates that total regional output will increase by \$2586, \$1000 due to the original export order and \$1586 due to economic spin-offs within the community amongst both industrial/business and household sectors.

In more general terms, the Type I and Type II output multipliers are described by the following ratios:

a) Type I output multiplier derived from the open I-O model;

$$\frac{\text{direct and indirect changes in output}}{\text{direct change in output}}$$

b) Type II output multiplier derived from the closed I-O model;

$$\frac{\text{direct, indirect, and induced changes in output}}{\text{direct change in output}}$$

The output multipliers for the six economic sectors of the above hypothetical region are listed in Table 2.7. For illustration purposes,

TABLE 2.7 HYPOTHETICAL OUTPUT MULTIPLIERS

	Output Multipliers	
Sector	Type I	Type II
A	1.26	1.92
B	1.39	2.09
C	1.67	2.59
D	1.46	2.02
E	1.27	2.29
F	1.39	1.63

let us examine sector C, the farm crop sector. With the open model, for every dollar's worth of output this sector sells to final consumers, total regional output, including the additional dollar output of the farm crop sector, increases by $1.67. With the closed model, i.e., including the effect of increased household spending, total regional output would increase by $2.59.

Employment Multiplier

I-O analysis is used to estimate the effect on the regional economy of changes in the final (output) demand of one sector. The above section describes how total regional output is expected to change in response to changes in the final sales of one sector. This section describes how regional employment is likewise expected to change in response to changes in the final sales of one sector.

The employment multiplier traces the impact of changes in final demand sales on regional employment. In order to make this prediction, an additional strong assumption must be made: the labour to sales ratio in each sector using current technology and at current levels of production is assumed to hold at different production levels. That is, the average labour/sales ratio experienced in each sector is assumed to be fixed regardless of the level of production.

With a fixed labour/sales ratio, an increase in the final demand sales of one sector will lead to a proportional increase in employment in that sector. Using the output multiplier and the fixed labour/sales ratios of all other local economic sectors, the proportional increase in employment in all other sectors can also be calculated. The employment multiplier for a specific sector thus indicates the total change in regional employment resulting from a unit change in employment in that sector. That is, for each person-year increase in direct employment, the employment multiplier indicates the expected total increase in regional employment.

In more general terms, the Type I and Type II employment multipliers are described by the following ratios:

a) Type I employment multiplier derived from the open I-O model;

$$\frac{\text{direct and indirect change in employment}}{\text{direct change in employment}}$$

b) Type II employment multiplier derived from the closed I-O model;

$$\frac{\text{direct, indirect, and induced change in employment}}{\text{direct change in employment}}$$

TABLE 2.8 HYPOTHETICAL EMPLOYMENT MULTIPLIERS

		Employment Multipliers	
Sector	Labour/Sales Ratio	Type I	Type II
A	0.030	1.26	2.25
B	0.025	1.62	2.90
C	0.040	1.52	2.55
D	0.035	1.51	2.22
E	0.020	1.51	3.81
F	0.045	1.27	2.17

The employment multipliers for the six economic sectors of the above hypothetical region are listed in Table 2.8. The Table also lists the labour/sales ratios used as the basis of the multipliers. To illustrate, we will again examine sector C, the farm crop sector. This sector is more labour intensive than most of the others - the labour to sales ratio is 0.04 persons per 1000 dollars of output. The Type I employment multiplier is 1.52; for each new employee in this sector, total regional employment, including this farm crop worker, will increase by 1.52 person-years. With the closed model, i.e., when increased household spending is considered, the (Type II) employment multiplier is calculated at 2.55 person-years for each new employee in the farm crop sector.

Income Multiplier

The income multiplier is analogous to the employment multiplier. It traces the impact of changes in final demand sales on regional income. Specifically, the income multiplier is a measure of the total change in household income due to a change in the expenditures on labour in a given sector. For each one-dollar increase in direct labour expenditures by a given sector, the income multiplier shows the total effect on regional household income.

In more general terms, the Type I and Type II income multipliers are described by the following ratios:

a) Type I income multiplier derived from the open I-O model;

$$\frac{\text{direct and indirect change in income}}{\text{direct change in income}}$$

b) Type II income multiplier derived from the closed I-O model;

$$\frac{\text{direct, indirect, and induced change in income}}{\text{direct change in income}}$$

The Type II income multipliers for the six economic sectors of the above hypothetical region are 1.58, 1.77, 1.86, 2.43, 1.40, and 1.56 respectively. Thus, for the farm crop sector, a one dollar increase in payments to farm labour, resulting from an increase in final sales of \$2.78, will result in an increase of total regional income of \$1.86. (The sales figure of \$2.78 is the total sales-to-labour expenditures ratio as calculated from column three of the transactions matrix).

Although it is possible to calculate Type I income multipliers, the software program used in this research does not automatically do so. The developers of the program do not offer an explanation for this omission. In any case, it is not as important to list Type I income multipliers separately as Bradley and Gander (1969) have shown that the values of

Type II sectoral income multipliers are a constant multiple of the values of the Type I multipliers for a particular set of input-output coefficients. Consequently, the rank of income multipliers will never vary between the two input-output assessment models. This is not true for either output or employment multipliers. In view of this, the Type I income multipliers will similarly be omitted from this study.

2.3 Mathematical Framework

The Input-Output model is a type of macroeconomic general equilibrium model. Macroeconomics is the study of economic relationships and behaviour at the aggregate scale. Examples include the analysis of national production trends, the study of national interest rates, and their impact on national rates of capital stock investment, and the projection of future national or regional levels of economic activity. Microeconomics, on the other hand, is the study of economic relationships at the firm level. Thus, the I-O model is a macroeconomic model primarily because the level of analysis is at the industry level rather than at the firm level. Each row/column of the transactions matrix represents an economic sector rather than an individual enterprise. It is a general equilibrium model because (a) the model includes all aspects of the economy in question and (b) all of the factors within the model - in this case, cells within the transactions matrix - must 'balance'.

In this section, we will discuss in greater detail the mathematical framework and the economic theory underlying I-O analysis. As such, the section supplements the more general description provided in section 2.2.

2.3.1 Keynesian Macroeconomics

The foundations of modern macroeconomics can be attributed to the work of John M. Keynes. Classical economics was based upon the assumption that wages, prices, and interest rates were perfectly flexible, and thus automatic forces would would keep the economy at, or close to, full employment. With this understanding, no need was seen for government intervention at the national level of economic activity. This economic doctrine is encapsulated by Say's Law, after the French economist, Jean Baptiste Say - "Supply creates its own demand." Keynes argued that aggregate demand need not equal aggregate supply, and that government intervention, either through reduced taxes or increased spending, is required at times to move the economy to full employment (Stager, 1973, p. 89).

At the most aggregated level, the Keynesian macroeconomic model is expressed as two equivalent identities of national economic activity, (5) a product identity and (6) a factor payments identity:

$$Y = C + G + K + (E - M) \tag{5}$$

where:

Y = national expenditures;

C = household consumption;

G = government expenditure;

K = investment;

E = exports;

M = imports;

$$W = L + N \tag{6}$$

where:

W = national income;

L = payments to labour;

N = other value added (payments to/for government services, land rental, interest on capital, entrepreneurship, etc.).

Note that the term (E - M) represents net export earnings.

Equation 5 is refered to as the gross national expenditure (GNE) and equation 6 the gross national product (GNP).[1] These concepts are not intuitive: GNE is the sum of expenditures for all final goods and services in the economy during the year; GNP is the value of all payments made to factors of production in one year (Stager, 1973, p. 75). The latter term is analogous to gross value-added at the enterprise or sectoral level.

The GNE concerns only the actual goods and services used by final consumers (net of imports). This does not include the value of intermediate products - goods and services used as inputs to final consumption goods. The largest categories of final consumers are those represented in equation 5; households, government, investment, and net exports. Similarly, payments for primary factor inputs (GNP) do not include payments for intermediate goods and services. To include the value of intermediate goods in either identity would be double counting as their value is already reflected in the value of the final consumption goods.

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1 As is often the case in economics, alternate definitions can be found in the literature. For example, Miller and Blair (1985, p. 10), using the identical notation, describe equation 5 as gross national product and equation 6 as gross national income.

A third identity states that the amount of gross national expenditures must equal the value of the gross national product:

$$GNE = GNP \tag{7}$$

In other words, the final accounts of an economy must balance.

Macroeconomics is essentially a study of the structure and dynamics of national accounts. The 'balance' of the two sides of equation 7, according to Keynesian economics, is ensured by the dynamics of the market place - by fluctuations in prices (product prices, labour wages, land rental rates, interest rates, etc.) and the adjustment process which automatically occures in response to these price fluctuations - and by managed government spending. While the I-O model is a general equilibrium model, in its most common applications it is static rather than dynamic: the model assumes that all price levels remain constant. Thus, static equilibrium models do not indicate how, or by what path, the economy arrives at its balanced equilibrium defined by equation 7.

2.3.2 The Input-Output General Equilibrium Model

MacMillan, Lu, and Framingham (1975) describe how the national accounts framework of I-O analysis is analogous to short-run macroeconomic analysis. The I-O model is a direct application of equations 5 and 6. The primary difference is that the model further identifies the value of products used as intermediate inputs to products sold to final consumers. The I-O model identifies total national output which is related to gross national product by the following expression:

$$X = Z + Y \tag{8}$$

or,
$$X = Z + C + G + K + (E - M) \tag{9}$$

where X is the total national output and Z is the total amount of goods and services used up in the production of final consumption goods.

The equivalent set of equations in terms of expenditures rather than output are:

$$X = Z + Y \tag{10}$$

and,
$$X = Z + L + N \tag{11}$$

A further distinction of the I-O model over the above macroeconomic model (equations 5 and 6) is that each equation is subdivided into a number of identical equations each representing a distinct industry/ economic sector. The reason separate 'total output' equations are drawn up for different sectors is because a primary objective of I-O analysis is to assess how individual sectors contribute to the economy. If we assume the economy has only two producing economic sectors, X_1 and X_2, then equation 9 can be expanded as follows:

$$\begin{aligned} X_1 &= Z_{11} + Z_{12} + C_1 + G_1 + K_1 + E_1 - M_1 \\ X_2 &= Z_{21} + Z_{22} + C_2 + G_2 + K_2 + E_2 - M_2 \end{aligned} \tag{12}$$

where:

X_1 = total output of sector 1;

X_2 = total output of sector 2;

Z_{11} = the amount of sector 1's output used by sector 1 in the production of final consumer products;

Z_{12} = the flow of goods from sector 1 to sector 2 to be used as intermediate inputs;

$Z_1 = Z_{11} + Z_{12}$ = the total amount of sector 1's output which is used as intermediate inputs in the production of all final consumer products;

C_1 = household consumption of sector 1's output;

G_1 = government expenditure on the production of sector 1;

K_1 = investment by sector 1;

E_1 = exports by sector 1;

M_1 = imports by sector 1.

Using summation notation to simplify the expression, the above set of equations become:

$$X_i = \sum_{j=1}^{n} Z_{ij} + C_i + G_i + K_i + E_i - M_i \tag{13}$$

where Z_{ij} is the flow of goods from sector i to sector j to be used as intermediate inputs into the production of sector j. In this example, both i and j can refer to either sector 1 or 2. With n sectors, i and j are defined as follows:

$i = 1,2,\ldots,n;$

$j = 1,2,\ldots,n.$

At this point, we arrive at the key convention, or assumption, of I-O analysis: to express Z_{ij} as a function of X_j:

$$Z_{ij} = a_{ij}X_j \tag{14}$$

In other words, the flow of goods from sector i to sector j (Z_{ij}) is expressed as a proportion (a_{ij}) of the total output value of sector j, with a_{ij} termed the technical coefficient. The reason for this, as will become clearer in the following paragraphs, is to facilitate the use of matrix algebra, the technique used to calculate the sector multipliers. Substituting equation 14 into equation 13 yields:

$$X_i = \sum_{j=1}^{n} a_{ij}X_j + C_i + G_i + K_i + E_i - M_i \tag{15}$$

where:

X_i = total output of sector i;

a_{ij} = the percentage of sector j's total inputs which are purchased from sector i, or technical coefficient;

$\sum_{j=1}^{n} a_{ij}X_j$ = the total amount of outputs of sector i used as inputs by other sectors = Z_i.

The technical coefficients (a_{ij}) are determined by the technology used by each sector.

With more than two economic sectors, the above set of equations becomes very awkward. To simplify the representation of the model, matrix notation is introduced:

$$X = AX + C + G + K + E - M \tag{16}$$

where:

X = vector of output by sector;

A = matrix of technical coefficients by sector;

C = vector of total household expenditures by sector;

G = vector of total government expenditures by sector;

K = vector of total capital formation by sector;

E = vector of exports by sector;

M = vector of imports by sector.

Equations 12 - 16 represent an expansion of equation 9, total national expenditures. A similar expansion of equation 11, total national product, yields the following expression:

$$X_j = \sum_{i=1}^{n} a_{ij}X_i + L_j + N_j \qquad (17)$$

where:

X_j = total expenditures of sector j;

a_{ij} = the percentage of sector i's total inputs which are purchased from sector j;

$\sum_{i=1}^{n} a_{ij}X_i$ = the total expenditures on intermediate inputs by sector j;

L_j = total expenditures of sector j on labour;

N_j = total payments to primary inputs other than labour.

In matrix notation, equation 17 becomes:

$$X = AX + L + N \qquad (18)$$

With I-O analysis, it is often more convenient to represent imports as an expenditure rather than having it tucked away within 'net exports'. This is achieved simply by adding the vector M to both equation 16 and 18. The new equations are:

$$X = AX + C + G + K + E \tag{19}$$

and,

$$X = AX + L + N + M \tag{20}$$

Notice that the first terms of equations 15 and 17, X_i and X_j, are equal - they are the same expression represented from different perspectives (GNE = GNP). The second terms, when summed over all intermediate sectors - $\sum_{i=1}^{n} \sum_{j=1}^{n} a_{ij}X_j = \sum_{j=1}^{n} \sum_{i=1}^{n} a_{ij}X_i$ - are also equivalent. However, an individual sector's intermediate sales need not equal its purchases from local firms. Similarly, a firm's final demand need not equal its primary inputs. The input-output model is constructed by combining these equations as illustrated in Table 2.9.

The total output equations of each producing sector (equation 15) are listed as the first n rows of the Table where n is the number of producing sectors represented in the model. The total expenditure equations of each producing sector (equation 17) are listed as the first n columns of the Table. As with all general equilibrium models, the total output of the producing sectors, the sum of the last column in Table 2.9, is equal to the total expenditures of the producing sectors, the sum of the last row. The grand total represents total national output which is equal to the GNP plus total intermediate production.

TABLE 2.9 THE INPUT-OUTPUT TABLE

Revenue / Expenditures	Producing sectors	Final demand				Total sales
Producing sectors	$a_{11}X_1 \ldots a_{1n}X_n$	C_1	G_1	K_1	E_1	X_1
	$\vdots\ a_{ij}X_j\ \vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$
	$a_{n1}X_n \ldots a_{nn}X_n$	C_n	G_n	K_n	E_n	X_n
Primarys inputs	$L_1 \ldots L_n$					
	$N_1 \ldots N_n$					
	$M_1 \ldots M_n$					
Total expenditures	$X_1 \ldots X_n$					X_{total}

2.3.3 Regional Input-Output Model

The I-O model as developed above is a good approximation of an economy when imports and exports are a relatively small portion of total output in most economic sectors. The reason for this is that intermediate inputs to economic sectors are said in the model to be purchased primarily from other sectors within the area (e.g. national) economy. These intermediate inputs are represented for sector j by the term $\sum_{i=1}^{n} a_{ij}X_i$ the (the first n elements of column j). In the above model, each sector obtains most of its intermediate inputs from other firms within the area: imports of intermediate inputs are not as significant. Furthermore, imported intermediate products are assumed to maintain a constant proportion of total inputs regardless of the amount of the sector's total output. In these times, it is more realistic to assume that a large portion of the intermediate products used up in local economies, regional and even national, are imported from outside the area: trade has become a major component of all developed economies.

To make the model more representative of regional economies, the technical coefficients are further subdivided into two categories of trade coefficients; local intermediate input coefficients and imported intermediate input coefficients. Thus, the origin of the intermediate product is identified as either regional or imported. As with all coefficients in I-O models, these new trade coefficients are assumed to be constant over the short-term. As well, it is assumed that the technology of production in each sector in the region is the same as the nation as a whole (Miller and Blair, 1985).

As an example, a_{ij} is the proportion of sector j's total expenditures which are directed to the purchase of sector i's outputs for use as intermediate inputs in its own production process. The regional model further disaggregates this into regional purchases, r_{ij}, and imported inputs from the rest of the nation, t_{ij} (see MacMillan, Lu, and Framingham, 1975). These coefficients will be referred to more simply as regional input and regional trade coefficients respectively.[2] Formally, the relation is:

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2 Miller and Blair (1985) describe how regional coefficients can be estimated as input percentages of national technical coefficients - $R = PA$ - where P is a diagonal matrix of sector regional purchase percentages. Similarly, import coefficients can be estimated as $T = (I - P)A$. In other words, each sector in the region that uses output from sector j as an input in its own production process is assumed to import an identical percentage of sector j's products from outside the region.

$$a_{ij} = r_{ij} + t_{ij} \tag{21}$$

In matrix notation:

$$A = R + T \tag{22}$$

Using these new trade coefficients, the regional equivalents of equations 19 and 20 are:

$$X = RX + TX + C + G + K + E \tag{23}$$

and,

$$X = RX + TX + L + N + M \tag{24}$$

where:

X = vector of total regional output by sector;

R = matrix of regional input coefficients;

T = matrix of non-regional input coefficients (trade coef.);

C = vector of regional household consumption by sector;

G = vector of government expenditure within the region by sector;

K = vector of regional investment by sector;

E = vector of area exports;

L = vector of payments to regional labour (households) by sector;

N = vector of payments for primary inputs by sector;

M = vector of area imports by sector (including intermediate goods and services).

Since the importation of intermediate goods does not lead to any local economic spin-off benefits, they are combined with other imports:

TABLE 2.10 THE REGIONAL INPUT-OUTPUT TABLE

Revenue / Expenditures	Regional producing sectors	Final demand	Total reg'l sales
Regional producing sectors	$r_{11}X_1 \cdots r_{1n}X_n$ $\vdots \quad r_{ij}X_j \quad \vdots$ $r_{n1}X_n \cdots r_{nn}X_n$	$C_1 \quad G_1 \quad K_1 \quad E_1'$ $\vdots \quad \vdots \quad \vdots \quad \vdots$ $C_n \quad G_n \quad K_n \quad E_n'$	X_1 $\vdots$ X_n
Primary inputs	$L_1 \cdots L_n$ $N_1 \cdots N_n$ $M_1' \cdots M_n'$		
Total regional expenditures	$X_1 \cdots X_n$		X_{total}

$$X = RX + L + N + M' \tag{25}$$

where $M' = M + TX$ = vector of total imports. E' is similarly defined.

The regional I-O model is represented in Table 2.10.

2.3.4 Sectoral Multipliers

Sectoral multipliers can be used in a number of ways. Their most common application is to estimate how overall activity in a regional economy responds to changes in the final demand of the output of one local economic sector. These multiplier estimates are derived from equation 23 through a few simple steps of matrix algebra.[3] This regional total output equation is reproduced below:

$$X = RX + C + G + K + E' \quad (26)$$

Notice that the first two terms in the equation include the variable X, total regional output. The remaining four variables are the four main classes of final demand. The output multiplier relates how the term X responds to the last four terms. To determine this response, we must isolate X on the left hand side of the equation, thus representing it as a function of C, G, K, and E. This is achieved in the following three steps:

$$X - RX = C + G + K + E' \quad (27)$$

$$(I - R)X = C + G + K + E' \quad (28)$$

and,

$$X = (I - R)^{-1}(C + G + K + E') \quad (29)$$

where I is the identity matrix, a square matrix with ones in the diagonal and zeros in all other cells. The identity matrix is analogous to the number one in ordinary algebra.

In equation 29, X, total regional output by sector, is expressed as a function of final demand (C + G + K + E) by sector. They are related to one another by the term $(I - R)^{-1}$, the Leontief inverse matrix. While X is a vector of regional output by sector, $(I - R)^{-1}$ is a nxn matrix of

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[3] The regional expenditures counterpart to equation 23, namely equation 24, cannot be used to derive economic sectoral multipliers because multipliers relate total output (X_i or X_j) to final demand, not primary inputs.

coefficients which relate total regional output to total regional final demand.

The above equation represents an input-output model in which households are not treated as a local economic sector, but rather are included as a class of final demand. This type of I-O model is used to derive Type I output multipliers. The Type II output multiplier, on the other hand, is derived from an I-O model that treats households as a local economic sector which contributes to the spin-off effect. This I-O model is described by the following relation:

$$X = (I - R^*)^{-1}(G + K + E') \tag{30}$$

In the above equation, the household sector, C, has been included in the regional inter-industry transactions matrix, RX. R* is a new matrix of regional input coefficients with an added row and column representing the household sector.

The output multiplier for a particular sector j is derived by summing column j of the Leontief inverse matrix $(I-R)^1$. In summation notation:

$$O_j = \sum_{i=1}^{n} r_{ij} \tag{31}$$

where:

O_j = output multiplier for sector j;

r_{ij} = the corresponding cell entry of matrix $(I - R)^{-1}$.

The employment multiplier is derived (see Hushak, Ro, and Husain,

1983) through the expression:

$$E_j = [\sum_{i=1}^{n} (N_i/X_i)r_{ij}]/(N_j/X_j) \tag{32}$$

where:

E_j = employment multiplier for sector j;

N_i = employment in person-years for sector i;

N_j = employment in person-years for sector j;

X_i, X_j = total output in sector i and j respectively;

r_{ij} = the corresponding cell entry of the matrix $(I - R)^{-1}$.

Similarly, the income multiplier is derived through the expression:

$$S_j = [\sum_{i=1}^{n} (U_i/X_i)r_{ij}]/(U_j/X_j) \tag{33}$$

where:

S_j = income multiplier for sector j;

U_i, U_j = incomes of sectors i and j respectively;

X_i, X_j, and r_{ij} are as defined above.

2.4 Model Assumptions and Limitations

In the preceding section, the I-O model is shown to be an application of linear, or matrix, algebra. The I-O model is a set of linear equations representing; (a) output by sector (the first n rows) and (b) total regional primary inputs (the remaining rows). The multipliers are derived by calculating the inverse of the technical coefficients sub-matrix through the use of matrix algebra. Since the I-O model is based on matrix algebra, it is subject to a number of important assumptions.

The most fundamental of these assumptions is that all economic sectors operate according to a fixed coefficients production function. That is, each sector is faced with constant input/output ratios which are expressed as fixed technical coefficients in the direct requirements matrix. In economic terms, it is assumed that each sector has a single, linearly homogeneous production function.

In more simple terms, for a firm with fixed input/output ratios to double its output, it must double each of its inputs. Under these conditions, firms are said to be subject to constant returns to scale. However, most industries are able to adopt new methods of production in response to new technological advancements, changes in prices, input constraints or new levels of demand leading to different configurations of optimal production. Therefore, I-O analysis is applicable only to short-run situations. In order to appropriately address medium-term responses, a new transactions table reflecting changes in the methods of production would have to be constructed.

A related assumption is that of constant relative prices of inputs and outputs. The transactions table represents values of inputs and outputs rather than quantities. When prices vary, both households and businesses tend to vary their buying patterns through input substitution. Thus, for the technical coefficients to be representative of the economy, both prices and the input/output ratios must be held constant (or prices must all change by the same proportion). Periods of severely fluctuating price regimes will reduce the predictive power of this type of economic model.

Regional I-O models are also structured around trading coefficients rather than strictly around technical coefficients. Each sector imports a portion of the intermediate inputs it purchases from every other sector. Consequently, an additional assumption of regional models is that of fixed trading coefficients. For example, if, on average, a local economic sector currently imports (from outside of the region) fifteen percent of its inputs from some other economic sector, it is assumed that the sector will continue to import fifteen percent of its inputs from this other sector no matter what changes in production levels occur. Just as with the assumption of fixed technical coefficients, this assumption can only realistically hold over the short-term.

A fourth assumption is that each sector is homogeneous - that the input requirements are generally the same for each of the products of a particular industry or economic sector. This is to help ensure that the sector has a fairly homogeneous, or even, production function. This, in turn, will help to ensure that the technical and trading coefficients of any given economic sector are representative of all the firms grouped within that sector.

A fifth assumption requires that the household sector have a fixed consumption pattern. This is essentially the same as the first assumption, that of fixed input/output ratios, but is applied to the household economic sector rather than a 'producing' sector. It states that households, as a group, will spend extra income in the same manner as their previous average household consumption pattern. In economic terms, the household's marginal expenditure profile is assumed to be equal to its average expenditure profile.

For a single household, this is obviously not very plausible.

Households demonstrate markedly different expenditure profiles at different levels of income. As a household's income increases, a smaller percentage of the budget will be spent on necessity goods, such as food and housing, and more on luxury goods, such as entertainment and furniture.

However, in many situations, the overall marginal expenditure profile of the household sector may not be appreciably different than the average profile. As an industry expands, it usually hires a broad range of people at different stages in their own life cycles. In many instances, it is reasonable to assume that the expenditure pattern of this new group is similar to that of the community at large.

The final assumption is that each producing sector has a fixed labour/output ratio. This simplifying assumption must be made in order to estimate the employment effects of changes in output as represented by the employment multiplier.

In addition to these stringent assumptions, the I-O model is also subject to a number of more general limitations. One limitation involves its treatment of supply and demand.

Some economists sugggest that the multipliers calculated through I-O analysis are misleading. The reason for this is that I-O analysis only considers the demand side and ignores the supply side of the story. The I-O model is demand driven; the economic multipliers are calculated as a spin-off effect of final demand for goods and services. In the case of a contraction in a local industry, multipliers indicate how much total regional output, employment, and income will decrease. However, economists note that supply-side forces will help to reduce the muliplier effect of a contraction in an industry. Their argument is that the resources made available from failing industries will 'fuel' an expansion in other, more competitive industries. The void left by the contraction of one industry will be filled as a matter of course by some other, more aggressive industry.

This criticism of I-O analysis is more valid for large study areas that have a strongly diversified economic base. Small, regional economies, however, are often highly dependent on one or two economic sectors. If these 'pillars' of the local economy should falter, new growth opportunities may be slow to materialize.

Another important consideration is that impact analysis based upon an input-output model only describes an equilibrium situation: that is, it usually does not take into account the time dimension. With impact analysis, we begin with a model of an economy in equilibrium where supply is equal to demand. The analysis then describes a new equilibrium point arrived at after some flux or change in the final demand for regional production. It does not indicate how the economy would move from one equilibrium point to another. This type of economic analysis is common and is generally referred to as comparative statistics.

In summary, the assumptions required of an I-O model are:

1. fixed coefficient production functions (constant input to output ratios;
2. constant relative prices of inputs and outputs;
3. constant trading coefficients;
4. production of homogeneous output by each sector;
5. constant household expenditure patterns; and
6. constant labour/output ratios.

3.0 Input-Output Analysis - Issues, Techniques, Developments

Input-output analysis, over the last forty-five years, has been intently studied and widely applied. In this section, a general review is undertaken of the many aspects of this economic impact assessment model. In section 3.1, three widely used alternate model formats are presented. In section 3.2, a number of important model adaptations are reviewed. Several technical considerations of I-O analysis are reviewed in section 3.3. And finally, a number of case studies of input-output model construction and application are reviewed in section 3.4.

3.1 Alternate Model Formats

The principles and interpretation of I-O analysis were outlined in detail in section 2. The most basic of I-O model formats, the 'square' transactions matrix applied to a single region, was used as the basis of the discussion. However, several alternate model formats have become increasingly popular. These are outlined below.

3.1.1 Rectangular Input-Output Model

The square I-O model begins with a transactions matrix which has four quadrants. These were illustrated in the hypothetical I-O transactions matrix (Table 2.3). They are represented more schematically in Table 3.1.

Quadrant I reveals the inter-industry transactions. An identical list of industries, or economic sectors, is displayed across the top and left-hand sides resulting in a 'square' quadrant. A consequence of this format is that each economic sector is assumed to produce a single

TABLE 3.1 SQUARE INPUT-OUTPUT TRANSACTIONS TABLE

	Economic Sector A B	Final Demand	Total Output
Economic Sector A B	I	II	
Value-Added	III	IV	
Total Inputs			

commodity; that no secondary production occurs. For example, the dairy sector is assumed to produce only milk. Furthermore, each enterprise is assigned to an economic sector "according to the output ... which comprises the primary source of revenue" (Miller and Blair, 1985, p. 153). This can introduce a considerable degree of inaccuracy into an I-O impact analysis.

An alternate format which is now adopted by most projects is the 'rectangular' I-O model. It is also known as the commodity-industry format. The main advantage of this format is that it more accurately accounts for secondary production. Rather than accounting for industry transactions in a single table, this format establishes two sets of accounts representing the flow of commodities to and from industries. For example, the dairy sector could produce both milk and forage. Furthermore, milk could itself be broken down into more than one commodity; for instance, low-fat and fat-rich milk. The advantages of the rectangular format over the square format were summarized by Lal (1982, p. 411): (i) it admits as much detail as is available in the basic economic records, (ii) the meaning of each entry is straightforward because observed transactions are not combined with ficticious transfers, a common adjustment procedure of the square format, and (iii) it provides a statistical audit of the consistancy, integrity, and comprehensiveness of economic statistics.

A hypothetical rectangular transactions table is provided in Table 3.2. The rectangular transactions table has two matrices which represent inter-industry flows; the make matrix (V) and the use matrix (U). V represents the amount of commodity j produced by industry i while U represents the amount of commodity i used by industry j. Both of these matrices are rectangular, with opposite dimensions. The final demand and value added vectors (E and W) have the same conceptual meaning as in the

TABLE 3.2 RECTANGULAR INPUT-OUTPUT TRANSACTIONS TABLE

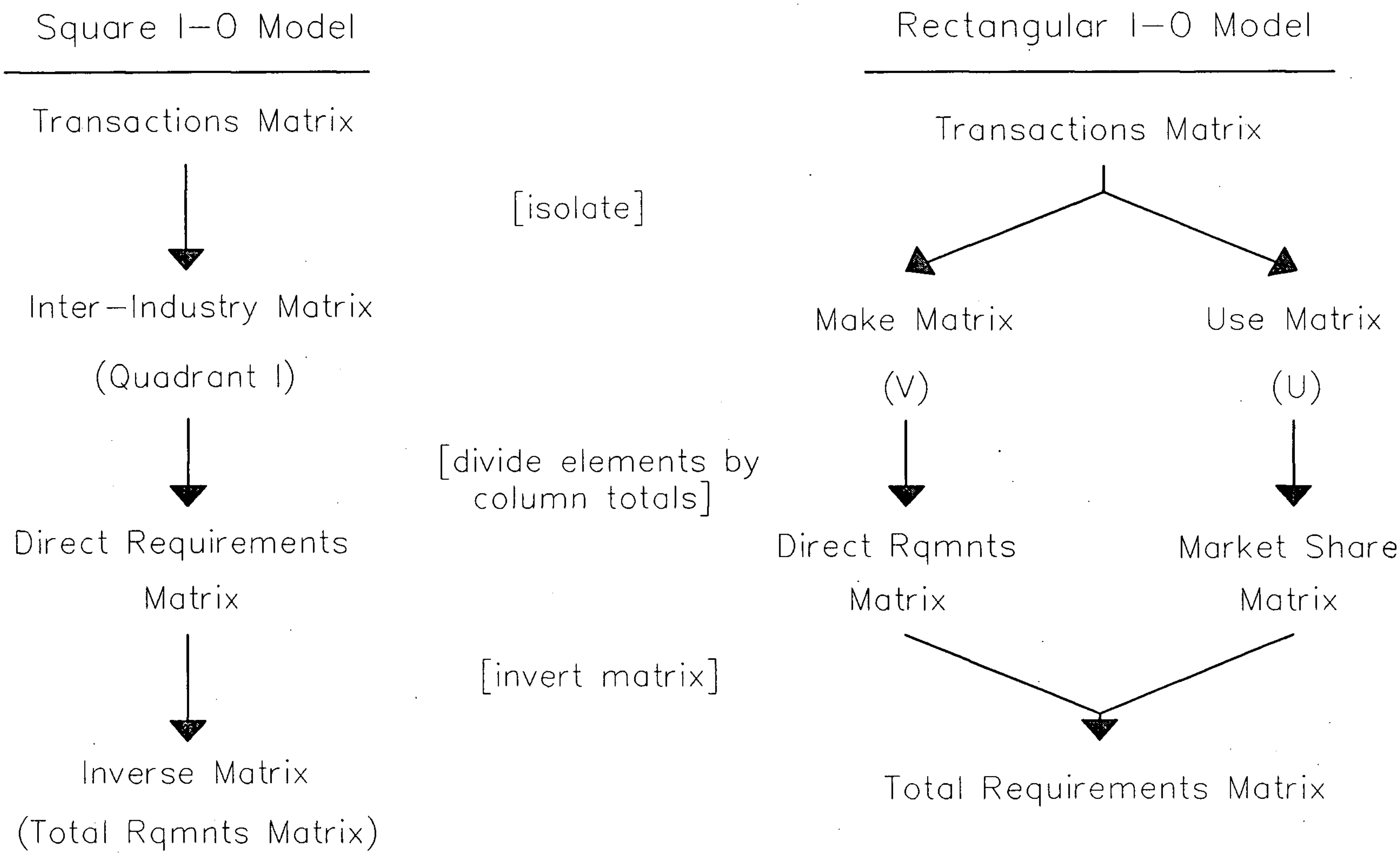
	Commodities A	Commodities B	Industries A	Industries B	Final Demand	Total Output
Commodities			U		E	Q
A			10	10	80	100
B			10	7	83	100
Industries	V					X
A	90	0				90
B	10	100				110
Value-Added			W 70	93	163	
Total Inputs	Q' 100	100	X' 90	110		200

square I-0 model. W has the same definition as the components in quadrant III of the square I-0 matrix; it represents industry value added inputs. The final demand vector, E, is synonomous with quadrant II; however, is defined in different terms. It represents the commodity deliveries to final demand rather than industry deliveries.

The general procedure used to calculate the economic multipliers is the same for the rectangular I-0 model as for the square I-0 model (see Statistics Canada, 1979; Miller and Blair, 1983; DiPietre, Walker, and Martella, 1980). The difference is that two inter-industry matrices are mathematically manipulated rather than just one. This is illustrated in Figure 1. It is a flow chart of the multiplier calculation process for the two I-0 models.

With both approaches, the process begins with the regional accounts represented by the transactions matrix. You will recall (section 2.2) that the first step using the square I-0 modal was to isolate the inter-industry matrix which is a component of the transactions matrix (quadrant I). A direct requirements matrix is then calculated by dividing all of the elements of the matrix by the column totals (which includes value added and imports). Finally, the inverse of this matrix is calculated, of which the column totals are the industry output multipliers. With the rectangular model, two sub-components are isolated: the make matrix and the use matrix. Both matices are manipulated as with the square model - the elements of the matrices are divided by their column totals. (The column totals for the use table manipulation includes value added - W). While both of these matrices are rectangular, they have the opposite dimensions. Therefore, they can be multiplied together to obtain a square matrix, which can be inverted using matrix algebra to

FIGURE 1 CALCULATION PROCESS FOR SQUARE AND RECTANGULAR INPUT–OUTPUT MODELS



arrive at the total requirements matrix. The industry output multipliers, which are the respective column totals, are equivalent to those calculated using the square model.

The mathematical steps followed to calculate these industry output multipliers are only a little more involved than with the square model. Equation 26 describes total regional industrial output:

$$X = RX + C + G + K + E' \tag{26}$$

Through matrix algebra, this was rearranged as equation 30:

$$X = (I - R)^{-1}(C + G + K + E') \tag{30}$$

The analogous group of equations with the rectangular model for equation 26 are:

$$Q = BX + C + G + K + E' \tag{34}$$

and,

$$X = DQ \tag{35}$$

where:

- Q = (mx1) vector of total regional commodity output;
- B = (mxn) matrix of regional commodity-by-industry technical coefficients - the direct requirements matrix;
- X = (nx1) vector of total regional industry output;
- D = (nxm) matrix of commodity output coefficients - the market share matrix.

Final demand is represented by the vectors C, G, K, and E', which are as defined in section 2.3. Also, m represents the number of commodities identified by the model and n represents the number of industries.

An intermediate step is required before the industry-by-commodity total requirements matrix can be calculated, from which the industry output multipliers are derived. This step is to calculate the commodity-by-commodity total requirements matrix. Equation 35 is substituted into equation 34, and then rearranged through matrix algebra:

$$Q = (I - BD)^{-1}(C + G + K + E') \qquad (36)$$

By multiplying B, a mxn matrix, with D, a nxm matrix, we obtain a mxm matrix, a requirement for the matrix operation known as inversion (synomnomous with the the ordinary algebraic operation division, and represented by the raised term -1). The term $(I - BD)^{-1}$ is the commodity-by-commodity total requirements matrix. The column totals are the commodity output multipliers.

Substituting equation 35 into equation 36 yields:

$$X = [D(I - BD)^{-1}](C + G + K + E') \qquad (37)$$

The term $D(I - BD)^{-1}$ is the industry-by-commodity total requirements matrix from which the industry output multipliers are derived. It is the equivalent of the total requirements matrix $(I - R)^{-1}$ derived in section 2.2 for the square I-O model.[4]

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4 This process results in industry output multipliers. It is based on the assumption of an industry-based technology. A similar process could be used based on a commodity-based technology.

3.1.2 Inter-Regional Model

The single region model, whether using the square or rectangular format, provides a good representation of the local economy; however, it does not address the interconnections between regions. As an illustration, suppose the final demand for a meat packing plant in region L is stimulated via an increase in export contracts. This will result in increased livestock production within the region as well as within a neighbouring region M. An input to the livestock sector is feed rations. If region L is a major supplier of feed rations to both regions, then that sector will experience an increase in demand for its products from both regions, not just region L. Single region models ignore the multiplier effect of the feedback described above. Therefore, the economic multipliers themselves are biased downwards. This bias will be most pronounced for I-O studies of large regions with significantly diverse industrial bases. Small regions will usually not experience a significant feedback effect because the small number of trade oriented economic sectors that dominate these regions typically will not have any circular input production links back into the region. National I-O models similarly may not be overly biased since international trade is relatively small compared to total production.

To address this limitation, I-O models were developed which incorporate feedback effects. This section reviews one example, the inter-regional I-O (IRIO) model (see Miller and Blair; 1983, 1985). It was first described by Isard (1951). As can be expected, the IRIO model requires a large amount of detailed data. For this reason, it is not as common.

In order to describe the characteristics of the IRIO model, a more detailed equation notation than used in previous sections is required. The primary terms for I-O matrices and vectors will be identical to those used in section 2.3.2 describing a national economy. However, to document regional matrices, superscripts are used rather than new terms. To begin with, the equivalent to equation 14 is reproduced below. It defines national technical coefficients.

$$a_{ij} = z_{ij}/X_j \tag{38}$$

It describes the amount of inputs required from sector i to produce a dollar's worth of output from sector j.

Through detailed survey work, it would be possible to derive a specific set of regional input coefficients:

$$a_{ij}^{LL} = z_{ij}^{LL}/X_j^L \tag{39}$$

The term a_{ij}^{LL} is synononous to r_{ij} described in section 2.3.3. It is the amount of sector i's output in region L that is used to produce a dollar's worth of output from sector j in region L.

Likewise, t_{ij} is alternately represented as:

$$a_{ij}^{ML} = z_{ij}^{ML}/X_j^L \tag{40}$$

It represents the amount of sector i's output in region M (e.g. the rest of the nation) that is used to produce a dollar's worth of output from sector j in region L. Since this notation is cumbersome, the subscripts are deleted from subsequent equations. Keep in mind that each term/coefficient represents a flow of goods from sector i to sector j.

Using this notation, the regional total demands equation (30) would be given by:

$$X^L = (I - A^{LL})^{-1}Y \tag{41}$$

where Y is equal to (C + G + K + E')

With the IRIO model, three additional trade coefficient matrices must be derived; A^{LM}, A^{ML}, and A^{MM}. To get an idea as to how they relate, a complete coefficient matrix for a two region inter-regional model can be represented as:

$$A = \begin{bmatrix} A^{LL} & A^{LM} \\ A^{ML} & A^{MM} \end{bmatrix} \tag{42}$$

This multi-regional technical coefficients matrix is interpreted the same as a single region matrix - columns represent expenditures by industry j. However, each industry is represented twice in the matrix; first in region L and then in region M. In a single region model, inputs from region M would constitute imports.

Instead of a single total demand equation as in the single region model (equation 28), the IRIO model yields two equations:

$$(I - A^{LL})X^L - A^{LM}X^M = Y^L \tag{43}$$

and,

$$-A^{ML}X^L + (I - A^{MM})X^M = Y^M$$

If we are examining a change in final damand only in region L, then we can let Y^M equal to zero (no change in the final demand vector for region M). Substituting the second part of equation 42 into the first part yields:

$$(I - A^{LL})X^L - A^{LM}(I - A^{MM})^{-1}A^{ML}X^L = Y^L \quad (44)$$

Solving for X^L results in:

$$X^L = [(I - A^{LL}) - A^{LM}(I - A^{MM})^{-1}A^{ML}]^{-1}Y^L \quad (45)$$

The term in front of Y^L is the total requirements matrix which reveals the overall multiplier effect. The component $(I - A^{LL})^{-1}$ describes the regional multiplier effect as revealed in single region models. The component $(A^{LM}(I - A^{MM})^{-1}A^{ML})^{-1}$ represents the complex feedback effect. Notice that the feedback effect is not determined only by the regional trade coefficient matrices A^{LM} and A^{ML}, but also by the regional input coefficient matix of the other region as represented by the Leontief inverse $(I - A^{MM})^{-1}$.

3.1.3 Multi-Regional Model

The IRIO model, though illuminating, requires more data than is available in all but a few cases. Researchers therefore have developed an alternate format which is less data demanding. It is known as the multi-regional input-output (MRIO) model. It was first proposed by Chenery in 1953 and Moses in 1955. A particularly ambitious application of this model is the U.S. MRIO project directed by Polenske (e.g. 1980).

The model consists of 51 regions (50 states and Washington, D.C.) and 79 economic sectors.

The primary difference between the IRIO and the MRIO models is that the latter is based on regional technical coefficients rather than regional input coefficients. Regional input coefficients were described in equations 39 and 40. They identify in a single step the specific production functions (e.g. input ratios) of a region as well as from which region the inputs are purchased. The MRIO model estimates the same information but does so in two steps.

First, the regional technical coefficients are determined. They are represented by:

$$a^{\cdot L} = z^{\cdot L}/X^{L} \tag{46}$$

They identify the product input mix of sector j regardless of the region of origin of the inputs. The superscript dot signifies 'any' region. Thus, $a^{\cdot L}$ is the amount of inputs required from sector i in any region to produce a dollar's worth of output from sector j in region L. Regional technical coefficients are often estimated as weighted averages of national coefficients. Coefficients from highly disaggregated national I-O tables are assigned to specific regional sub-sectors. They are then aggregated somewhat through weighted averages based on value of local production.

The second step is to estimate regional trade coefficients. Not all possible combinations of trade between economic sectors in all regions are estimated. Only the total trade flows (C_i^{kM}) of product i from all regions into region M, regardless of destination sector, are estimated.

They simply represent the proportion of sector j's inputs of sector i's production which comes from each of the regions. In other words, each sector j in region M is assumed to import the same proportion of good i from any particular region. Miller and Blair (1985, pp. 74-75) provide an example based on two regions and two economic sectors. Four matrices would need to be estimated:

$$A^L = \begin{bmatrix} a_{11}^{.L} & a_{12}^{.L} \\ a_{21}^{.L} & a_{22}^{.L} \end{bmatrix} \qquad A^M = \begin{bmatrix} a_{11}^{.M} & a_{12}^{.M} \\ a_{21}^{.M} & a_{22}^{.M} \end{bmatrix} \tag{47}$$

$$C^{LM} = \begin{bmatrix} c_1^{LM} & 0 \\ 0 & c_2^{LM} \end{bmatrix} \qquad C^{MM} = \begin{bmatrix} c_1^{MM} & 0 \\ 0 & c_2^{MM} \end{bmatrix}$$

Regional input matrices are then obtained by premultiplying the regional technical coefficients matrices with the respective regional trade coefficients:

$$C^{LM}A^M = \begin{bmatrix} c_1^{LM}a_{11}^{.M} & c_1^{LM}a_{12}^{.M} \\ c_2^{LM}a_{21}^{.M} & c_2^{LM}a_{22}^{.M} \end{bmatrix} \qquad C^{MM}A^M = \begin{bmatrix} c_1^{MM}a_{11}^{.M} & c_1^{MM}a_{12}^{.M} \\ c_2^{MM}a_{21}^{.M} & c_2^{MM}a_{22}^{.M} \end{bmatrix} \tag{48}$$

The total requirement matices, from which the impact multipliers are calculated, are then derived using matrix algebra in a similar fasion as with the IRIO model.

The main difference, then, between the IRIO and MRIO models is that the IRIO model uses trade flow data specific to every sector in every region whereas the MRIO model uses the same inter-regional trade flow (import) percentages for every sector within any given region. This is evident in identical trade flow proportions for each of the four row pairs above (e.g. matrix 1, row 1: $c_1^{LM}a_{11}^{\cdot M}$ and $c_1^{LM}a_{12}^{\cdot M}$). Another primary difference between them is that the IRIO model requires detailed data that can only be obtained through extensive surveys while the MRIO model can utilize various data estimates, such as weighted averages of national technical coefficients matrices for regional equivalents, and any of many proxy methods used by economists to estimate trade flows.

It is also important to note that the standard multiplier calculation applied to the IRIO and MRIO models produces regionally-specific multiplier estimates which are not directly comparable (Miller and Blair, 1983). The reason is that the final demand estimates of the two models are defined differently. "In the MRIO model the new final demands are destination specific; in the IRIO model and the national and single region intra-regional models, the new final demands are origin-specific." (p. 238) A simple adjustment is shown which will bring the two multiplier estimates into common terms.

3.2 Model Adaptations

In previous sections, the basic I-O model formats were described. They included the square and rectangular matrix formats, and the single and multi-regional formats. Each of these (paired) formats require large amounts of data which are not all available through standard census surveys. To construct an I-O table, extensive survey work is required to fill in the numerous gaps. While a demanding task at the national level, it is even more formidable at the regional level. Consequently, considerable research has been extended to devise short-cut methods of I-O model construction.

These short-cut methods are grouped under the generic term 'non-survey techniques of I-O model construction'. Though grouped together, they actually include a wide range of techniques, or model adaptations. As well, though the 'survey' and 'non-survey' techniques are differentiated in name, in reality most I-O tables, regional and national, are constructed using both types of data. As Round (1983, p. 190) points out, "... in practice virtually all input-output tables are hybrid tables constructed by semi-survey techniques, employing primary and secondary sources to a greater or lesser extent. Therefore, there can be few regional I-O tables, if any, that have not relied to some extent on the use of indicators, ad hoc judgement, or some form of data smoothing technique." Several of the more common non-survey techniques are reviewed in sections 3.2.1 through 3.2.5.

In addition to non-survey techniques of model construction, other types of model adaptation have occured. One group is primarily concerned with the application of I-O analysis. Specific examples include the use of specially constructed I-O tables to assess the effects of economic development on resource use and environmental pollution. These types of adaptations are briefly reviewed in section 3.2.6.

3.2.1 Regional Models Adapted from National Models

One class of non-survey techniques of I-O model construction involves the adjustment of national transactions tables to reflect regional production and trade characteristics. Many reviews have been conducted of these model adaptations (Schaffer and Chu, 1969; Morris and Smith, 1974; Miernyk, 1976; Round, 1983). They consist of three main groups; a) commodity-balance or supply-demand pool techniques,

b) location-quotient techniques, and c) iterative simulation techniques. Each of these groups involve techniques which "... can be reduced to simple mechanical routines; they are easily programmed and use minimum supplemental data." (Schaffer and Chu, 1969, p. 83) "The fundamental assumption in all of these nonsurvey methods is that the national technical input requirements hold true at the regional level." (Eskelinen and Suorsa, 1980, p. 262) In addition to these three well-established groups is the more recent approach by Stevens et al. (1983), which is described as a delivered cost technique. The following review is brief: for a more detailed description, refer to the above cited reviews, especially Schaffer and Chu.

Commodity-Balance Techniques

Round (1983) reports that the earliest attempts to "circumvent" the need for full surveys involved commodity-balance approaches. One such approach is the supply-demand pool technique. Beginning with a national transactions table and estimates of regional production and final demand by sector, the technique provides an estimate of a regional transactions table. Regional technical coefficients and final demand coefficients are calculated as follows:

$$r_{ij} = x_j A_{ij} \tag{49}$$

and,

$$c_{if} = (y_f / Y_f) Y_{if} \tag{50}$$

where lower case letters represent regional variables and upper case national.

Next, the regional input coefficients are estimated.

> ... commodity balances for each industry i (are computed) as the difference between input requirements and locally produced supply... This pool procedure allocates local production, where adequate, to meet local needs; where the local output is inadequate, however, the procedure allocates to each purchasing industry j its share of regional output i, based on the needs of the purchasing industry itself relative to total needs for output i ($x_{ij} = x_i{*}r_{ij}/r_i$). (Schaffer and Chu, 1969, p. 90)

Location-Quotient Techniques

The next class of non-survey techniques which estimate regional transactions tables from national ones makes use of the location-quotient (LQ). LQs are used in economic base studies (see section 1.2.1) to assess the importance of exports to a region. They have been adapted in I-O studies to estimate regional trade coefficients. Many variations of LQ techniques have been developed. We will first review the simple location quotient (SLQ) as described by Schaffer and Chu (1969). We will then briefly list the distinguishing features of the purchases-only variation (POLQ) and the cross-industry variation (CILQ). Another variation assessed by Morrison and Smith is the logarithmic cross-quotient (RND).

Using I-O notation (rather than economic base notation), the SLQ is described as:

$$LQ_i = \frac{x_i/x}{X_i/X} \tag{51}$$

The quotient represents the relative importance of an industry in a region to its relative importance in the nation. When the quotient is equal to one, the region is self-sufficient with respect to industry i; that is, it has its "proper share" of production in that industry. A quotient of greater than one means that the region exports some of that industry's output. In this case, the regional input coefficient is assumed to be equal to national technical coefficient and regional inter-industry flows are:

$$x_{ij} = a_{ij}x_j = A_{ij}x_j \tag{52}$$

In other words, the regional trade coefficient is said to be zero. Exports are easily calculated as the difference between regional production and the sum of regional intermediate demand (x_{ij}) and regional final demand.

A quotient of less than one means the region imports some of its needs of industry i's output. Therefore the regional input and trade coefficients, and regional inter-industry flows are calculated as:

$$a_{ij} = LQ_iA_{ij} \tag{53}$$

$$t_{ij} = 1 - LQ_iA_{ij}$$

$$x_{ij} = a_{ij}x_j = LQ_iA_{ij}x_j$$

This procedure allocates the local sales of an industry producing insufficient output to meet local needs proportionally across all local purchasing industries. Imports are thus calculated as the difference between local needs and local production.

The POLQ approach was formulated by Tiebout (CONSAD, 1967) to help make the quotient better reflect local industry characteristics. His recommendation was that "... the summation of total output (or employment) used in the calculation of LQi should be confined to those sectors which makes purchases from sector j." (Morrison and Smith, 1974, p. 8) The CILQ approach, on the other hand, also takes into consideration the size of the purchasing industry; it compares the proportion of national output of selling industry i in the region to that of the purchasing industry j.

Iterative Techniques

Several techniques have been developed to project a new I-O table from an existing table through iterative programming techniques. One of the more popular techniques is know as the RAS method. It was first developed by Stone and Brown (1962) as a method of updating national I-O models. Specifically, it estimates an I-O table for year 1 based on an existing model for year 0 by adjusting each technical coefficient, a_{ij}, to reflect changes in technology between the two years.

> These changes are of the following three types: (1) changes in the relative levels of prices, (2) changes in the degree to which commodity i has uniformly been substituted for or replaced by other intermediate inputs (called the substitution effect), and (3) changes in the degree to which intermediate inputs have uniformly increased or decreased in weight in the fabrication of commodity j (called the fabrication effect). (McMenamin and Haring, 1974, p. 192)

McMenamin and Haring further point out that the method requires; (a) the coefficients of the base-year table, (b) the total gross output vector for Year 1, and (c) vectors of total intermediate inputs and total intermediate outputs for Year 1. Items b and c can be derived from a combination of census data and surveys, though the survey work would not have to be as detailed or extensive, and therefore costly, as with full survey I-O models.

An early adaptation of the RAS method was developed by Czamanski and Malizia (1969). This adaptation was specifically designed to estimate regional models from national ones. As with the original RAS method of Stone and Brown, this version concentrated on the adjustment of the inter-industry component of the transactions table. In general terms, the method "... simply adjusts individual, pre-assigned elements (A_{ij}) to conform with known constraints, which in this case are vectors of total intermediate sales and purchases within the region." (Round, 1983. p. 199) The equations used in the program are involved, therefore, they will not be reviewed here.

McMenamin and Haring developed an iterative I-O model estimation technique (H-M) which is similar to the RAS method. The main difference between the H-M and the RAS techniques is that the H-M approach uses estimates of total regional output as the constraints for the program rather than estimates of regional intermediate sales and purchases. That is, they "... adjust the entire matrix (including final demand and value added) by RAS to conform to known gross output and gross outlay vectors for the region." (Round, 1983, p. 200)

Other types of iterative model projection techniques include the RIOT simulator developed by Schaffer and Chu (1969), linear programming (LP) approaches, and methods which combine features of the RAS method and LP/QP procedures. The RIOT approach applies several location-quotient and commodity-balance techniques in an iterative procedure to redistribute local sales between cells of the inter-industry transactions matrix as necessary to best satisfy local needs. For a review of LP approaches, see Gould, Sampson, and Kulshreshtha (1983a). In a recent paper, Kaneko (1988) describes a technique which combines a biproportional projection (e.g. RAS) with quadratic programming adjustments.

Evaluation of Techniques

The three non-survey techniques of estimating regional I-O models from national tables described above have been extensively applied; however, their ability to accurately reflect regional characteristics has been seriously questioned. Several studies have evaluated these techniques in comparison to actual regional I-O tables. One of the first was by Scaffer and Chu (1969). Using a chi-square statistical test, they evaluated the column totals estimated by a basic LQ method, the CILQ method, and the pool technique (commodity-balance) against the survey based column totals of the 1963 Washington State I-O table aggregated to 23 economic sectors. The test suggested that only seven sector estimates of column totals could be accepted as statistically significant.[5] Nevertheless, they conclude that "... nonsurvey methods may prove useful supplements to survey studies." At the same time, they state that "... it seems, at the moment, there is still no acceptable substitute for a good survey-based study." (p. 96)

Morrison and Smith (1974) applied several statistical tests to eight different non-survey techniques (SLQ, POLQ, CILQ, modified CILQ,

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5 Many methods have been used to evaluate the accuracy of non-survey I-O estimates. Each have inherent constraints. For example, Round (1983, p. 202) claims that the chi-square test used by Schaffer and Chu is statistically invalid because the cell entries are not interpretable as frequencies as in a goodness of fit test.

logarithmic CILQ, modified logarithmic CILQ, supply-demand pool, and RAS). They found that the RAS method produced far superior simulations under each of the different tests. This is not suprising "... given the technique employs a certain amount of survey material." (p. 11) They also demonstrated that the the RAS method produced better multiplier estimates, between 1 and 6 percent of the survey-based estimates. Again, this is consistant with expectations since the other non-survey methods tend to maximize intra-regional flows, leading to high multiplier estimates.

Eskelinen and Soursa (1980) have demonstrated that non-survey methods of I-O model estimation need not always lead to over estimations of regional input coefficients (i.e., regional inter-industry trade flows). In isolated regions, the regional technical coefficients will vary even more from national counterparts as firms try to minimize transportation costs. In testing non-survey methods with the North Karelia I-O model, they demonstrated that the estimated cofficients varied significantly in both directions around the 'true' coefficients. They conclude that; "Each nonsurvey method under evaluation produces a very inaccurate description of the regional economy of North Karelia ... (however, they) do not systematically overestimate the local input use." (p. 266)

Several studies have concentrated evaluation on RAS techniques. One of the first was the paper by Czamanski and Malizia (1969). The mean percentage error of coefficients for seven different cases ranged from 39 to 80 percent. The best rating was only achieved after eight 'problem' sectors were deleted from the model. These sectors represented highly specialized regional industries, usually primary sectors, which demonstrate markedly different technologies from national averages.

Another noteworthy evaluation of iterative techniques was conducted by McMenamin and Haring (1974). One concern of theirs was that previous evaluations did not include the base model as a case to be evaluated (the naive model). Their principal conclusion was that none of the iterative methods, including the one they had developed, "... provide dramatic improvements in accuracy over the naive model." (p. 204) Furthermore, in terms of error comparisons, the H-M method was roughly comparable to the RAS method.

Despite evidence that suggests iterative techniques are not all that accurate, they are adopted in most recent non-survey applications of I-O model estimation or, more frequently, model updating. This concerns some I-O researchers. Miernyk has been especially critical. He observes that RAS methods have no special economic meaning; that they "... substitute computational tractability for economic logic." (1976, p. 48) He further suggests that; "It seems clear that the search for mechanical methods of projecting input-output coefficients has yet to produce useful results."

Delivery Cost Technique

An interesting adaptation of regional input coefficient (A^{LL}) estimation from a national model was proposed by Stevens et al. (1983). The main premise of the approach is that relative shipments of a good from within and from beyond a region should be a function of the relative delivered costs. Using notation adopted in section 3.1.2:

$$X^{LL}/X^{ML} = f1(P^{LL}/P^{ML}) \tag{54}$$

where X^{LL} is the amount of locally supplied goods, X^{ML} is the amount of imported goods, P^{LL} is the delivered cost of locally supplied goods, and P^{ML} the cost of imported goods. The objective was to derive from this general relationship an equation which could be estimated through regression analysis of secondary data.

Guided by neoclassical location and trade theory, they incorporated a number of explanatory variables, such as transportation costs per unit and distance between producers, in an attempt to derive an acceptable model. They eventually arrived at, after several stages, the conceptually satisfactory regional input coefficient equation:

$$A^{LL} = K(w^L/W^M)^{b1}(o^L/o^M)^{b2}(X^L/X^M)^{b3}(W/V)^{b4} \\ [(n^L/N^L)/(n^M/N^M)]^{b5}(A^L/A^M)^{b6} \tag{55}$$

where K is a constant, w is wages, o is other costs, X is total output, W/V is the weight/value ratio, n and N are the numbers of producers and users of the good, and A is the area of land, all defined in terms of the respective region or good.

A number of practical constraints prevented the estimation of equation 55. For instance, no regional data are readily available for 'other' relative costs such as capital. Therefore, Stevens et al. made use of proxies for the data deficient variables, with the new estimation equation taking the form:

$$A^{LL} = K(w^L/w^M)^{b1}(e^L/e^M)^{b2}[W^M/(e^L/w^M)]^{b3} \\ [(e^L/E^L)/(e^M/E^M)]^{b4}(A^L/A^M)^{b5} \tag{56}$$

where e is employment and E is total manufacturing employment. This equation was thus used to estimate regional technical coefficients for only manufacturing, agricultural, and mining sectors - a constant coefficient of .95 was arbitrarily set at for all other sectors.

Since the fourth term is the simple location quotient, equation 56 could be viewed as more of an embellished location-quotient technique rather than a new approach based on the cost of delivery. The only terms that directly reflect the cost of goods in a specific region are W and A. The other terms represent "...multiple proxies (which) had to be used" (Stevens et al., 1983, p. 278) because of constraints in data availability. Nevertheless, this approach may add to the theoretical foundation of the LQ technique. Stevens et al., however, suggest that the equation is more similar in concept to commodity-balance techniques.

The regression equation was tested against two survey based I-O models. They describe the results of the comparison as "not disappointing". The mean absolute relative difference (MARD) with the Washington State model was calculated at 2.11. Excluding a construction input sector because of definition difficulties between the two tables results in a MARD of 1.36. It is not explained how this compares with the performance of LQ techniques.

3.2.2 Hybrid Models

Another type of model adaptation, referred to as 'hybrid' in this text, involves the construction of non-standard formats. The basic objective is to reduce the data requirements by reducing the number of cells within the transactions matrix. With reduced data requirements, sufficient resources may become available to collect primary and secondary data (surveys, census statistics, etc.) for the remaining cells. Prominent contributions to this area of research are reviewed in chronological order.

An early example of hybrid models is provided by Williamson (1970). Three economic impact assessment models were constructed for a small south Texas region; i) a standard 12 x 12 I-O model, ii) a hybrid I-O model with dimensions of 6 x 12,[6] and iii) an economic base model. The multiplier results from the hybrid I-O and economic base models were then compared to those of the full I-O model. Two primary steps were required to estimate the hybrid model multipliers; first, the direct requirements were distributed among the six sectors, and, second, multipliers calculated from the aggregated 6 x 6 I-O model were applied to the broader group of 12 sectors. Williamson found that the hybrid model arrived at multiplier estimates that differentiated by only 0.2 percent from those of the full I-O table, and thus demonstrated tremendous promise.

A more detailed investigation into hybrid model construction was undertaken by Davis in 1976. He devised three alternate approaches to constructing rectangular industry-by-industry formats. The standard nxn transactions matrix is estimated by a nxm matrix. The data requirements for each approach are: i) total current purchases from each of the m sectors, and ii) total sales. As well, for each approach, estimates of direct requirements for the n sectors are obtained as:

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6 Though the hybrid model is rectangular in shape, it should not be confused with the rectangular commodity-by-industry model described in section 3.1.1. It is still an industry-by-industry model with aggregated selling sectors .

$$[\sum_{i=1}^{m} a_{ij}]\, y_i \qquad (j=1,\ldots,n) \tag{57}$$

The calculation of the indirect effect varies for each approach. They each involve the power series expansion of the Leontief inverse. Method 1 utilizes multiplier estimates of an mxm aggregated version of the rectangular, nxm model to estimate multipliers for the j economic sectors (as per Williamson, 1970). With methods 2 and 3, an iterative calculation procedure is conducted with the power series expansion of the nxm matrix. Inter-industry spending pattern ratios required in this expansion are assumed to equal unity with method 2. With method 3, these required ratios are drawn from another nxn I-O matrix.

Davis compared the results of these three approaches with actual nxn I-O models of Washington State, metropolitan Vancouver, and the City of Stockton, California. The percentage error ratings for the three approaches are listed in Table 3.3. Method 3, he concludes, achieves the least error; however, method 2 also rates very well. With either method, multiplier estimates can be achieved with much less onerous data requirements than with the full I-O model.

In a later study, Davis (1978) combines features of the rectangular matrix method (RMM) described above with the TAP approach proposed by Bonner and Fahle (1967). The main premise of the TAP approach is that some local sectors do not contribute much to the overall multiplier effect; that is, they have large import coefficients. Consequently, it is not as vital to collect inter-industry trade data for these sectors. Detailed inter-industry trade data are only collected for the n-m main economic sectors. In other words, the sales of the main n-m sectors to

TABLE 3.3 PERCENTAGE ERRORS OF THREE MULTIPLIER ESTIMATION METHODS PROPOSED BY DAVIS (1976)

Method No.	State of Washington	Metropolitan Vancouver	City of Stockton
1	19.0	6.0	12.4
2	5.9	1.7	1.0
3	3.3	1.2	0.6

Source: Davis, H.C. "Regional Sectoral Multipliers with Reduced Data Requirements." Inter. Reg. Sci. Rev., 1(2), Fall 1976.

all n sectors are recorded as well as the purchases of the main n-m sectors to all n sectors. Thus, only n^2-m^2 transactions data are required rather than the usual n^2.

By combining the principles of the RMM method with the TAP model, the last m rows (the minor sectors) are collapsed into a single row, thereby further reducing the data requirements. With the TAP-RMM model, only $n^2-nm+n-m$ transactions data are required.

The three methods (TAP, RMM, TAP-RMM) were tested against the metropolitan Vancouver I-O model. The RMM method achieved the lowest average percent error in multiplier estimation for the 18 sectors of the model (0.8). The TAP method had the highest average percent error at 2.4. The combined method, TAP-RMM, achieved marginally better results than the TAP method (2.0). Nevertheless, the greatly reduced data requirements of this method may increase its attractiveness to researchers.

3.2.3 Input-Output Type Multipliers with No Input-Output Table

The emphasis of the research described in the previous section was to develop hybrid I-O tables that require less data than full I-O tables. Though the size of the tables are reduced, an objective of the models is to estimate multipliers for each of the identified economic sectors. In this section, I-O model adaptations are reviewed that are designed to estimate multipliers for a select number of industries without constructing I-O tables. Multipliers could, of course, be derived for all of the economic sectors, but this is not envisioned as the main goal of these model adaptations. These models are best used to assess and compare the impact of two or more options for regional development.

An early short-cut approach was summarized by Nelson and Perrin (1978). This approach, they report, was independently proposed by Bromley (1972) and Salcedo (1972). Rather than calculating an economic multiplier from an I-O table, Salcedo estimates it from a fitted line relating multipliers (dependent variable) to a ratio of imported inter-industry inputs to total inter-industry inputs (independent variable). The X axis ranges from zero to one. When the ratio of imported inputs to total inputs is equal to unity, the multiplier is also equal to unity (the direct effect is equal to unity; the indirect effect to zero). The Y intercept, representing zero imports of inter-industry commodities, is estimated from secondary sources. A line (constant slope) is plotted between these two points.

The Salcedo fitted line was tested against three I-O models; two representing the Texas economy at different periods (1967 and 1972), and one representing the U.S. economy in 1967. A least squares estimated line of the I-O based multipliers were plotted along side the fitted line. The r^2 values for the three regression lines were .927, .925, and .81 respectively. A frequency analysis was then performed of the differences between the 'actual' multipliers calculated from the I-O table, the least squares estimated multipliers, and the Salcedo fitted multipliers. The Texas models varied the least from the two linear estimations. For instance, the least squares estimates of the 1972 Texas models were within .29 of the actual multipliers for 34 of 35 sectors, whereas the estimations from the fitted line were within this range for 32 of 35 sectors. Similar least squres estimates by Bromley were reported by Nelson and Perrin to lead to r^2 figures of between .82 and .9974 for regions of different sizes. They conclude that the fitted line demonstrated a close estimation of the least squares line, which itself was a quite reasonable estimation of I-O multipliers.

A pioneering effort in this direction was the procedure proposed by Drake (1976). The approach was later referred to as the regional industrial multiplier system, or RIMS (Latham and Montgomery, 1978). It is similar to the model proposed by Davis in the same journal volume. The three main multiplier components are identified; the initial change, the direct effects, and the indirect effects. As with all multiplier estimations, whether using a full table or a hybrid table, the initial change is by definition unity and the direct change is sum of the national/regional input coefficients derived for the industry in question. Drake estimates the regional input coefficients by selecting the appropriate national technical coefficients which are then "scaled down" by using a location quotient (see section 3.2.1). The principal feature of this approach is the estimation method for the indirect and induced components.

A chief premise of this method is that empirical regularities can be demonstrated between the direct effect and the total multiplier. Drake first demonstrates how the indirect effect for any industry can be estimated as a scalar product of its column sum of the direct effects matrix given the assumption that the covariance between column elements of the technical coefficients matrix (A) is close to zero. The scalar product is shown to be inversely related to the average of the direct effects over all regional sectors. He then demonstrates how this average of direct coefficient column sums can be estimated through regression analysis.

As with the Davis approach, the method is illustrated through the power series expansion of the Leontief inverse matrix:

$$\text{Lim } A^0 + A^1 + A^2 + \ldots + A^{n-1} = (I - A)^{-1} \tag{58}$$

The indirect effect is represented by the matrix:

$$\text{Lim } A^2 + A^3 + \ldots + A^{n-1} = B \tag{59}$$

In other words, the indirect effect for a specific industry is equal to the sum of n-2 matrix column totals. Drake notes that each column total is the sum of products (elements of the matrix), which can be represented "... as the sum of the values of one factor, times the average value of the other factor, plus a covariance term." (p. 3) He then demonstrates that if this covariance term is equal to zero, the column sum of each column in the matrix A^2 is equal to the average of the column sums, represented by the scalar s^2, times the respective column total of the direct effects matrix (A^1). When all of the n-2 indirect matrices are taken into account, the total indirect effect is expressed as:

$$b_j = (s^2 + s^3 + \ldots + s^{n-1})a_j = s^*a_j \tag{60}$$

> A critical assumption required for this linear, homogeneous relation between components of I-O multipliers to hold is that the sum of the covariance terms ... must equal zero. In general, nothing can be said about the size of this covariance except that it is likely to be small, because all of the numbers involved in an A matrix are less than one. (Drake, 1976, p. 4)

The scalar s* is referred to as the 'interdependancy coefficient', and is represented by the expression:

$$s^* = \frac{1}{1 - \sum_i \sum_j a_{ij}/n} - 1 \tag{61}$$

If no I-O table exists for the region, the above term must be estimated via "suitable proxies." (p. 5) Drake estimated s* through a regression analysis. The best results were from an equation which related s* to three variables; i) agricultural proportion of total non-governmental earnings, ii) manufacturing proportion of total non-governmental earnings, and iii) the size of the regional economy relative to the national economy.

Drake tested his regression based multipliers with those of six regional survey-based I-O models. About 20 percent of the estimated values fall within 5 percent of the survey value, and about 75 percent fall within 25 percent. Over half of this error is due to the estimation of the direct effect rather than the indirect. This is partly because the direct effect is larger relative to the indirect effect. Consequently, Drake suggests that refinements be designed to develop better direct effect estimates rather than do additional work on the procedure for estimating the indirect effect component.

Latham and Montgomery (1978) compared the multiplier estimates of the RIMS method with the SLQ method described in section 3.2.1. The differences between these two methods, they observe, are that; i) RIMS does not have to be performed for every industry in the economy, whereas the entire regional direct requirements matrix must be estimated to develop the SLQ multipliers, and ii) the SLQ procedures require the inversion of a matrix of significant size or other computer-dependent procedures. Their first conclusion is that both non-survey methods produce "very crude approximations of industry-specific output multipliers." (p. 6) Secondly, the RIMS method is shown to produce better multiplier estimates than the SLQ method, though only to a small degree. An important point against the RIMS method, however, is that the regression coefficients are based on the 1967 U.S. model and an assortment of regional models, therefore, are not applicable to future periods without modification.

3.2.4 Further Developments of the RIMS Method

The RIMS method has been investigated extensively since its original formulation by Drake, especially by Burford and Katz (1977; 1981; Katz and Burford, 1981a). In each of these articles, they provide a more detailed mathematical explanation of the formulation.[7]

While Drake estimated the scalar approximation s*, and thus the output multiplier, through regression analysis of existing I-O tables from other regions, Burford and Katz calculate the multiplier based on information supplied through an 'incomplete' I-O table for the region under study. Specifically, estimates are required of i) the proportion of an industry's purchases from within the region (i.e., its intra-regional inputs), and ii) the average intra-regional proportion of

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7 Burford and Katz suggest in their articles that they have furthered the initial work of Drake by "... introducing a formula that estimates output multipliers with only column total data." (1981, p. 152) This formula is represented by:

$$u_j = 1 + \frac{1}{1 - w} w_j \tag{62}$$

where $w = \Sigma\, \Sigma\, a_{ij}/n$ and $w_j = \Sigma\, a_{ij}$. However, this formula was all but explicitely stated by Drake (1976). He stated that industry j's output multiplier is expressed by three components; i) the initial effect which is equal to one, ii) the direct effect which is equal to the sum of column j of the direct coefficients matrix, and iii) the indirect effect which is "... related to the average of the direct-effect components." The specific relationship is described by the scalar:

$$s^* = \frac{1}{1 - \sum_i \sum_j a_{ij}/n} - 1 \tag{63}$$

Although not specified explicitly, the approximation of industry j's output multiplier is therefore:

$$u_j = 1 + \sum_i a_{ij} + \left(\frac{1}{1 - \sum_i \sum_j a_{ij}/n} - 1\right) \sum_i a_{ij} \tag{64}$$

The contribution of Burford and Katz was thus to simplify the above equation to the form represented in equation 67, an elementary exercise. It is unfortunate that this model is now referred to in the literature as the Burford and Katz method (Phibbs and Holsman, 1981; Harrigan, 1982; Round, 1983). In this paper, it will be referred to as the Drake method.

purchases of all industries within the region. Although this is substantially less information than required for a full I-O table, it is still a demanding task. While Burford and Katz describe the data requirements as "very limited" (1977, p. 21), Round describes them as "considerable" (1983, p. 208).

In a later study (Katz and Burford, 1981), they test two additional variations of the Drake method. The first requires the intra-regional proportion of sector j as well as the relative values of the I-O table row totals. This approach is similar to the Drake formulation. The second variation requires the column totals of the coefficients matrix and the specific inter-industry coefficients of industry j (i.e., each a_{ij} for column j).

Several empirical comparisons with survey-based I-O tables are provided. The average percentage error of the estimated multipliers is 3.51. Two of the 26 sectors had estimates which vary by more than 6 percent from their survey-based counterparts. The estimates of the Georgia I-O multipliers were even closer to the mark. The mean error was calculated as 0.68 percent. They also demonstrate, not surprisingly, that there is a direct relationship between the average column total and the average error. In testing the two variations described above with three State I-O models, they found that the first produced results very close to the original Drake formula (with errors in the range of 1.1 to 2.8 percent), but that the second produced better results (0.10 to 0.44 percent error). Though the second method produced better multiplier estimates, it requires a little more data.

Phibs and Holsman also have tested the Drake formulation. They selected seven regional I-O tables, mostly Australian, as the base cases.

The output multipliers estimates were encouraging, with the mean error ranging from -2.4 to 6.6 percent of the survey-based multipliers. The income multiplier extension described by Burford and Katz (1977), though, did not have as favourable results, with mean errors ranging from -2.3 to 10.2 percent. Though the errors are higher than those obtained by Burford and Katz, they may still be within a tolerable range.

An interesting observation has been made by Harrigan (1982). He noted that the Drake method documented by Burford and Katz is actually based on the assumption that all possible direct requirement matrices are equally likely, and therefore the expected value of each element of the matrix is equal to the column mean. This obviously does not reflect real situations as direct requirement matrices usually share a common structural shape, and always contain many elements which are equal to zero. To help alleviate the bias in the multiplier estimates caused by this assumption, he proposed another adaptation. The main feature of the proposal is that prior probabilities of the magnitude of technical coefficients based on existing I-O models are added to the multiplier estimation formulas. In their reply, Katz and Burford (1982) acknowledge the value of the Harrigan adaptation, but also note that a series of adaptations have been formulated, each assuming an increasing amount of information at the disposal of the researcher, and each demonstrating an increasing level of accuracy in the estimation of industry multipliers.

3.2.5 Non-Survey Methods for Multi-Regional Models

A primary criticism of the inter-regional input-output (IRIO) model is that it requires an exorbitant amount of survey data. Not surprisingly, therefore, efforts have ensued to introduce non-survey methods of model construction. Round (1978b, 1978a) provides a clear treatice of the use of LQ techniques (see section 3.2.1) to estimate regional input coefficients for the separate regions of the model.

Two main difficulties of the LQ technique are illustrated. Firstly, a LQ of greater than one for a region is taken to mean that the regional technical coefficient is equal to the national figure, and that the remainder is exported. Round (1978b) points out that; "...unlike the single region case, even though (LQ) values greater than one are not taken into account directly, they are accounted for indirectly through the incorporation of complementary (LQ) values for the other region." (p. 183)

The second difficulty of the LQ is that it does not account for cross-hauling between regions, which can arise in part from inefficiencies in the product market or aggregation of dissimilar products. This results in overestimation of intra-regional transactions. Round introduces a factoring procedure which accounts for cross-haulling.

3.2.6 Resource/Environmental Models

Leontief compiled the first I-O table specifically "...to explain the effects of technology change on the American economy." (1985, p. 28) The traditional use of the I-O model subsequently has been to describe the overall structure of a specific economy at a point in time, and to estimate the economic multiplier effects associated with exogenous changes to final demand. In addition to these basic economic formats, several non-economic adaptations have also been developed. One such adaptation is the use of I-O analysis to describe the relationship between economic development and resource use.

The specific formulations of economic-resource (E-R) models are beyond the scope of this study. The purpose here is rather to summarize the assessment objective and approach. The objective of E-R models is to describe the total resources required to deliver a product to final demand, both directly as the resources consumed by an industry's production process and indirectly as the resources embodied in that industry's inputs (Miller and Blair, 1985, p. 200). It is most often expressed as the quantity of a resource (e.g., gallons, BTU, etc.) required to deliver a dollar's worth of output from an economic sector.

Three basic approaches are adopted. The most simple approach (1) is to calculate a fixed ratio representing the quantity of resource required to produce a single dollar's worth of output for each economic sector. The resource multiplier is then calculated using a formula which relates resource use to output for each economic sector. An example is the employment multiplier expressed in equation 32.

The remaining two approaches each develop a separate resource I-O transactions table to accompany the economic I-O transactions table. The method by which resource use multipliers are derived is synonomous with that of the economic I-O model multipliers, though specific details vary. With approach 2, the most common, all inter-industry transactions are expressed in physical units.[8] Zeros are entered in the inter-industry matrix when the resource category being assessed is not traded between two economic sectors. Once the Leontief inverse matrix is derived, the resource multipliers can be calculated in the same fasion as the economic

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8 This type of E-R model is suited to resources which are traded, such as energy, and not to labour, since all sectors employ labour.

multipliers. This approach (2) is essentially the same as approach 1, except that a resource I-O model is explicitly constructed.

With approach 3, a hybrid resource transactions table is developed in association with the economic I-O model. Instead of having all cells within the matrix expressed in physical units, only rows of sectors which produce the resource as their primary economic product are expressed in physical units (e.g., energy) - the remaining rows relate the dollar transactions as expressed in the economic model. Once the total requirements matrix is calculated (through matrix inversion), the resource rows are extracted to isolate the total resource requirements matrix. Miller and Blair maintain that approach 2 has several inherent technical limitations (e.g., resource conversion conditions), and therefore approach 3 is most desirable.

A primary way in which resource multipliers are used is to compare the trade-offs that are incurred between economic growth and resource use. An example is the E-R model developed by Harris and Ching (1983) for a two county region in Nevada. The resource assessed is water. In addition to the usual impact multipliers (output, employment, income), the model estimates four types of water use multipliers; (i) total gallons required per gallon used in a specific industry, (ii) gallons consumed per dollar of final sales, (iii) gallons consumed per unit increase in household income by sector, and (iv) gallons consumed per unit increase in sector employment.

Gould and Kulshreshtha (1985) make use of an E-R model to evaluate the impacts of various export demand scenarios upon the Saskatchewan economy and the level of provincial resource use. The premise was that "...certain export development scenarios may increase regional growth at the expense of the conservation of resources ... Attempts to expand provincial exports should (therefore) be evaluated in a broad framework that takes into account the trade-offs of regional economic growth and resource use." (p. 128)

The resources identified in the model are labour, energy, and water. The input ratios of each resource by each sector were estimated through regression analysis using resource-production functions. The independent variables were the real value of gross output by sector and time. A resource multiplier matrix (i.e., a Leontief inverse matrix of resource use as per approach 2 above) was then generated using the technical resource use coefficients. The trade-offs between economic and resource use multiplier effects were then assessed by ranking five export scenarios in terms of economic growth and resource use.

Another example is the E-R model developed by Conrad and Henseler-Unger (1986) to assess the long-term impact of alternate technologies in the electricity industry on growth and price levels throughout the German economy. The model permitted the measurement of "...the overall economic effects of an energy policy that favors nuclear power or coal-fired power plants" (p. 542). The primary objectives of the project, though, were to extend the capabilities of dynamic I-O modeling, a level of I-O analysis which is not adressed in this text.[9] A dynamic macro-economic model estimates supply and demand shifts and their effect on

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9 Two objectives of the project were; (a) to estimate the parameters of the price funactions and input demand functions from a single I-O table, and (b) to determine the prices of capital and labor, and final demand levels endogenously instead of using a separate growth model as an engine for economic development.

prices. These models can thus take into account input substitution effects. The results of the exercise suggest that a policy framework which supports nuclear power could lead to a higher national GNP and lower price levels, but higher unemployment, than one which supports coal generated electricity.

The I-O framework can also be used to assess the effect of alternate economic development scenarios on regional pollution levels through the development of economic-environmental (E-E) models. The approach is akin to that of E-R models.[10] Technical (or direct impact) coefficients of pollution generated by economic activity are used in conjunction with an economic transactions table to determine the overall pollution levels associated with alternate economic development scenarios. An example application of an E-E model is the study by Pasurka (1984), which assesses the short-run impact of environmental protection costs on U.S. product prices. The model projects individual industry price increases to range between 0.12 and 6.58 percent. The weighted average price increase was estimated to be only 0.97 percent. Pasurka cautions that the assumptions involved in the I-O analysis reduce the reliability of the findings.

3.3 Technical Considerations

The preceding sections examined the different types of I-O formats which are in common usage. This section reviews several technical considerations important in the actual construction and operation of an I-O table.

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10 An excellent review of the most common approaches is provided in Miller and Blair (1985, pp. 236-65).

3.3.1 Aggregation

A major constraint to the implementation of I-O analysis is the massive data requirement. This is especially true at the regional level where trade data are less readily available. As shown in section 3.2, extensive research has been directed into model adaptations as a means of reducing data collection needs. A more direct way of making I-O analysis more economical is simply to reduce the number of distinct economic sectors described in the I-O model. This is achieved by combining related industries into more broadly defined sectors; that is, by constructing a more aggregated transactions table.[11] While less demanding of data, increasing the level of aggregation of an I-O model raises some concerns. Firstly, the structure of the economy is described in less detail. If the I-O model is constructed primarily for impact analysis of one or a few sectors, then this would not be a constraint. A more persistent concern is whether an aggregation bias is introduced.

Through the 1950s, numerous theoretical studies of aggregation concerns emerged (see Crown, 1987). Amongst the first empirical assessments were studies by Doeksen and Little (1968) and Hewings (1972). Doeksen and Little assessed the effect of severe aggregation on four I-O models, two hypothetical 25 sector models and two actual state I-O models, consisting of 27 and 29 sectors. Each model was reduced to four sectors by combining all but three into a single sector. In each case they noted very little effect on the regional output multipliers of the

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11 The model adaptation developed by Williamson (1970), as described in section 3.2, aggregated only the rows of the transactions table, and not the columns, resulting in a hybrid mxn matrix. The aggregation described in this section is equally applied to rows and columns.

three unaggregated sectors, with coefficients of variation ranging between 0.12 and 2.55 percent.

Hewings (1972) further substantiated this conclusion. However, he also demonstrated that an aggregation bias in the estimated total output of a single sector becomes apparent when the model is aggregated to less than ten sectors. Williamson (1972), though, points out that regional planners are primarily concerned with the overall effect on a region of a change in a single sector's final demand, and not with the overall change in output of a single sector given a specified change in final demand.

The above two studies investigated the effect of aggregation amongst sectors not subject to the impact assessment. Different results have, not surprisingly, been demonstrated when the sector subject to the impact assessment is itself aggregated with other sectors. Schaffer (1979) shows that "...even though the overall impact through standard multiplier analysis may be correct, the distribution of the impact to the various supplying industries may be substantially in error" (p. 2). The reason is the frequent lack of homogeneity in the trade patterns among the establishments or industries grouped within broad economic sectors. To test this notion, he surveyed three individual firms and combined this data with the Nova Scotia I-O model. The direct requirements information from the survey was inserted into the I-O matrix in place of the industry average coefficients. For two firms, the resulting impact assessment with the 32 sector model varied little from that of the original 64 sector model. However, for the third firm, the multiplier estimate changed dramatically when the 64 sector I-O model was aggregated to 32 sectors. The reason is that the firm was grouped together with a much larger sector which had a lower propensity to import. Care must therefore be taken when using the results from highly aggregated I-O models.

These results were further illustrated by Katz and Burford (1981b) using the 1967 I-O model of the U.S. The full model has 367 sectors while the condensed version has 81. They calculated the range of output multipliers demonstrated by the individual sectors which were combined into one broadly defined sector in the aggregated model. Twenty five of the 81 sectors of the aggregated version demonstrated an absolute range of component multipliers of over 0.5. They conclude that not only are these aggregated multipliers not a good representation of specific firms, but neither are the highly disaggregated models. To alleviate this problem, they expand upon Hewings' (1972) suggestion to include a separate row and column representing the transactions of a highly disaggregated industry or a specific firm. The algorithm they developed computes the output multiplier of the firm using only expenditure data (column data). In a trial, the aggregation error of 12.8 percent in the U.S. model was reduced to 3.2 percent in the new model for the identified industries.

In a more recent study, Crown (1987) presents a methodology for calculating consistent aggregate I-O multipliers. Researchers have shown that an aggregation bias will not occur if the aggregated industries have homogenous input structures. Crown's aggregation procedure allows the relaxation of this stringent assumption.

The level of aggregation of an I-O model is frequently determined by the reporting systems of national statistic agencies, such as the Standard Industrial Classification (SIC) of Canada and the U.S. Miller and Langley (1974) maintain that regional I-O studies constructed to fit the SIC usually do not achieve the optimal size because "...the four-digit level of the code provides too many sectors for a small model, and the two-digit code ... is so broad that it covers most of the rural agribusiness functions." (p. 450) To alleviate this problem, they suggest twelve agribusiness sectors formed by grouping four-digit sectors which "... produced a commonly recognized class of products and could generally be characterized as producing almost exclusively for farming or purchasing from farming."

A limitation of the economic sectors Miller and Langley suggested for rural area I-O models is that only one farm sector is delineated. Even highly disaggregated national I-O models rarely identify many primary agricultural sectors. The Canadian I-O model lists only one sector and 13 commodities. Since primary agricultural sectors vary substantially, and since an understanding of the distinct nature of different farm sectors is vital to rural development issues, more recent studies have specifically endeavoured to further disaggregate farm sectors.

Several Canadian examples deserve mention. The first is the agriculturally oriented I-O model of the Ontario economy (Ong, 1977). It is a square I-O model comprised of 89 economic sectors/commodities; 23 farm sectors, 16 food processing sectors, and the remainder non-agricultural sectors. The Prairie Farm Rehabilitation Administration (Kulshreshtha, S.N. and M.T. Yap, 1985), in constructing an I-O model for the prairies, also concentrated on disaggregating agricultural sectors, though not quite as extensively. Even though the model has a rectangular format, the list of agricultural producing and processing sectors closely resembles the list of primary and secondary agricultural products (see section 4.5.1). Finally, Agriculture Canada has recently completed an expansion of the national I-0 model. The disaggregation of the single agricultural sector to twelve 'farm types' increases the overall model size to 202 economic sectors by 595 commodities. The report by Thomassin and Andison (1987) provides a detailed review of the methods used to specify the most effective level of disaggregation of agricultural sectors. They clearly outline the process followed to establish the farm type expenditure patterns for the Use Matrix, and the farm type revenue patterns for the Make Matrix.

3.3.2 Data Collection

The agricultural sector can be disaggregated only to the extent that disaggregated data are available. Consequently, a number of texts have been published which emphasize data collection issues and techniques. Three most noteworthy examples are the books by MacMillan, Lu, and Framingham (1975); Morrison and Smith (1977); and Jensen, Mandeville, and Karunaratne (1979). The later book, essentially an I-0 model development manual, describes in detail an approach to constructing I-0 models using primary and secondary data sources where appropriate. The book combines 'top-down and bottom-up' approaches to the compilation of a regional transactions table.

Henry et al. (1981) also describe a data base collection and monitoring system that combines primary and secondary sources. The objective was to develop a cost-effective collection system for a uniform data base. This approach to combining primary and secondary data sources was usually implied in the non-survey I-0 model adaptations discussed in section 3.2, though details were rarely outlined.

The system has two main features; (1) State Tax Department files are used to determine overall sales and expenditures data by broad categories, and (2) field surveys are used to establish detailed transactions information between sectors and between regions. The field surveys recorded only percentage estimates of total sales and expenditures by sector and region, not absolute trade values. By asking for less confidential data, survey response rates can be dramatically improved. This also contributes to lower survey costs. Hewings (1983) further observes that studies have shown that cells within the transactions matrix with small values are less critical to the accuracy of the impact assessment than large cell values. Therefore, field surveys could concentrate on only large inter-industry transactions with further cost savings.[12]

An impressive review of data sources and collection issues and techniques is contained in the report by Thomassin and Andison (1987) concerning the disaggregation of the agricultural sector in the Canadian I-O model. They list the advantages and disadvantages of four primary sources of farm economic data; the Agriculture Census, the National Farm Survey, published series on farm receipts and expenditures, and taxfiler information. The method used to disaggregate the agriculture sector is then explained in detail. It involved both the simple allocation of

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12 Henry (1983) laments that while reduced detail in the I-O transactions tables may reduce costs, it also precludes a detailed analysis of regional economies other than simple impact analysis. However, he also erroneously suggests that the emphasis on transactions table cells with large values will undermine the ability of the regional I-O model to identify regional versus non-regional impacts.

expenditures and revenue from these data sources and the development of data proxies when data from all sources was insufficient in detail.

3.3.3 Reconciliation of Rows and Columns

Once piecemeal data are collected from the many disparate sources, they must be assembled into a complete transactions table representing all aspects of the subject economy. While Pleeter (1980, p. 35) notes that the reconciliation process of I-O analysis is not based upon any generally accepted procedures, research has provided a general framework of ground rules.

During the mid 1970s, Jensen and McGuarr (1976, p. 60) "...became concerned at the failure of the literature to disclose some fundamental methodological procedures..." necessary to I-O model construction. Of particular concern was the problem of deriving single-valued cell entries when two estimates of each cell have been estimated through 'sales' and 'purchases' surveys of economic sectors. The reconciliation procedure they adopted was designed to meet three conditions; (1) that the judgement of the analyst be incorporated in both an explicit and systematic manner, (2) that the use of methods which merely imply confidence in estimates be avoided, and (3) that the method be consistant with the logical and theoretical structure of I-O modelling. In mathematical terms, the problem was to derive the transactions matrix x_{ij} from a 'rows only' estimate matrix r_{ij} and a 'columns only' matrix c_{ij} such that $\sum_{j=1}^{n} x_{ij} = X_i$, $\sum_{i=1}^{n} x_{ij} = X_j$, and $X_i = X_j$ for $i = j$ given that $r_{ij} = c_{ij}$. The procedure involves two phases: (1) the calculation of initial estimates n_{ij} from r_{ij} and c_{ij} based on the subjective reliability weightings attached to each of the dual estimates, and (2) the treatment of n_{ij} by an appropriate technique to achieve consistency within the I-O table, and to obtain x_{ij}. The RAS technique was selected. Though a cumbersome process, the resulting estimate of the x_{ij} matrix may be more reliable than using only cost data (c_{ij}).

In a subsequent paper, Jensen and McGuarr (1977) compare the multiplier and output projections of reconciled and unreconciled tables. The reconciled tables are rows only and columns only tables while the reconciled tables are based on arithmetic means, geometric means, two types of weighted averages, and the Friedlander and RAS techniques. The Chi-square statistic was employed as a distance measure between sets of multipliers (the RAS estimates were used as the base). The rows only unreconciled table produced the worst results whereas the columns only table produced respectable results. The arithmetic and geometric mean reconciliation techniques produced similar results. The weighted average techniques tended to produce multipliers closer to the RAS multipliers. Though several types of comparisons were tabulated, the authors were unable to qualify the apparent level of 'accuracy' of the different approaches. The measures of error were generally low. When it is further considered that subjective assessments may actually improve the reliability of transactions tables - i.e., the assumption that the most technical adjustment method is the most reliable is not fully convincing - then the need for a mechanical adjustment technique becomes more questionable. This concern is also expressed by Miernyk (1976, p. 51); "If the differences between row and column sums are not large, it probably does no harm to reconcile by the RAS method, which can be accomplished easily and quickly. But if the differences are large, one should be wary of substituting computational tractability for economic logic."

Quantitative techniques are applied even more rigorously in Gerking's paper (1976b) on reconciling rows only and column only coefficients. The paper "describes a systematic reconciliation procedure based on the economic theory of estimating linear equations using instrumental variables." (p. 30) In other words, regression analysis is used to estimate regional I-O coefficients.

A concern of Gerking's is that most explanations of reconciliation methods consider the 'reliability' of coefficient estimates without adequately defining the term. He suggests that regression estimates of coefficients are reliable when they are based on the 'consistent' technique which yields the minimum variance of the estimate. Three consistent regression techniques are considered; (i) the Wald-Barlett method, (ii) the Durbin method, (iii) and the two-stage least squares method (2SLS). He concludes that the 2SLS method produces the least variance of the estimates and is therefore the most reliable.

The new method was tested using data from an I-O model developed by Miernyk for West Virginia. The regional input coefficients derived by this approach were shown to vary substantially from Miernyk's results. Gerking admits that these results are not necessarily better than conventional methods, which rely more on judgement; he simply offers the method as an alternate approach. The advantages attributed to this method are that; (i) the rows only and columns only estimates are weighted inversely according to the amount of misinformation each is likely to provide, and (ii) the standard errors of the new method will always be no larger than those of the rows or columns only approaches.

Nevertheless, Miernyk (1976) is highly critical of Gerking's method. He raises several technical criticisms. Firstly, he doubts that the regression coefficients are reasonable proxies of I-O coefficients because limited data will always lead to very small degrees of freedom. Secondly, he maintains that the Gerking method defies a basic restriction of I-O anlysis - that the sum of the inter-industry coefficients plus the primary input coefficients equal unity. And, thirdly, the diagonal elements in Gerking's approach are forced to be smaller than expected given non-homogeneity common to most economic sectors.

Meirnyk's has a more fundamental concern with the assumption of Gerking's that statistical rationalization is better than rational judgement. He claims that while Gerking's method is "elegant and judgement free ... it does violence to reality." (p. 52) Judgement is indeed an integral part of constructing any I-O table because of data limitations. Judgements must be made by the researchers, and also by all those who fill out surveys. Ideally, these many judgements help to refine the matrix, not to impair it. While judgements cannot be scientifically replicated; "The reasoning behind each decision can be carefully documented, so those who plan to use an I-O table will know why the decisions were made." (p. 53)

3.4 Case Studies

The review has thus far concentrated on technical aspects of input-output analysis; alternative model formats, model adaptations, and technical issues involving model construction and interpretation. In this section, specific case studies are reviewed. Since examples of I-O analysis are both numerous and broad in scope, a brief review of a broad range is first offered. A more comprehensive review of three studies similar in emphasis, scope, and detail follows to provide comparisons for this I-O analysis of the Chilliwack regional economy.

3.4.1 Exemplary How-To Case Studies

Two exemplary case studies which provide detailed explanations of theoretical and practical concerns in I-O analysis, in addition to a specific case study, are Regional Economic Planning: Generation of Input-Output Analysis (Jensen, Mandeville, and Karunaratne; 1979) and Manitoba Interlake Area: A Regional Developement Evaluation (MacMillan, Lu, and Framingham; 1975).

The first text describes in detail a system (GRIT) for constructing I-O tables which was designed to maximize the accuracy of a regional transactions table while minimizing primary data requirements. The authors describe the GRIT system as "... a variable interference non-survey technique, producing tables which would be termed hybrid tables." (p. 42)[13] This construction process permits the operator the discretion to exchange non-survey data with superior survey data when available. Although this process may not be explicitly described with other non-survey methods, similar techniques no doubt have been vital to the construction of most non-survey I-O tables. The study by Jensen, Mandeville, and Karunaratne formalizes the procedure.

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13 Hybrid I-O tables are defined by the authors as mechanically produced tables (i.e., national I-O tables adjusted through secondary information) with specific cells supplemented by survey-based data. In this text (section 3.2.2), hybrid models refer to tables which have been aggregated to non-standard dimensions or formats.

The GRIT system is most succintly relayed in the following table. It was used to devise a 'square' I-O table for Queensland, Australia, and for ten regions comprising Queensland. Each of the eleven regional I-O tables have the same dimensions; eleven inter-mediate sectors, three categories of final demand (including households), and three categories of primary inputs (including households). Three types of multipliers

TABLE 3.4 THE GRIT METHODOLOGICAL SEQUENCE

Step No.	PHASE I ADJUSTMENTS TO NATIONAL TABLE
1	Start with national input-output table.
2	Adjustment of national table for price levels and updating.
3	Adjustment for international trade.
	PHASE II ADJUSTMENT FOR REGIONAL IMPORTS
4	Calculation of non-competing imports.
5	Calculation of competing imports.
	PHASE III DEFINITION OF REGIONAL SECTORS
6	Insertion of disaggregated superior data.
7	Aggregation of sectors.
8	Insertion of aggregated superior data.
	PHASE IV DERIVATION OF PROTOTYPE TRANSACTIONS TABLES
9	Derivation of initial transactions tables.
10	Manual or iterative adjustments to initial tables to derive prototype tables.
11	Aggregation if uniform tables are required.
12	Derivation of inverses and multipliers for prototype tables.
	PHASE V DERIVATION OF FINAL TRANSACTIONS TABLES
13	Final superior data insertions and other adjustments.
14	Derivation of final transactions tables.
15	Derivation of inverses and multipliers for final tables.

were calculated from the transactions tables; output, income, and employment. The range of output multipliers was between 1.1 and 1.7 for the closed model (Type I) and between 1.4 and 2.5 for the open model (Type II). Income and employment multipliers were not directly specified; instead, the components of multipliers were listed (i.e., direct, indirect, and induced effects).[14]

If regional I-O models are to be constructed from national models, then the GRIT system can help to minimize model error. The authors maintain that the resulting multipliers can be used confidently in regional impact analysis; they "... do not claim accuracy in detail in that individual cells are accurate, but merely that the tables as a whole reflect the appropriate economies without errors which are significant in analytical uses or which are noticable to experienced observers." (p. 107) Overall accuracy is achieved because larger coefficients, which contribute most to the multiplier effect, are usually adjusted to reflect regional conditions. Nevertheless, the overall level of accuracy would likely improve if the reverse procedure were followed; if regional data were collected to the fullest possible extent, and the gaps filled with national data adjusted to regional conditions.

The text by MacMillan, Lu, and Framingham provides a detailed explanation of regional development evaluation for the Central Manitoba Interlakes area using I-O analysis. Specifically, it presents an approach to regional analysis designed to provide a basis for the

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14 An indepth assessment of case study multipliers will be provided in a later section.

determination of regional development strategies. A primary concern is to assess the trade-offs between urban and rural growth.

The model identifies 17 intermediate sectors, and, in addition to the households sector, six categories of final demand (government, inventory additions, sales to investment, unallocated, exports to Manitoba, and exports to Canada) and eight categories of primary inputs (government, inventory depletion, depreciation and retained earnings, rent, interest, unallocated, imports from Manitoba, and imports from Canada). Since the area is primarily rural, the sector breakdown distinguishes four agricultural sectors; livestock, crops, food and beverage manufacturing, and farm supplies.

The direct requirements coefficients for the food and beverage processing, and primary agricultural sectors are shown to be the largest of all sectors. This means that these sectors purchase a higher percentage of their inputs locally than other sectors. The overall multiplier effect is highest for food processing. Transportation and insurance sectors have stronger indirect effects locally than do primary agricultural sectors leading to slightly larger output multipliers. However, these sectors are not 'basic' industries; that is, sectors which can independently create local economic growth - they are service industries which are dependent upon the level of activity of other sectors. Type I output multipliers range from 1.02 for petroleum wholesale and auto sales sectors to 1.92 for food and beverage processing. Type II output multipliers range from 1.16 for petroleum wholesale to 2.55 for food and beverage processing.

The analysis is not restricted to I-O model formats. Data collected for the transactions table are also organized into a 'gross area income and expenditures account.' Total regional income is shown to equal total regional expenditures, as is required in double entry accounting.

The I-O model is used to assess:

1. federal regional economic development (FRED) program expenditures;
2. the potential importance of the recreation sector;
3. the importance of basic sector exports; and
4. the impact of the Gimli Air Base closure on the Interlake econmy.

Rural economic development expenditures are assessed in terms of impact on total area sales. Programs that have a high percentge of payments going to the household sector are shown to have the highest multiplier effect because of the household sector's high propensity to spend locally (i.e., multiplier of 1.8). An example is Canada Manpower and Immigration allowances. Recreation programs, on the other hand, have lower multiplier effects because they spend a high percentage of funds on construction which, in turn, has a low local multiplier.

The effect of basic sector exports on regional income is compared. Agricultural sector (food processing and crops) exports lead to higher regional incomes than the mining and other manufacturing sectors. As well, the closure of the Gimli Air Base is shown to have a substantial negative impact on area sales and income due to decreased sales to households and the elimination of purchases by the military base.

A chapter is also included illustrating the derivation of employment impacts from regional accounts. Many studies simply list the employment-output ratios used to derive employment multipliers. The Interlake study shows how employment-output functions are synthesized with the Interlake I-O table to analyze impacts of changes in demand for area products. The food and beverage processing sector is shown to have the highest employment effect, with the farm supply a close second.

In summation, the Interlake study had a clear objective: to assess the effectiveness of the FRED program to increase the number of jobs in the area and to reduce the number of area households in the lower income classes. It also assessed three other ways in which regional sales could be affected; purchases to travellers, exports by basic sectors, and the closure of the air base. A positive feature of this study is that real scenarios are assessed in absolute terms rather than simply listing sectoral multipliers. The expected impact on a region is a function of both the feasibility and magnitude of the direct impact (e.g., expected number of tourists), and the associated indirect-induced effects (respending patterns initiated). Tourism opportunities are shown to have the highest local sales impact while the FRED program has the highest local income effect.

3.4.2 Further Applications of Input-Output Analysis

Input-output analysis has been applied to a diverse range of development and fiscal policy issues. Many case studies describe impact assessments of regional economies. Examples are studies by Long (1972a, 1972b), Goldman (1975), Schaffer (1977), Morrison and Smith (1977), Chossudousky (1977), Hope (1978), U.S. Department of Agriculture (1978), Penson and Fulton (1080), Harris and Pierce (1981), Johnson and Kulshreshtha (1981), and Hushak, Ro, and Husain (1983). In addition to presenting impact evaluations, these studies also present instructional guides to I-O model construction and operation, though not as detailed as the two texts described in the above section.

Long (1972a, 1972b) provides an example of how I-O analysis can be effectively used to evaluate irrigation projects. The study area is the

South Saskatchewan River Basin (SSRB) in southern Alberta. In the first report, Long presents a thiry-five sector square I-O model of the SSRB. The model concentrates on agriculture identifying four dryland crop sectors, six irrigated crop sectors, and five livestock sectors. As well, four agricultural processing sectors are modelled. In the second report, Long (1972b) develops an Income-Maximizing model, which applies linear programming to I-O analysis. Though linear programming is beyond the scope of the present study, it will be useful to briefly demonstrate a different application of I-O analysis.

The model was designed to maximize total regional value added subject to sectoral and total regional water constraints, and the production constraints identified by the I-O model. Parametric programming was applied to the model by varying the amounts of water available to the economy to determine the effect on the overall solution. The water constraint was varied at 100,000 acre-foot intervals to determine the effect on value added and gross output. This information was used to estimate the marginal return and marginal value added per acre-foot of water at differnet levels of water availability.

The range of feasible solutions to the income maximizing program in 1969 was from 600,000 to 1,500,000 acre-feet of water availability. Below 600,000 acre-feet regional economic needs would not be met, and any water supply over 1,500,000 acre-feet would be in surplus. This range in water utilization represents an increase in regional income of $136.7 (11 percent). The same assessment was conducted for forecasts of the economy in the years 1980 and 2000.

The marginal returns of water at the various levels of supply illustrate clearly the value of resources when in short supply, and how this value declines as more of the resource becomes available. A marginal cost function is then derived from estimated irrigation development costs for 25 projects. While the marginal investment cost per acre-foot was shown to be quite high, the average cost amortized over fifty years was much lower. The author uses these two cost curves as a minimum investment guide and a maximum development guide for water storage development.

The evaluation of water demand and economic growth in the SSRB was continued in a later study, as described by Anderson and Manning (1983). The objectives were to determine the relation of water use to economic activity in the region and to forecast potential future demands for water.

A square I-O model was first constructed but the results were felt to not adequately reflect the regional economy. The errors were thought to be caused by the high degree of aggregation - the assumption of homogeneity amongst firms represented by economic sectors was excessively violated. Some of these homogeneity problems were solved by turning to a rectangular I-O model. The new SSRB I-O model identified 67 industries and 71 commodities. Agriculture comprised 27 sectors producing 22 commodities. The large number of sectors compared to commodities arises from the need to identify sectors which use substantial amounts of water, such as irrigation.

Goldman (1977) prepared a layman's guide to the interpretation of I-O analysis for extension personnel and local decision-makers. The case study was a 24 sector model of Napa County, California, though the publication aggregated the results to seven sectors for demonstration purposes. Schaffer (1977) provides a concise explanation of the rectangular I-O model format, and describes various aspects of the construction of the Nova Scotia I-O model. He concentrates on the primary and secondary data sources used, and the procedures followed to develop the several component matrices of rectangular I-O models.

Penson and Fulton (1980) developed a quadratic input-output model of the Texas economy. The I-O model is used to delineate the production constraints of a quadratic programming model. The objective function is to maximize consumer and producer surplus. The quadratic element of the objective function is based on econometric estimates of linear supply functions for each primary input and linear demand functions for the production of each sector. Unlike the standard I-O model, the quadratic model endogenously determines the level of final demand for the production of each sector. Consequently, the model dispenses with the need for the assumption of constant relative prices.

Since the model includes exports in the objective function, it reflects the well-being of consumers and producers in Texas plus those who trade with Texans. As well, the surplus changes of each sector are revealed. The model is used to illustrate the effect of a cut-back in agricultural production in Texas. Two scenarios were assessed relating to whether imports increased to replace production declines. If imports of agricultural products is not increased, total consumer and producer surplus in Texas was shown to fall. However, the agricultural producers would have realized a gain due to higher commodity prices. If imports increased, then consumer surplus would also increase, but not at the rate expected had agricultural production continued to grow.

Harris and Pierce (1981) present a case study of the Humboldt and Lander Counties, Nevada. The study provides a brief explanation of I-O analysis and presents the case study results; few instructional details of I-O model construction are offered.[15] The Hushak, Ro, and Husain study (1983) provides a brief technical explanation of I-O analysis using a square format. The case study illustrates the use of the location quotient to develop a regional I-O model from a national model. The study region comprises five counties in southeastern Ohio.

Input-output analysis is used to evaluate many issues which are closely related to impact analyis of agricultural development. For instance, studies have been prepared specifically to assess the impact of forestry development on regional economies (Diamond and Chappelle, 19??; Thomassin and Baker, 1985). Input-output impact analyses concentrating on agricultural and forestry industries demonstrate several important similarities. Firstly, both are primary export oriented industries. Secondly, both are land extensive, and therefore lend themselves to resource (land) utilization I-O formats. And thirdly, they are the dominant economic mainstays of many underdeveloped regions.

Input-output analysis can also be used to assess impacts related to the expansion/contraction of agricultural support sectors, or to public

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15 The study illustrates a major inconsistency in I-O analysis involving multiplier definitions. Two multipliers assessed in the study are final demand and output multipliers. The final demand multiplier is defined as the change in regional economic activity from a change in sales to final demand. The output multiplier is defined as the change in regional economic activity from increased output by sector j. Most I-O studies refer only to output multipliers, and they are given the first definition above. The multiplier defined above as the output multiplier is rarely derived.

policies related to agriculture. Gould (1986) has used an inter-regional I-O model (PRAIRIO) he developed to assess the impacts of prairie branch line rehabilitation expenditures by the federal government.[16] The inter-regional model is adopted to better reflect regional differences arising from differing production technologies, commodity prices, or production mixes across regions.

Based on 1983 program expenditures, direct and total effects for four factors (sectoral output, value-added, household income, and employment) are derived for the four regions identified in the model (Alberta, Saskatchewan, Manitoba, and other Canada), and for Total Canada. As well, Gould calculates total/direct ratios (i.e., ratio multipliers) for each factor. Saskatchewan demonstrates the lowest ratios whereas 'other Canada' registers very high value-added, household income, and employment ratios and Alberta tallies the highest output.[17]

Pseudo-multipliers based on total final demand are calculated to standardize the comparison across regions because the value of the rehabilitation expenditures spent in each province varied so widely. The pseudo-multiplier refers to the ratio of the total change in a variable per unit change in total final demand (e.g., growth in the number of employees per dollar increase in final demand). The largest gross output, value-added, and household income pseudo-multipliers are recorded

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16 Interestingly, no explanation is provided as to what degree this model is related to the PRAIRIE model of the prairie provinces developed by his colleagues (Kulshreshtha and Yap, 1985)

17 Gould states that Saskatchewan has low multipliers in spite of the fact that the province is the most dependent on imports. Actually, high import ratios are a main cause of low multipliers.

for other Canada, whereas Manitoba recorded the highest employment multiplier.

Finally, pseudo-multipliers based on provincial final demand are calculated to illustrate the degree to which final demand in one region affects other regions. Gould identifies several trends; i) the flow of trade is in one direction, towards 'other Canada', ii) 'other Canada' has more associated international trade resulting from the program expenditures, and iii) while 'other Canada' has the highest output multiplier, it has the lowest value-added and household income multipliers. The final point may be "... explained by the relatively large proportion of the rehabilitation expenditures in the prairie provinces being associated with the direct expenditures on wages and salaries." (p. 327)

Conclusions from the assessment are that there are substantial indirect impacts outside the prairie region resulting from the program expenditures. This illustrates that areas targeted for development by policies or programs often are not the areas most affected by the policies. Gould maintains that without the inter-provincial linkages of the PRAIRIO model, these impacts could not be identified.

3.4.3 Three Input-Output Studies of Small Regions

Three case studies are presented in this section to serve as comparisons to the results obtained for the Chilliwack region. These studies are chosen because they each are similar in scope and purpose to this study. They are studies of small, resource industry based regions and they adopt the traditional impact assessment approach.

Clatsop County, Oregon

Thomas Carroll and Herbert Stoevener of Oregon State University updated to 1977 conditions an earlier I-O study of Clatsop County, Oregon. Employment in the region was estimated at 11,733. The model adopted the square format and consisted of 26 interemediate sectors including households, city government, county government, and state and federal agencies. Total sales and output multipliers by sector are provided in Table 3.5.

TABLE 3.5 TOTAL SALES AND OUTPUT MULTIPLIERS - CLATSOP COUNTY, OREGON

Sector	Total Sales ($1,000)	Total Sales Rank	Output Multiplier Multiplier	Output Multiplier Rank
Other Fishermen	6,173	20	3.2	1
Financial	8,628	17	3.1	2
Education	22,402	7	3.0	3
County Government	4,996	22	2.9	4
Fed. and State Agencies	20,258	11	2.9	5
Professional	12,997	15	2.8	6
Retail Service	20,212	10	2.8	7
Salmon Processing	6,909	19	2.7	8
Households			2.7	9
Restaurants	16,042	13	2.6	10
Agriculture	4,372	23	2.6	11
Troll Fishermen	1,234	24	2.6	12
Construction	29,136	5	2.6	13
Gillnet Fishermen	1,116	25	2.4	14
Lodging	6,115	21	2.4	15
Logging	39,451	4	2.4	16
City Government	11,659	16	2.3	17
Transportation	21,699	8	2.3	18
Other Fish Processing	59,730	3	2.1	19
Combination Fishermen	8,091	18	2.0	20
Manufacturing	16,784	12	1.9	21
Automotive	21,697	9	1.6	22
Service Stations	28,611	6	1.6	23
Wood Processing	168,929	1	1.5	24
Retail and Wholesale	110,776	2	1.5	25
Communications	13,460	14		

The authors state that the greatest value of the study is; "... its description of the Clatsop County economy ... to learn (about the) size of its components and their various interrelationships ..." (p. 29). They state, however, that most applications will deal with its predictive capabilities. They also caution against using the model after the technical coefficients no longer reflect area production techniques.

Moffat, Routt, and Rio Blanco Counties, Colorado

The second case study is of an I-O model developed by John McKean and Joseph Weber, Colorado State University, for Moffat, Routt, and Rio Blanco Counties. The 1976 regional population was estimated at 23,060 inhabitants with an adjusted gross income of $118 million. The major exporting activities were extractive industries and the recreation industry. The purpose of the study was to develop a detailed description of the present economy and an analytical framework capable of assessing the direct and indirect consequences of alternate scenarios for resource exploitation. The square I-O model comprised 18 sectors. Table 3.6 only lists the Type I multipliers.

The report also assesses the effect of economic development on water withdrawl and consumption. Table 3.6 lists the estimated direct and direct plus indirect water withdrawl rates by sector. Irrigation is the largest consumer of water; however, manufacturing produces the largest backward-linked water consumption.

Blaine County, Idaho

The last example of regional I-O modelling to be examined is for Blaine County, Idaho. Roger Long and Neil Meyer produced a small, square

TABLE 3.6 OUTPUT AND INCOME MULTIPLIERS - MOFFAT, ROUTT, AND RIO BLANCO COUNTIES, COLORADO

Sector	Output Multiplier Type II	Output Multiplier Rank	Income Multiplier Type II	Income Multiplier Rank
Local Taxes	2.2	1		
Elec/Gas Utilities	1.9	2	2.3	1
Agriculture/Livestock	1.6	3	2.3	2
Construction	1.4	4	1.3	5
Retail	1.4	5	1.3	6
All Manufacturing	1.3	6	1.2	7
Wholesale	1.3	7	1.5	4
Finance/Real Estate	1.1	8	1.2	8
Services	1.3	9	1.2	9
Local Government	1.3	10	1.2	10
Coal Mines	1.2	11	1.2	11
Trans/Communications	1.2	12	1.1	12
Oil/Gas Production	1.2	13	1.9	3
Water/Sanitation	1.2	14	1.1	13
Local Roads	1.2	15	1.1	14
Medical	1.1	16	1.1	15
Education	1.1	17	1.0	16

TABLE 3.7 WATER WITHDRAWL RATES - MOFFAT, ROUTT, AND RIO BLANCO COUNTIES, COLORADO

Sector	Direct Water Withdrawl (gallons per dollar of output)	Total Water Use Direct Plus Indirect (gallons per dollar of output)
Agriculture/Livestock	1,535.0	1,821.6
Elec/Gas Utilities	267.0	313.2
Oil/Gas Production	27.0	37.2
All Manufacturing	21.6	247.9
Coal Mines	9.9	24.9
Medical	5.1	7.4
Construction	4.0	13.0
Retail	3.9	16.1
Services	3.5	13.9
Wholesale	2.3	8.8
Trans/Communications	2.1	4.8
Education	1.5	9.3
Water/Sanitation	-0-	16.0
Local Government	-0-	9.9
Local Roads	-0-	10.2

format model comprising 15 sectors (Table 3.8). The county is small in population: 9,825 persons in 1979. With snow skiing a major activity in the County, employment opportunities can fluctuate significantly with changes in winter snow conditions. The economic study was conducted to assist Chamber of Commerce personnel in planning for future growth.

TABLE 3.8 OUTPUT, VALUE ADDED, AND OUTPUT MULTIPLIERS - BLAINE COUNTY, IDAHO

Sector	Gross Output ($1,000)	Value Added ($1,000)	Output Multiplier Type I	Output Multiplier Type II
Crop Agriculture	5,870	1,572	1.5	1.9
Livestock	11,853	4,074	1.7	2.2
Construction	26,858	9,790	1.5	2.5
Manufacturing	9,044	5,024	1.3	2.3
Transportation	4,916	1,262	1.1	1.5
Comm., Utilities, Publ.	7,185	1,775	1.1	1.6
Wholesale and Retail	68,426	23,243	1.2	1.6
Finance, Insur., R. Estate	52,821	31,101	1.2	1.5
Services	14,464	6,873	1.3	2.3
Lodging	22,171	9,389	1.2	1.9
Medical	4,054	1,405	1.5	2.6
Local Government	9,712	7,248	1.1	2.5
State Government	3,450	1,898	1.2	1.6
Federal Government	2,345	1,708	1.2	3.3
Households	43,507	--	--	2.7

4.0 THE CHILLIWACK REGIONAL INPUT-OUTPUT MODEL

In this section, an input-output model is developed for the Chilliwack regional economy. The study area and its characteristics are described in section 4.1. Model formulation details are reviewed in section 4.2 relating to aggregation of economic sectors, model format, and modelling approach. The structure of the regional economy is described in section 4.3. First, the regional economic sectors are defined and the 1984 transactions table is presented. Second, the sources of data of revenue and expenditures for each sector are identified. Third, general observations are made with regard to the flow of money through the regional economy. And finally, the relative importance of each sector, in terms of value of output, is summmarized. The output, employment, and income multipliers of the regional economy are presented in section 4.4. Based on these multiplier estimates, the relative importance of each sector is assessed in terms of overall impact on regional growth.

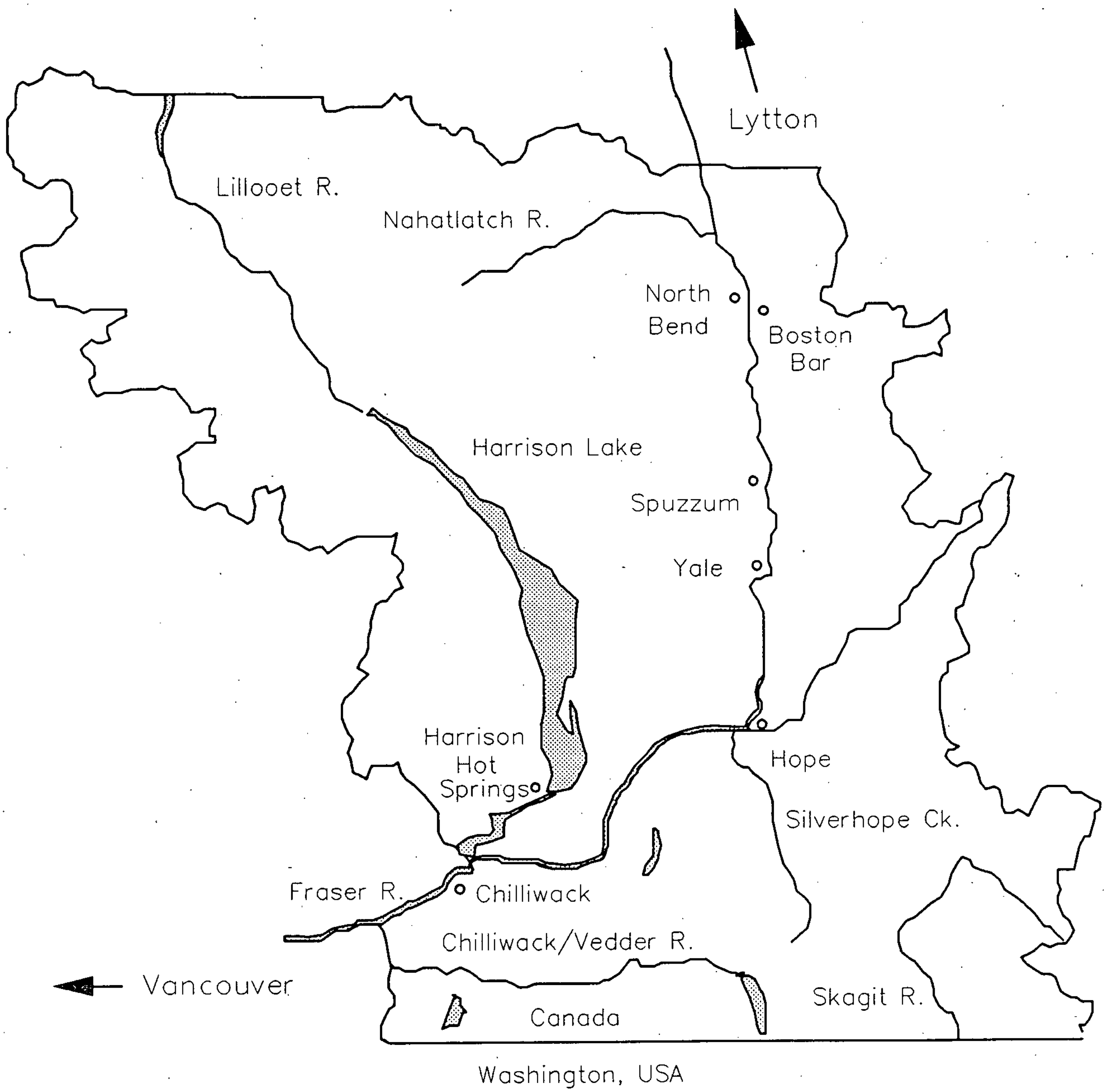
4.1 The Study Area

4.1.1 Study Area Boundary

The boundary chosen for this analysis corresponds to the boundary of both Census Division No. 9 and the Regional District of Fraser-Cheam (see Figure 2). The area includes the most easterly portion of the Lower Mainland as well as most of the Fraser Canyon south of Lillooet. The western boundary is marked by the Vedder Canal while the southern boundary follows the Canada-U.S. boundary.

FIGURE 2 THE CHILLIWACK REGION

REGIONAL DISTRICT OF FRASER-CHEAM



The over-riding reason for using this boundary is that most federal and provincial statistics are published for census districts. The federal government has divided each province into a number of regions, or census districts, which are used as the geographical basis for elections and for most administrative programs, such as social assistance and job creation programs. Since the main constraint for this project is the availability of data, it was essential to choose the boundary to minimize obstacles to data collection. Another important factor was that the Regional District of Fraser-Cheam, a level of local government, has an administration dealing specifically with this area.

Though this boundary was selected primarily for practical reasons, it also satisfies important conceptual requirements. Most of the farms in the Regional District are found in the southwest portion surrounding Chilliwack and Agassiz, a small community located across the Fraser River. To a large extent, this is a separate farming community. The narrowing of the Fraser Valley in the vicinity of the Vedder Canal serves to some extent as both a physical and psychological break from the larger Abbotsford community to the west. Nevertheless, the Chilliwack farming community is an integral part of the the Lower Mainland agricultural complex and has very strong economic ties with establishments in those other communities.

4.1.2 Study Area Topography and Demography[18]

The Regional District of Fraser-Cheam study area encompasses approximately 11,000 square kilometers, 200 of which are water bodies. The majority of the region has a mountainous terrain. Almost all of the agricultural land is situated in the southwest corner at the eastern end of the Fraser River flood plain. A smaller tract of land with agricultural capability is situated within the Skagit River valley to the east.

The population of the study area in 1981 was almost 57,000. Over 71 percent - 40,640 people - resided in the District Municipality of Chilliwack (consequently, the study area is often referred to simply as the Chilliwack area). Chilliwack is located 100 kilometers east of Vancouver and only a few kilometers from the U.S. border. Another 3,960 lived in the nearby District of Kent and Village of Harrison Hot Springs. Of the remaining population, 3,200 live in the City of Hope located 55 kilometers east of Chilliwack, 7,160 live within six Electoral Areas, and 1,970 live on Indian Reserves. Most of the region's farming population is located within the two District Municipalities.

4.1.3 Study Area Economic Characteristics

The area labour force is occupied in a diverse range of economic sectors (Table 4.1). The service sectors - trade, finance, and other services - accounted for 45.6 percent of the total labour force of 26,275 persons in 1981. Public administration and defence is another important economic classification, with a labour force of 3,520 persons in 1981, well over half of whom are with the National Defence Base. Primary agriculture directly accounts for 1,745 persons, or 6.6 percent, of the labour force. Manufacturing industries have a labour force of 2,780 persons, the majority of which are involved with agricultural food processing industries.

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18 Much of the information of sections 4.2 through 4.4 has been drawn from Economic Profile, Regional District of Fraser-Cheam, 1984.

TABLE 4.1 REGIONAL LABOUR FORCE BY INDUSTRY SECTOR, 1971-1981

Industry Division	1971 No.	1971 %	1981 No.	1981 %
Agriculture	1,485	9.3	1,745	6.6
Forestry	925	5.8	1.230	4.7
Fishing and Trapping	25	0.1	60	0.2
Mines, Quarries	220	1.4	165	0.6
Manufacturing	1,770	11.0	2,780	10.6
Construction	1,365	8.5	2,380	9.1
Transportation, Communication, and Utilities	865	5.4	1,355	5.2
Trade	2,465	15.4	4,025	15.3
Finance, Insurance, and Real Estate	415	2.6	955	3.6
Community, Business, and Personal Services	3,880	24.2	7,010	26.7
Public Admin. and Defence	2,475	15.4	3,520	13.4
Industry Unspecified or Undefined	140	0.9	1,055	4.0

Source: Statistics Canada. Census of Canada, (Cat. No. 71-001), 1971 and 1981.

4.1.4 Agriculture and Related Industries

Agriculture is a major driving force in the Chilliwack regional economy. The 1981 census shows that the Regional District of Fraser-Cheam produced $76,966,032 dollars worth of primary agricultural products, just under 10 percent of the provincial total and over 18 percent of the lower mainland region total. Moreover, the region's farms are intensive operations; the 1,109 area farms in 1981 accounted for only 5.5 percent of all the farms in the province and had an average size of only 21.8 hectares.

Dairy operations are the largest component, or sub-sector, of the regional agricultural sector. In 1983, the Ministry of Agriculture and Food estimated regional dairy production to total about $60 million, fifty percent of the estimated total regional agricultural production of $120 million. Crop production has been growing in importance; in 1983, it was estimated at about $40.5 million, about 34 percent of the provincial total. Other major agricultural sub-sectors include swine production and poultry (primarily egg) production. The value of agricultural output is described in more detail in Table 4.2.

Food processing industries comprise the largest component of the manufacturing sector. In 1984, the largest firms included Fraser Valley Frosted Foods, Westvale (East Chilliwack Fruit Grower's Co-op.), Berryland Foods, and the Fraser Valley Milk Producers Association. In addition, the East Chilliwack Agricultural Co-op is a major producer and distributor of feed and fertilizer. Several smaller food processors are located within the region and include abattoirs, dairy processors, and feed manufacturers. Total production of the food and beverage sector in 1981 was estimated to be $120 million, about 48 percent of total regional manufacturing. The second largest component of the manufacturing sector is forest products. Production in 1981 was estimated at $82 million, about 33 percent of total regional manufacturing.

The District of Chilliwack is a major commercial, business, and professional service center for the region. As shown in Table 4.1, the service sector, broadly defined, accounted for 11,990 persons, 46 percent of the regional labour force. Many of these commercial/sevice enterprises gain considerable business from the agricultural sector, both primary and secondary. Some are geared specifically to the agricultural sector, such as crop dusting and seeding establishments, farm and dairy equipment dealers/repair shops, feed and fertilizer dealers, and veterinarians, while for others the farm sector is only one of several sources of business.

TABLE 4.2 APPROXIMATE VALUE OF AGRICULTURAL OUTPUT, REGIONAL DISTRICT OF FRASER-CHEAM, 1983

	Approx. Hectares	Approx. Production (tonnes)	Approx. Value ($)
Crops			
Field Crops wheat, oats, barley, rye	100	300	30,000
Forage Crops corn (for silage), hay	16,250	400,000	22,850,000
Major Vegetable Crops beans, peas, carrots, sweet corn, cole crops, potatoes	1,685	20,200	3,330,000
Major Fruit Crops raspberries, strawberries, blueberries, sour cherries	460	4,917(1)	5,608,300
Other Crops filberts (hazelnuts), nursery (fruit ornamentals), greenhouse crops, mushrooms, hops	730(2)		8,650,000
Approximate value of crops			40,468,300
Livestock			
Dairy Production (27 % of Province)			60,000,000
Local Cattle Sales			3,000,000
Local Calf Sales			1,000,000
Hogs Marketed			5,950,000
Cull Sows and Boars			500,000
Poultry (primarily egg production)			9,000,000
Approximate value of livestock sales and related production			79,450,000
Approximate total value of crops and livestock			119,918,300

1. Excludes sour cherries and other fruit
2. Excludes greenhouse crops and mushrooms

Source: District Agriculturalist, Chillwack, Ministry of Agriculture and Food, November 1983 cited in Regionl District of Fraser-Cheam, Economic Development Commision, Economic Profile, February 1984.

4.2 Model Formulation

The diversity of approaches to input-output modelling, and the range of issues to be addressed, was demonstrated in section 3.0. In this section, the modelling approach adopted in the present study is described.

4.2.1 Aggregation of Economic Sectors

One of the first issues to address in constructing an I-O model is the desired level of aggregation. The study area economy must be divided into an exhaustive and mutually exclusive set of economic sectors. By 'exhaustive' we mean that all regional economic activity should be represented by the selected group of economic sectors. Thus, the transactions table represents total regional output. By 'mutually exclusive' we mean that the economic activity of every firm or establishment is recorded in only one economic sector. Thus, each sector represents a unique set of establishments.

In selecting a set of economic sectors, various trade-offs occur. The primary goal is to have the transactions table as good a representtation of the area economy as possible. Therefore, a primary objective is to have the model as disaggregated as possible. By dividing the economy into many sectors, we improve the likelihood that each sector is a good representation of each of the establishments represented by that sector.

However, disaggregation - dividing the economy into finer categories of economic activity - is costly in terms of both time and effort. Moreover, readiy available published data becomes more scarce with increasing disaggregation. Therefore, the number of sectors represented by the I-O model needs to be carefully considered.

The level of disaggregation amongst I-O models varies considerably. Perhaps the largest square I-O model is that of the U.S. (prior to 1972) with 496 economic sectors. The national Canadian I-O model, which adopts the rectangular format described in section 3.1.1, also identifies a large number of economic sectors and, like the U.S. model, the information is organized into three levels of aggregation. The most disaggregated version contains 192 'producing' sectors, 602 output commodities, and 136 categories of final demand. The medium aggregation contains 43 economic sectors, 92 commodities, and 14 categories of final demand. The numbers for the smallest transactions table are similarly 16, 43, and 14. Large national I-O models are feasible because; (a) an enormous amount of information is collected at the national level, particularly with regard to national imports and exports, and (b) the wide applicability of the national model justifies a large amount of effort.

Regional models, on the other hand, are usually much smaller; that is, they are usually much less disaggregated. Many factors contribute to this. First, regions are often less diversified than large economies, therefore, they have a lower maximum level of disaggregation. Second, census data is often not available at the same level of disaggregation as the national level, primarily due to confidentiality requirements. This constraint is most evident with regard to regional exports and imports. And third, the narrower scope of the regional model means that fewer resources can be devoted to these projects. An additional constraint of this study is that it is a pilot project undertaken by a lone (but dedicated) university student.

Upon considering the limited resources of this study, the limited amount of census data available specific to the Chilliwack area, and the focused nature of the project, it was decided to represent the Chilliwack economy by twelve local (producing) sectors, four categories of final demand, and four categories of primary inputs. The economic sectors selected are:

1. Crops
2. Dairy
3. Swine
4. Poultry
5. Fruit and vegetable processing
6. Other food/beverage/feed processing
7. Forestry
8. Manufactured forest products
9. Other manufacturing
10. Services and trade
11. National defence
12. Local government

Since this study focuses on the impact of the agricultural community, half of the economic sectors of the model involve agricultural activities; four sectors represent primary agriculture and two represent food, beverage, and feed processing sectors. The remainder of the local economy is represented by six categories of activity; one primary (forestry), two manufacturing, one for all service and trade activities, and two for local institutional sectors (national defence and local government).

As described in section 3.3.1, researchers have shown that little error is introduced into the impact assessment of specific sectors when the remaining sectors of the economy are highly aggregated (Doekson and Little, 1968; Hewings, 1972). Therefore, grouping a diverse range of sectors into the residual category 'services and trade' should not have an adverse effect on the reliability of multiplier estimates of disaggregated key sectors. Furthermore, the twelve sectors of this model surpasses the recommended minimum level of disaggregation suggested by Hewings. However, the multiplier estimates generated in this study for the services/trade and 'other manufacturing' sectors could be subject to significant estimation errors because they are highly aggregated.

4.2.2 Model Format

The second issue to address is whether to adopt a square or rectangular format. Although the rectangular format is generally more versatile and better reflects the actual workings of an economic system, it was not chosen for this study for several reasons. Firstly, data collection needs for the rectangular format are more demanding. In particular, the modellers must determine the flow of specific commodities within the economy. In view of the strict limitations of this study outlined above, resources were not available to determine specific commodity flows within the Chilliwack economy.

Even with additional resources, the advantages of developing a commodity-industry format for a project of this nature - an agricultural impact assessment of a small regional economy - would not be as significant as for broader based I-O impact studies. In most cases, primary agricultural sectors concentrate production in a single class of commodities: the dairy sector produces milk, the grain sector produces grain, the swine sector produces swine, etc. Mixed farms are common, of course, but in many regions, the Chilliwack region included, their size in terms of total production is substantially below that of more specialized farm enterprises. Consequently, a rectangular I-O model of primary agricultural sectors will not vary that much from the square format.

In support of this view, we draw attention to the recent interregional I-O study prepared for the Prairie Farm Rehabilitation

Administration (Kulshreshtha and Yap, 1985). An objective of the project was to expand the breakdown of agricultural commodities/industries listed in provincial I-O tables. Most provincial tables, as well as the national table, identify only one primary agricultural sector producing nineteen or twenty farm commodies. The PFRA PRARIE model identifies thirteen primary agricultural sectors and eleven farm commodities (Table 4.3).

TABLE 4.3 LIST OF AGRICULTURAL SECTORS FOR THE PFRA PRAIRIE MODEL

Sector Description	Commodity Description
A. Primary Agriculture	
1. Wheat Farms, Brown Soil	1. Wheat
2. Wheat Farms, Dark Brown Soil	2. Other Grains
3. Wheat Farms, Black Soil	3. Cattle and Calves
4. Other Grain Farms, Br. Soil	4. Hogs
5. Other Grain Farms, Dk. Br. Soil	5. Poultry
6. Other Grain Farms, Bk. Br. Soil	6. Other Live Animals
7. Cattle and Lvsk. Comb. Farms	7. Milk
8. Hog Farms	8. Eggs
9. Poultry Farms	9. Fruits and Vegetables
10. Dairy Farms	10. Oilseeds, Nuts, Kernels
11. Fruits, Vegetables, Other Farms	11. Other Agricultural Products
12. Intensive Irrigation	
13. Backflood Irrigation	
B. Food and Beverage Processors	
1. Slaughtering and Meat Processing	1. Meat Excl. Poultry
2. Poultry Processors	2. Poultry
3. Dairy Factories	3. Dairy Products
4. Fruit and Vegetable Processing	4. Fruits and Vegetable Preps.
5. Feed Manufacturers	5. Feeds
6. Flour and Breakfast Cereals Ind.	6. Flour, Meal & Other Cereals
7. Bakeries	7. Breakfast Cer./Bakery Prod.
8. Vegetable Oil Mills	8. Vegetable Oils and Fats
9. Miscellaneous Food Industries	9. Miscellaneous Food Products
10. Soft Drink Manufacturers	10. Soft Drinks
11. Margarine and Shortening	
12. Alcoholic Beverages	

Source: Kulshreshtha, S.N., and M.T. Yap. The Prarie Regional Input-Output and Employment Model. PFRA, August 1985.

Though the classifications describe very clearly the separate identities of farm sectors and commodities, there is nevertheless a strong correlation between the two. This link between sector and commodity is even more evident among food processing industries. The advantages of the rectangular format over the square format are most evident when irrigation sectors are identified since irrigation farms tend to produce a more varied range of commodities than dryland farms (e.g. grains, cash crops, forages, livestock) and the production functions (i.e., technological structure) for each of these commodities can vary significantly from their dryland counterparts.

Nevertheless, industries and commodities can be further differentiated, as was demonstrated by Thomassin and Andison (1987). The express purpose of their study was to disaggregate the Canadian I-O model agricultural sector/commodity classes. The report lists 12 primary sectors producing 19 commodities, and 17 secondary agricultural sectors producing 69 commodities.

The computer program used to operationalize the I-O model[19] (i.e., to calculate the direct and inverse matrices, and to derive the multiplier estimates) is designed for the square I-O format, nevertheless, the availability of this specific package was not a major factor in the initial selection of an I-O model format. Had the rectangular format been chosen, several other computer packages/systems could have been

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19 The program, IO/EAM (An Input-Output Economic Assessment Model), and was developed by Jordan, Brooks, and Lee (1985). A summary of the program is provided in Jordan, Brooks, and Lee (1984). The software package is designed for IBM-comapatable personal computers with more than 64K of memory. It can accommodate an I-O model with up to 50 economic sectors.

utilized to undertake the necessary computations (see Gould, Sampson, and Kulshreshtha, 1983b). In addition, the program used in this study could be utilized for most of the computations once an additional matrix algebra package is used to calculate the product of the m x n direct requirements coefficients matrix and the n x m market share coefficients matrix.

4.2.3 Model Approach

The modelling approach adopted for this study drew upon many of the examples reviewed in section 3.0, particularly the GRID approach developed by Jensen, Mandeville, and Karunaratne (1979) described in section 3.4.1. A major difference is that GRID begins with a national I-O model and supplements it with regional data where possible while the approach taken here was to collect as much regional data as possible first and then to fill in the holes in the transactions table with national technical coefficients adjusted to reflect regional import propensities. As well, the adjusted technical coefficients (termed regional input coefficients) were factored upwards according to regional total production statistics. In summary, the main steps were:

1. Collect regional transactions data (revenue and expenditures) to the fullest extent possible.

2. Reconcile rows and column data - expenditure data was generally more reliable, therefore column data was usually selected over rows data (see section 3.3.3).

3. Assemble national technical coefficients for sectors lacking in regionally specific data.

4. Conduct surveys to determine the adjustment factor to convert technical coefficients to regional input coefficients (see sections 2.3.3 and 3.2).

5. Collect regional total output data for all sectors from secondary data publications.

6. Multiply regional input coefficients by regional total output figures to obtain transactions figures for sectors lacking in regional data.

7. Adjust regional transactions data collected from primary sources to reflect the total regional output as indicated in secondary data sources.

An important consideration was whether to adopt some form of model adaptation to reduce data requirements (e.g., a hybrid model which combines some rows resulting in a rectangular matrix). It was decided that this type of adaptation was not necessary in this study. Firstly, the number of economic sectors to be identified in the project was small (12). Secondly, the region was small, consequently the number of businesses needing to be surveyed was managable. Thirdly, the project was initiated by local agricultural interests; therefore, community cooperation would be higher than if the project was independently initiated. The membership of the agricultural interest group Agriscope commited themselves to assist in the collection of agricultural transactions data. This data represents almost half of the cells within the transactions matrix. Furthermore, these sectors are the main focus of the project. Cooperation for data collection was also offered by representatives of two other key sectors; the national defence base and local governments. Had there been a need to disaggregate the number of sectors further, or the region been larger, model adaptations would have been considered more intently.

4.3 The Structure of the Regional Economy

4.3.1 Regional Economic Sectors

The transactions table constructed for the Chilliwack region is provided in Table 4.4. The four categories of primary agriculture were selected on the basis of total output. Since I-O models deal with 'average' statistics, it is important to prevent the total of any one sector from being considerably smaller than that of the other sectors. The reason for this is that the multipliers of very small sectors would be made ineffective. The larger sectors would likely be able to accommodate changes in the smaller sector's spin-off economic activity without requiring significant changes in its own structure. The largest category of primary agriculture is the dairy industry. Two other livestock industries, swine and poultry, also warranted separate economic classifications. The final category includes all crops. This category could not be further disaggregated because (a) the wide variety of crops grown in the area means that the total output of any one crop is relatively small compared with other economic sectors and (b) it is difficult to assemble unique data for individual crops as several types of crops are grown on any given crop farm. Initially, a separate category for forage crops was included in the transactions table but it proved to be too difficult to distinguish the revenues and expenditures accruing to this crop. In the above table, forage crops are represented as a value added component of the dairy sector.

The three fruit and vegetable processors located within the study area boundaries had a combined total output large enough to warrant a separate economic classification. The remaining local food processing

TABLE 4.4 CHILLIWACK AREA TRANSACTIONS TABLE ($1000)

Purchasing Sector / Producing Sector	1 All crops	2 Dairy	3 Swine	4 Poultry	5 Forestry	6 Fruit & veg. proc.	7 Food/ bev/feed proc.	8 Manuftd forest prod.	9 Other primary & mnfg.	10 All services & trade	11 Nat'l Defence
1. All crops	0	0	0	0	0	15,275	0	0	0	1,535	0
2. Dairy	0	3,356	0	0	0	0	16,530	0	0	2,522	0
3. Swine	0	0	54	0	0	156	0	0	0	526	0
4. Poultry	0	0	0	0	0	52	0	0	0	51	0
5. Forestry	0	0	0	0	456	0	0	2,380	0	0	0
6. Fruit/vegetable proc.	0	0	0	0	0	0	0	0	0	2,019	0
7. Food/bev/feed proc.	1,018	12,541	5,725	986	0	0	0	0	0	11,387	180
8. Mnfd forest prod.	0	0	0	0	0	0	0	715	272	6,971	0
9. Other manufacturing	459	184	53	0	684	0	0	1,299	438	6,368	90
10. All services/trade	4,036	7,029	983	747	21,347	6,964	4,003	6,007	5,609	22,804	8,748
11. National defence	0	0	0	0	0	0	0	0	0	215	0
12. Local government	94	841	62	47	322	331	365	224	141	11,035	0
Total Intermediate	5,607	23,951	6,877	1,780	22,809	22,778	20,898	10,625	6,460	65,433	9,018
13. Households	6,228	16,741	647	1,068	20,815	12,655	7,823	14,195	7,867	116,708	40,394
14. Prov. & fed. gov't	74	303	0	37	8,469	740	557	458	565	10,621	0
15. Other value added	4,470	23,786	2,354	1,659	12,105	6,367	5,042	4,759	3,129	83,217	98
- R of B.C.	1,967	8,636	2,322	4,828	15,706	31,598	17,959	19,674	13,026		12,198
16. Imports - R of Cda	0	0	0	0	0	5,926	31,874	459	1,372	172,336	1,589
- Foreign	0	2,333	0	0	0	1,994	6,182	5,386	2,410		0
Total Primary Inputs	12,739	51,799	5,323	7,592	57,095	59,280	69,437	44,931	28,369	382,882	54,279
17. Total	18,346	75,750	12,200	9,372	79,904	82,058	90,335	55,556	34,829	448,315	63,297

TABLE 4.4 (cont.) CHILLIWACK AREA TRANSACTIONS TABLE ($1000)

Producing Sector / Purchasing Sector	12 Local gov't	Total Intermediate	13 Households	14 Prov. & fed. gov't	15 Other final demand	Rest of B.C.	16 Exports Rest of Canada	Foreign	Total Final Demand	17 Total
1. All crops	0	16,810	0	0	0	1,536	0	0	1,536	18,346
2. Dairy	0	22,408	0	0	1,440	51,902	0	0	53,342	75,750
3. Swine	0	736	0	1,106	0	10,358	0	0	11,464	12,200
4. Poultry	0	103	0	66	0	9,203	0	0	9,269	9,372
5. Forestry	0	2,836	0	0	6,712	65,964	0	4,392	77,068	79,904
6. Fruit/vegetable proc.	0	2,019	0	0	574	22,991	55,100	1,374	80,039	82,058
7. Food/bev/feed proc.	0	31,837	4,231	0	915	53,352	0	0	58,498	90,335
8. Mnfd forest prod.	0	7,958	896	174	1,462	11,761	12,990	20,315	47,598	55,556
9. Other manufacturing	0	9,575	0	0	877	19,657	4,670	50	25,254	34,829
10. All services/trade	19,996	108,273	305,711	10,000	4,000	0	20,331	0	340,042	448,315
11. National defence	0	215	5,912	57,170	0	0	0	0	63,082	63,297
12. Local government	2,623	16,085	15,059	8,599	1,951	1,767	2	0	27,378	43,463
Total Intermediate	22,619	218,855	331,809	77,115	17,931	248,491	93,093	26,131	794,570	1,013,425
13. Households	7,877	253,018	16,726	153,579	84,011	81,104	714	355	336,489	589,507
14. Prov. & fed. gov't	6,923	28,747	112,978						112,978	141,725
15. Other value added	3,608	150,594	84,317						84,317	234,911
- R of B.C.	2,125	130,039	28,946						28,946	158,985
16. Imports - R of Cda	311	213,867	9,543						9,543	223,410
- Foreign	0	18,305	5,188						5,188	23,493
Total Primary Inputs	20,844	794,570	257,698	153,579	84,011	81,104	714	355	577,461	1,372,031
17. Total	43,463	1,013,425	589,507	230,694	101,942	329,595	93,807	26,486	1,372,031	2,385,456

industries, including feed manufacturers, dairy processors, and meat processors, were combined into the second category.

The breakdown of the remainder of the economic sectors was based on several considerations. Again, total output was the chief criterion. Data availability was also paramount. Since provincial statistics would have to be used as proxies for regional characteristics in many instances, these remaining sectors were modelled after provincial classifications. A third important consideration was to place emphasis on exporting economic sectors since the regional I-O model is 'driven' primarily by exports out of the region.[20]

Primary forestry activity is important to the region. Manufactured forest products is also a large economic category. Likewise, national defence and local government each involve significant levels of regional economic activity. Though these two sectors are government institutions, they are primarily local in character. The final local economic sector, all services and trade, serves largely as a residual category. Though this sector represents a diverse range of establishments, they are all chiefly geared towards serving the local economy and population and are not 'export' orientated. More specifically, the economic sectors within this broad sector include construction, communications, utilities, retail, wholesale, finance, insurance, real estate, and business/personal services. It would have been more desirable to further disaggregate this

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20 'Exports' are usually the main source of final demand. The exceptions are government-related economic sectors (National Defence and municipal government) which receive a high proportion of total revenue from senior government levels.

sector but limited resources ruled out this option. The magnitude of these sectors is illustrated in Figure 3.

Four categories of final demand are identified; households, provincial and federal government, exports, and the residual category 'all other final demand'. The residual category includes capital investment, inventory changes, and 'unallocated' revenue.

Primary inputs similarly consists of the four categories; households, provincial and federal government, imports, and the residual category 'all other primary inputs'. This residual category includes items such as depreciation, inventory depletion, rent, interest payments, payments to profits, and 'unallocated' payments.

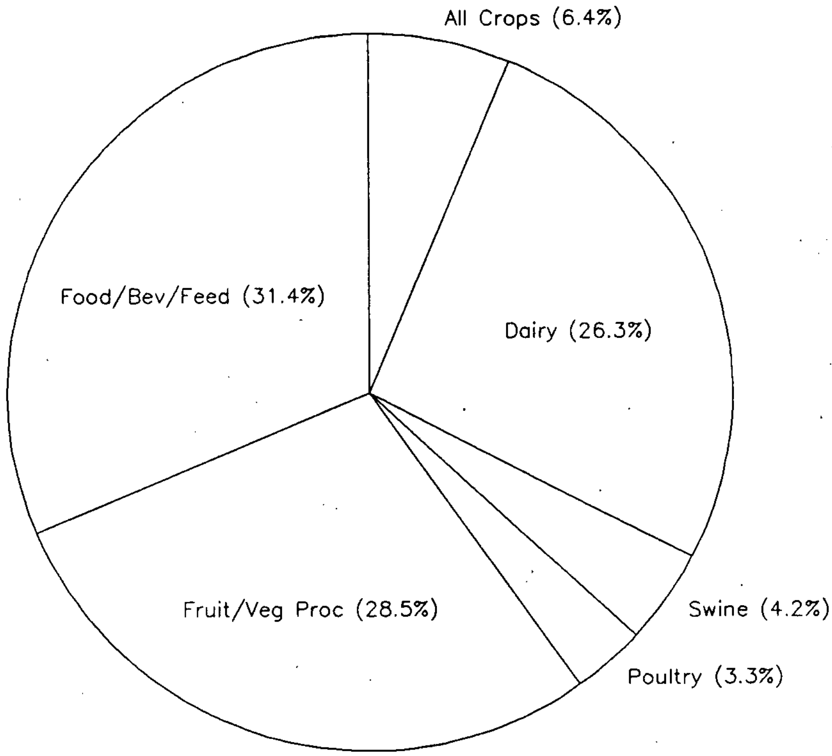
4.3.2 Data Sources

The number and quality of data sources varies for each economic sector. Below is a brief description of the data sources utilized for each sector.

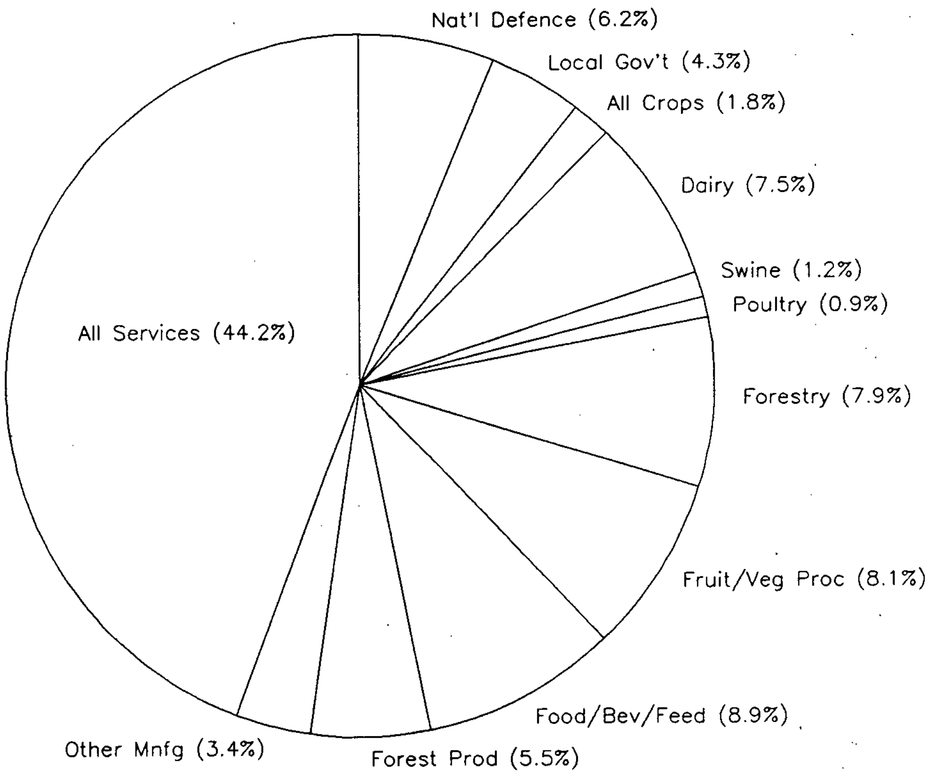
Since the primary goal of this study is to assess the economic impact of the agricultural community on the local economy, a higher degree of effort was extended to the collection of agricultural trade data. In addition to the usual published data sources, such as census information and provincial statistics, a number of primary data sources were developed. First, questionnaires were distributed to a group of local farmers and other local business persons knowledgeable in the make-up of the regional farming community. Second, summary statistics were provided by local professional accountants and bankers. This first-hand information was vital to the collection of acceptable data, particularly with regard to the destination of sales and the geographical

FIGURE 3 ECONOMIC SECTORS OF THE CHILLIWACK REGION

a) Agricultural Sectors – Primary and Secondary



b) All Economic Sectors – Agricultural, Manufacturing, and Services



location of purchases, i.e., information on regional imports and exports. It was used to directly estimate regional input coefficients (a_{ij}^{LL}) for the primary agricultural sectors.

Collection of reliable data for regional manufacturing sectors was also given a high priority as these sectors are export orientated and are thus important components of the area economic base. Special emphasis was placed on the collection of data concerning local food, beverage, and feed processors. Three page questionnaires were distributed to all area firms in this category and short interviews were held with various company representatives. Although the response to the questionnaires was only partially successful, the various interviews generated a substantial amount of useful information. Where information was still lacking, provincial statistics (averages) were used as proxies for regional characteristics (see section 4.2.3). The most recent provincial statistics were for either 1982 or 1983 and, therefore, needed to be inflated to 1984 dollars. Together, the primary and secondary data sources provided sufficient information with which to estimate reasonably reliable averages for the two regional food and beverage manufacturing sectors identified in this study.

The remaining regional manufacturing firms were divided into two categories; forest product manufacturers and all others. The three page questionnaire was distributed to over half of the regional manufacturers in these two categories but the response was very poor. As a back-up plan, a telephone survey was conducted over about 80 percent of the area manufacturers. The response rate to this survey was very high - almost 100 percent. Since information concerning the location of sales and purchases is most critical to I-O analysis, the following three questions were asked.

1. Of all of your expenditures on goods and services, what percentage are purchased from:
    a. regional suppliers;
    b. suppliers in the rest of British Columbia;
    c. suppliers in the rest of Canada;
    d. foreign suppliers?
2. What percentage of your sales are to persons or establishments:
    a. within the region;
    b. within the rest of British Columbia;
    c. within the rest of Canada;
    d. outside of Canada?
3. How many employees, on average, were employed by your firm in 1984?

Though this survey provided ample data on the location of sales and expenditures, it provided no information on the level of revenue and expenditures. Instead, national averages adjusted by regional trade coefficients were used as proxies, or best estimates, of regional characteristics. First, each firm was assigned to the appropriate four digit standard industrial classification. Next, the national average revenue and expenditure profiles for a firm of that size and type were applied to the firm. Again, these were 1982 or 1983 statistics and therefore needed to be inflated to 1984 dollars. Finally, the survey-generated trade coefficients were applied to the revenue and expenditure profiles to derive the estimated regional trade flows.

The revenue and expenditure accounts of the national defense and local government economic sectors were based completely on primary data. The national defense base representative provided complete accounts of annual revenue and expenses, and made estimates of regional trade coefficients. The data for the five area local governments were derived primarily from annual fiscal reports; however, several administrators provided vital information concerning the categorization, location, and appropriate corresponding household sector of revenue and expenditures.

The least reliable revenue and expenditure estimates are those for the 'all other services and trade' sector. Some of the cell entries are quite reliable as they are the double entry accounts of some other local sector. For example, the purchases of the services sector from the poultry sector are determined through the revenue data provided by the local poultry sector. However, regional data was not readily available for some of the other cells. In particular, the level of trade amongst local service enterprises (row 10, column 10) was not easy to estimate and little regional information was available for each of the corresponding entries of final demand and primary inputs.

As a proxy, detailed output/employment ratios based on provincial statistics and regional employment levels were used to estimate the total regional output of the services sector. The difference between this total and the several cell entries obtained by double entry accounting were allocated to the empty cells in the revenue and expenditure accounts of the service sector. Although most of the allocations were based on various examples at the provincial and at regional levels, some of the allocation decisions were completely arbitrary. The most important cases were the import and export trade values. While no information was available upon which to base this allocation, it is reasonable to assume that the retail sector imports almost all of its goods from outside of the region and it exports relatively little. This estimate will have a direct and substantial impact on the size of the service/trade sector multipliers generated by the I-O model.

An additional point concerns the method by which sales and purchases are recorded. The two methods from which to choose are (a) to record transactions at producers' prices or (b) at purchasers' prices. In the first case, the purchaser of the good or service is shown to pay for the trade margin - the transportation and distribution markup incurred to move the good between the producer and the purchaser. In the second case, the producer is shown to pay for this trade margin. In this study, every effort was made to represent all transactions in purchasers' prices since it is easier to formulate survey questions along this line. It is more common, however, for I-O studies to list producers' prices.

The transactions table shown in Table 4.4 uses these initial regional estimates for each of the economic sectors. However, upon review, some of the estimated entries of the services and trade sector appeared to be too small. In order to test how sensitive the I-O multipliers are to the trade values represented in that sector, the total output of the sector was arbitrarily increased by $80 million (18 percent). These new monies were allocated at will amongst the above mentioned estimated cell entries. A new set of multiplier estimates was then calculated. With the open model, i.e., with households treated as a category of final demand, no change at all occurred in either the rank or magnitude of the output multipliers. With the closed model, i.e., with households treated as a local economic sector, the rank of the output multipliers remained unchanged and only one of twelve changed in magnitude, but by only 0.01, or 0.5 percent. These findings indicate that the model is not sensitive to the magnitude of the estimates of trade values in the services and trade sector. The reason is the high rate of importation assigned to that section.

In view of its size, it was also deemed important to gather primary trading information with regard to the household sector. Ideally, a complete survey of expenditure practices would be conducted. However, limited resources made this impossible. As a second best effort, the provincial average expenditure profile was assumed to be fairly representative of the Chilliwack area and a survey was conducted to determine only the location of expenditures. This survey was conducted over 78 area households. Each household was asked to identify the geographical pattern of expenditures in fifteen different categories of consumption items. For each category, the household was asked to identify what percentage of their budget for items in that category is spent; (a) in the region, (b) in the rest of B.C., (c) in the rest of Canada, and (d) in other countries. The average response to the survey was then applied to the average provincial household expenditure profile.

Data for revenue from and payments to provincial and federal governments were obtained from both primary sources (surveys and fiscal reports) and from provincial averages.

In summation, a great deal of data, primary and secondary, were collected to undertake this study, a demanding task considering the very limited human resources available. Though the quality of data for most sectors is respectable, additional research resources would have enabled the collection of more reliable data.

4.3.3 The Regional Transactions Table

The regional transactions table (Table 4.4) shows how money flows into the local economy and how it then circulates for a short time before it eventually flows out of the local economy in the form of payments for imports. Of the eleven base economic sectors (excluding services and trade), the sector representing 'other food, beverage, and feed processors' has the largest output with total sales estimated at $90,335,000. This sector includes feed manufacturers, meat processors, and dairy processors.

To review how the table is interpreted, we will examine in detail the accounts of this sector. Beginning with revenues (i.e., reading across row 7), the sales of this sector to local dairy farms in 1984 totaled $12,541,000. The largest component of this involves the sale of feed by local feed processors to local dairy farms. Similarly, this combined manufacturing sector recorded sales of $1,018,000, $5,725,000, and $986,000 respectively to the crops, swine, and poultry sectors. Sales to the crops sector includes fertilizer which is an associated output of the feed manufacturing sector. In addition, it is estimated that total sales in 1984 to local retailers and other service sector firms amounted to about $11,387,000. Large components of these sales include the sale of meat and dairy products to local retailers. Intermediate sales to local firms totaled $31,837,000.

The remainder of the sales were to final demand. Direct sales to households totaled $4,231,000. As well, the 'other final demand' category (receipts for rent, inventory additions, etc.) accounted for about $915,000 of revenue. But the biggest component of final demand was exports, sales of about $53,352,000 primarily to retail outlets in other regions within the lower mainland.

The expenditures of this sector are listed in column 7. Dairy processors purchased about $16,530,000 worth of milk from regional dairy farms. The sector also purchased about $4,003,000 worth of products from area retailers and business firms and paid $365,000 to local governments as payments for taxes, licenses, etc. Total payments to local firms for intermediate products and services amounted to $20,898,000.

The remaining entries in column 7 represent payments of the food processing sector for 'primary inputs'. Labour received about $7,823,000 and the provincial and federal governments received about $557,000. 'Other value added' payments (depreciation, interest payments, profits, etc.) amounted to approximately $5,042,000. The largest component of primary inputs, however, is imports, which accounted for about $56,015,000, or 62 percent, of total expenditures.

Other sectors with particularly large outputs include, in descending order, the fruit and vegetable processing sector, primary forestry (logging), dairy farms, and the national defense base with total outputs (in thousands of dollars) of 82,058, 79,904, 75,750, and 63,297 respectively. Excluding the services and trade sector, primary agriculture accounts for about 20 percent of total regional output, or $115,668,000. The two food processing sectors together account for about 30 percent of total regional output, or $172,393,000. The national defense base, by itself, accounts for about 11 percent of regional revenue, again excluding the services and trade sector. Non-agricultural manufacturing accounts for about 16 percent of regional output, or $90,385,000.

The table also shows that for every sector, except crops, service/trade, national defence, and local government, exports account for a very large proportion of total output/revenue (reading down columns 16 and 17). This is a result of the small size of the study area. The national defense base, on the other hand, receives most of its revenue from the federal government, another category of final demand. With households treated as a local economic sector, only the crops, the services and trade, and the local government sectors receive the majority of their revenue from within the study area; the crops sector from the fruit and vegetable processors, and the service sector from local households and, to a lesser extent, from local businesses. For local government, revenue is generated almost evenly from local businesses and households.

Imports are a very large portion of total expenditures for six of the twelve economic sectors (sector numbers 4, 6, 7, 8, 9, and 10). These imports represent leakage of money out of the region. The magnitude of this leakage has a direct (reciprocal) relationship to the size of the economic multipliers, which are essentially a measure of the backward linkages between sectors - of how long money circulates within a region. The total multiplier is a measurement of the spin-off economic activity of dollars spent on goods and services by final users net of leakages. Therefore, large import numbers lead to small multipliers.

The most common way for money to leak out of the economy is through household expenditure on goods and services 'imported' into the region. Other factors, such as taxes and capital investment, also constitute leakage of money out of the local economy. While households may spend most of their income within the Chilliwack region, the main recipient of this spending, the retail sector, imports a very high proportion of their inputs (i.e., has a large import coefficient). Nevertheless, all sectors import some percentage of their inputs. The import coefficient estimates for the thirteen local economic sectors (including households) are provided in Table 4.5. The import coefficient for a sector is its expenditures on imports divided by its total expenditures (reading down columns of the transactions matrix). The intra-regional trade

TABLE 4.5 IMPORT AND TRADE COEFFICIENTS, CHILLIWACK REGION

Sector	Import Coefficient[a]	Rank	Intra-regional Trade Coefficient[b]
1. All Crops	0.11	11	0.89
2. Dairy	0.14	10	0.85
3. Swine	0.19	9	0.81
4. Poultry	0.52	2	0.48
5. Forestry	0.20	8	0.70
6. Frt/Veg Processing	0.48	3	0.51
7. Food/Bev Processing	0.62	1	0.37
8. Forest Prod. Manftg.	0.46	5	0.53
9. Other Manufacturing	0.48	3	0.50
10. Services/Trade	0.39	6	0.59
11. National Defence	0.22	7	0.78
12. Local Government	0.06	13	0.78
13. Households	0.07	12	0.73

a) $\text{Import Coefficient} = \frac{\text{Import Expenditures}}{\text{Total Expenditures}}$

b) $\text{Intra-Regional Trade Coefficient} = \frac{\text{Local Expenditures}}{\text{Total Expenditures}}$

coefficient, by contrast, is the sum of all local expenditures divided by total expenditures. In addition to imports, the trade coefficients also exclude payments to provincial and federal governments. The sum of these two coefficients will therefore usually be less than unity.

4.4 Regional Multipliers

The transactions matrix is a picture of an economy over the course of a year. Input-output analysis uses this transactions matrix to estimate the impact of changes in one economic sector on the overall economy. As outlined in section 2.2, the transactions matrix is first transformed into a direct coefficients matrix by dividing each of the cells in the matrix by the corresponding column total. Each expenditure item of an economic sector is divided by the total output value of that sector resulting in a table of input requirements per dollar of output for each local sector. The direct requirements matrix for the Chilliwack area is presented in Table 4.6.

As an example, column 2 of Table 4.6 lists the inputs of the dairy sector required to produce a dollar's worth of output. In the Chilliwack area, the dairy sector, on average, spends 16.6¢ for every dollar's worth of output on goods and services from the food/beverage/feed processing sector, primarily feed and fertilizers. As well, it purchases 9.3¢ worth of goods and services from other local trade and service establishments. Wages for hired labour and family farm profits together account for 22.1¢. The largest expenditure item is imports plus other value added at 45.9¢.[21] This last category, combined with payments to government, are the primary inputs - they do not contribute to the economic spin-off effect.

As another example, column 6 represents the expenditures of the fruit and vegetable processing sector required to produce one dollar's worth of output. This sector makes significant payments to two local economic sectors; 18.6¢ to the local farm crop sector for a portion of its fruit and vegetable inputs and 8.5¢ to the trades and services sector. Labour wages alone account for 15.4¢. Again, the primary inputs of imports and other value added, which include profits, account for the largest proportion of payments.

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21 The computer sofware program used in this study required that the imports and the all other value added categories be combined into one cateogry. This has no effect on the size of the multiplier estimates.

TABLE 4.6 CHILLIWACK AREA DIRECT REQUIREMENTS MATRIX[a,b]

	1	2	3	4	5	6	7	8	9	10	11	12	13 Households
	I												II
1	0.000	0.000	0.000	0.000	0.000	0.186	0.000	0.000	0.000	0.003	0.000	0.000	0.000
2	0.000	0.044	0.000	0.000	0.000	0.000	0.183	0.000	0.000	0.006	0.000	0.000	0.000
3	0.000	0.000	0.004	0.000	0.000	0.002	0.000	0.000	0.000	0.001	0.000	0.000	0.000
4	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000
5	0.000	0.000	0.000	0.000	0.006	0.000	0.000	0.043	0.000	0.000	0.000	0.000	0.000
6	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.005	0.000	0.000	0.000
7	0.055	0.166	0.469	0.105	0.000	0.000	0.000	0.000	0.000	0.025	0.003	0.000	0.007
8	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.013	0.007	0.016	0.000	0.000	0.002
9	0.025	0.002	0.004	0.000	0.009	0.000	0.000	0.023	0.013	0.014	0.001	0.000	0.000
10	0.220	0.093	0.081	0.080	0.267	0.085	0.044	0.108	0.161	0.051	0.138	0.460	0.519
11	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.010
12	0.005	0.011	0.005	0.004	0.004	0.004	0.004	0.004	0.004	0.025	0.000	0.060	0.026
	III												IV
13	0.339	0.221	0.053	0.114	0.261	0.154	0.087	0.256	0.226	0.260	0.638	0.181	IV 0.028
14	0.351	0.459	0.383	0.692	0.348	0.559	0.676	0.545	0.572	0.570	0.219	0.139	0.217
15	0.004	0.004	0.000	0.004	0.106	0.009	0.006	0.008	0.016	0.024	0.000	0.0159	0.192
16 TOTAL	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

a) Columns represent the purchases or payments required to produce $1.00 of sector output.
b) Column totals in this and subsequent tables may not add due to rounding errors in the computor program.

TABLE 4.7 INVERSE MATRIX OF THE CHILLIWACK REGIONAL INPUT-OUTPUT MODEL - TYPE I MULTIPLIERS[a,b]

	1	2	3	4	5	6	7	8	9	10	11	12
1	1.0011	0.0005	0.0005	0.0004	0.0012	0.1867	0.0003	0.0006	0.0008	0.0046	0.0006	0.0022
2	0.0138	1.0820	0.0946	0.0219	0.0033	0.0038	0.1986	0.0015	0.0020	0.0121	0.0022	0.0059
3	0.0003	0.0001	1.0046	0.0001	0.0003	0.0021	0.0001	0.0002	0.0002	0.0013	0.0002	0.0006
4	0.0000	0.0000	0.0000	1.0000	0.0000	0.0007	0.0000	0.0000	0.0000	0.0001	0.0000	0.0001
5	0.0002	0.0001	0.0001	0.0001	1.0059	0.0001	0.0001	0.0437	0.0005	0.0007	0.0001	0.0004
6	0.0011	0.0006	0.0006	0.0004	0.0013	1.0006	0.0003	0.0006	0.0008	0.0048	0.0007	0.0024
7	0.0643	0.1824	0.4903	0.1113	0.0082	0.0156	1.0348	0.0038	0.0050	0.0302	0.0071	0.0148
8	0.0041	0.0020	0.0020	0.0015	0.0047	0.0023	0.0012	1.0154	0.0109	0.0171	0.0024	0.0084
9	0.0291	0.0045	0.0065	0.0015	0.0131	0.0068	0.0016	0.0264	1.0156	0.0162	0.0037	0.0079
10	0.2481	0.1237	0.1248	0.0961	0.2930	0.1400	0.0725	0.1370	0.1788	1.0767	0.1493	0.5272
11	0.0001	0.0001	0.0001	0.0000	0.0001	0.0001	0.0000	0.0001	0.0001	0.0005	1.0001	0.0003
12	0.0125	0.0168	0.0120	0.0086	0.0122	0.0091	0.0087	0.0083	0.0092	0.0287	0.0040	1.0783
TOTAL	1.3746	1.4128	1.7360	1.2420	1.3435	1.3679	1.3180	1.2377	1.2238	1.1929	1.1704	1.6483

a) For the calculation of Type I output multipliers (excludes household effect).
b) Columnar totals represent the regional output multipliers:
Output multiplier = increase in total regional output resulting from a $1.00 increase in sectoral output.

TABLE 4.8 INVERSE MATRIX OF THE CHILLIWACK REGIONAL INPUT-OUTPUT MODEL - TYPE II MULTIPLERS[a,b]

	1	2	3	4	5	6	7	8	9	10	11	12	13 Households
	I												II
1	1.0024	0.0014	0.0010	0.0009	0.0023	0.1875	0.0008	0.0016	0.0016	0.0055	0.0027	0.0033	0.0031
2	0.0179	1.0849	0.0961	0.0234	0.0067	0.0064	0.2001	0.0047	0.0048	0.0151	0.0090	0.0093	0.0099
3	0.0007	0.0004	1.0047	0.0002	0.0006	0.0023	0.0002	0.0004	0.0005	0.0015	0.0008	0.0009	0.0009
4	0.0001	0.0000	0.0000	1.0000	0.0001	0.0007	0.0000	0.0000	0.0000	0.0002	0.0001	0.0001	0.0001
5	0.0004	0.0003	0.0002	0.0002	1.0061	0.0002	0.0001	0.0439	0.0006	0.0009	0.0005	0.0006	0.0006
6	0.0025	0.0015	0.0011	0.0009	0.0024	1.0015	0.0008	0.0016	0.0017	0.0058	0.0029	0.0035	0.0032
7	0.0768	0.1910	0.4948	0.1160	0.0185	0.0233	1.0393	0.0131	0.0133	0.0391	0.0272	0.0249	0.0295
8	0.0098	0.0059	0.0041	0.0036	0.0093	0.0057	0.0032	1.0196	0.0146	0.0211	0.0115	0.0129	0.0133
9	0.0336	0.0077	0.0082	0.0032	0.0168	0.0096	0.0032	0.0298	1.0186	0.0193	0.0110	0.0115	0.0108
10	0.5525	0.3337	0.2353	0.2083	0.5425	0.3273	0.1838	0.3636	0.3816	1.2936	0.6389	0.7721	0.7193
11	0.0056	0.0038	0.0020	0.0021	0.0046	0.0034	0.0020	0.0041	0.0037	0.0044	1.0087	0.0047	0.0129
12	0.0351	0.0324	0.0202	0.0168	0.0306	0.0230	0.0170	0.0251	0.0242	0.0448	0.0403	1.0964	0.0533
	III												IV
13	0.5303	0.3659	0.1925	0.1955	0.4346	0.3263	0.1939	0.3947	0.3532	0.3780	0.8529	0.4268	1.2530
TOTAL	2.2676	2.0289	2.0601	1.5711	2.0753	1.9172	1.6446	1.9023	1.8185	1.8294	2.6065	2.3669	2.110

a) For the calculation of Type II output multipliers (includes household effect).
b) Columnar totals represent the regional output multipliers:
Output multiplier = increase in total regional output resulting from a $1.00 increase in sectoral output.

The next step in the I-O modelling process is to calculate the inverse matrices. Table 4.7 lists the inverse matrix for the Type I I-O model. The output multiplier for each sector is determined by summing the respective column entries. As outlined in section 2.2, the output multiplier for the Type I I-O model represents the direct and indirect ripple effects of output growth in a given local economic sector. In other words, this output multiplier illustrates the spin-off effects of local inter-industry trade. It does not include the effects resulting from increased household spending.

Table 4.8 lists the inverse matrix for the Type II I-O model. The Type II output multipliers, like the Type I multipliers, are the respective column totals. These multipliers represent the direct, indirect, and induced ripple effects of output growth in a given economic sector. They illustrate the spin-off effects of local inter-industry trade plus the effect of increased spending by local households brought about by increased earnings. While Type I output multipliers are useful in the ranking of local industries in terms of economic impact, the Type II multipliers better represent what actually takes place in a regional economy. Research has suggested that the Type I multipliers tend to underestimate the 'true' economic impact of changes in the economy while Type II multipliers tend to overestimate it; therefore, both forms are usually presented to help provide a balanced view in the impact analysis.

The Type I output multipliers are listed more clearly in Table 4.9. This Table also lists the labour/output ratio and the Type I employment multipliers. The employment multiplier assumes a constant labour/output ratio. Because this is a pilot study, resources were not available to gather detailed employment data for each economic sector. Instead, crude

TABLE 4.9 ECONOMIC MULTIPLIERS - TYPE I INPUT-OUTPUT MODEL (excluding households)

Sector	Output Multiplier And Rank [a]	Labour/output Ratio [b]	Employment Multiplier And Rank [c]
1. All Crops	1.37 - 4	0.0340	1.30 - 10
2. Dairy	1.41 - 3	0.0150	1.54 - 8
3. Swine	1.74 - 1	0.0110	2.04 - 2
4. Poultry	1.24 - 8	0.0120	1.43 - 9
5. Forestry	1.34 - 6	0.0154	1.72 - 4
6. Frt/Veg Processing	1.37 - 4	0.0106	2.12 - 1
7. Food/Bev Processing	1.32 - 7	0.0106	1.58 - 7
8. Forest Prod. Manftg.	1.24 - 8	0.0106	1.59 - 6
9. Other Manufacturing	1.22 - 10	0.0106	1.65 - 5
10. Services/Trade	1.19 - 11	0.0351	1.13 - 12
11. National Defence	1.17 - 12	0.0380	1.15- 11
12. Local Government	1.65 - 2	0.0257	1.82 - 3

a) Output multiplier = increase in total regional output resulting from a $1.00 increase in sectoral final demand.

b) Labour/Output Ratio = $\frac{\text{Total Labour Expenditures}}{\text{Total Output}}$

c) Employment multiplier = increase in regional full-time equivalent employment positions for every job created in a sector.

estimates were derived from 1981 regional labour force statistics. In addition, general estimates were made as to the allocation of hired labour amongst the four primary agricultural sectors, with the majority being assigned to the crops sector. Finally, each of the manufacturing sectors was assigned the same labour/output ratio since individual statistics were not available. In view of these limitations, the employment multiplier estimates are not considered to be as reliable as the output multiplier estimates.

The sector which exhibits the largest output multiplier effect is the swine sector. The interpretation of the multiplier is that for every dollar increase in final demand for swine production (e.g., for every dollar increase in exports), total regional output will increase by $1.74. The reason for this large multiplier is that this sector buys a larger proportion of its inputs, particularly feed, from local suppliers.

The next largest output multiplier is that of local government at 1.65. An explanation for this is that local governments have a policy to buy from local suppliers and to hire local services.

The remaining three primary agricultural sectors also demonstrate relatively large multiplier effects; 1.41, 1.37, and 1.24 for the dairy, crops, and poultry sectors respectively. Out of twelve local economic sectors, primary agricultural output multipliers rank 1st, 3rd, and are tied for 4th and 8th.

The fruit and vegetable processing sector also demonstrates a relatively strong multiplier effect at 1.37, even with the crops sector at rank 4. The 'all other food, beverage, and feed processing' sector is close behind with a multiplier of 1.32. These two food processing sectors have significantly higher multiplier effects than the other two manufacturing classifications because a higher proportion of their expenditures for goods and services are made locally.

The trade/services and national defence sectors have the lowest multipliers because they both have relatively weak ties, or backward linkages, with other local industries. They each spend a smaller percentage of their total expenditures on goods and services from regional suppliers than do the other sectors. Instead, these two sectors are relatively labour intensive - a larger proportion of their expenditures is for labour rather than for goods and services. Consequently, the induced multiplier effect (due to increased household spending) will be relatively greater for these two sectors than for the others as is shown later in this section.

As for the employment multipliers, the fruit and vegetable processing industry takes top spot at 2.12. The interpretation of this multiplier is that for every job created in this sector, total regional employment will, on average, increase by 2.12 full-time equivalents (FTE), or person-years. This sector has a high employment multiplier because it has a strong link to a local sector with a relatively large labour/output ratio - the crops sector.

The swine sector also has a large employment multiplier - 2.04. Again, this multiplier is large because the swine sector purchases a larger proportion of its inputs locally than do other sectors. If this sector were to increase production significantly, then other local sectors would be expected to grow, and thereby increase employment. However, if the swine sector were to increase production by only a small proportion, other sectors would no doubt be able to deal with the small increase in business with the same number of employees. The employment multipliers are therefore meaningful only for significant changes in final demand. This point also applies to the output and income multipliers, but to a lesser extent.

It should be noted, however, that multiplier estimates are quite sensitive to estimates of regional import and export propensities. Therefore, the validity of the high output multiplier observed for the swine sector is dependent on the accuracy of the trade flow data recorded in the survey. Although care was taken to validate the survey trade data through published sources and expert judgement, the rank and magnitude of the multiplier estimate generated in this study may be affected by survey biases to a greater extent than larger I-O studies due to manpower limitations.

An additional point of concern is the single multiplier estimate obtained for the highly aggregated 'all services and trade' sector. This sector served to some extent as a residual category. Since manpower limitations precluded surveying this broad sector, a rough estimate was made of inter-regional trade flows. While the high import and low export propensity assigned to this sector is no doubt valid for retail sectors, the largest of the combined sectors, it is likely not a valid estimate for some sectors, such as the tourist industry. The services/trade sector multiplier estimate should therefore be considered cautiously.

In addition to tables listing economic multipliers for both types of I-O model, the computer software program used in this study also calculates a number of other useful tables. Table 4.10 lists the dispensation of output by components of final demand. That is, estimates are made, based on constant trade coefficients, as to the final consumers of regional output.

The last column lists the total output of the twelve regional economic sectors identified in this study, the sum of which is the total intermediate sector trade. These are the same regional output levels identified by the last column of the transactions matrix. The table also lists three categories of final demand; personal consumption, investments/exports, and government. The second category is a combination of the exports and 'all other final demand' categories identified in the transactions matrix. The sum of the estimated consumption by each category of final demand for each sector is equal to the total output of that regional sector (rows).

TABLE 4.10 DISPENSATION OF OUTPUT BY COMPONENTS OF FINAL DEMAND

Sector	Local Consumption ($1000)	Investment Exports ($1000)	Government ($1000)	Total Output ($1000)
1. All Crops	1,442	16,801	102	18,346
2. Dairy	4,651	70,693	407	75,750
3. Swine	402	10,659	1,139	12,200
4. Poultry	40	9,264	69	9,372
5. Forestry	271	79,610	24	79,904
6. Frt/Veg Proc.	1,524	80,426	108	82,058
7. Food/Bev/Feed	13,886	75,062	1,388	90,335
8. Forestry Mnfg.	6,278	48,720	558	55,556
9. Other Mnfg.	5,077	29,302	450	34,829
10. Services/Trade	338,396	85,918	24,001	448,315
11. National Def.	6,074	41	57,182	63,297
12. Local Gov't	25,072	8,588	9,803	43,463
Total	403,113	515,083	95,229	1,013,425

Investments/exports are seen to be by far the largest consumption route for regional production in ten of the twelve local economic sectors. This highlights how important inter-regional trade is to the area economy. The two sectors not as heavily dependent on exports are the services/trade and national defence sectors, with local personal consumption and government respectively the main sources of final demand.

The next two tables to be reviewed are constructed to aid in the actual impact assessment of the regional economy. However, they are also useful in assessing the initial structure of the regional economy. Table 4.11 provides an analysis of aggregated final demand in the Type I I-O model. It essentially describes the 'impact' of the existing regional economy - of having the regional economy grow from nothing to its present (1984) state. Total regional output is provided in column 2.

TABLE 4.11 AGGREGATED FINAL DEMAND - TYPE I INPUT-OUTPUT MODEL (excluding households)

Sector	Projected Change In Regional Final Demand ($1000)	Projected Change In Regional Output ($1000)	Percent Change In Regional Output (%)	Projected Change In Household Income ($1000)	Projected Change In Regional Employment (No. FTE)
1. All Crops	1,536	18,346	100	6,228	624
2. Dairy	53,342	75,750	100	16,741	1,136
3. Swine	11,464	12,200	100	647	134
4. Poultry	9,269	9,372	100	1,068	113
5. Forestry	77,068	79,904	100	20,815	1,231
6. Frt/Veg Proc.	80,039	82,058	100	12,655	870
7. Food/Bev/Feed	58,498	90,335	100	7,823	958
8. Forestry Mnf.	47,598	55,556	100	14,195	589
9. Other Mnf.	25,254	34,829	100	7,867	369
10. Services/Trade	340,042	448,315	100	116,708	15,736
11. National Def.	63,082	63,297	100	40,394	2,405
12. Local Gov't.	27,378	43,463	100	7,877	1,117
Total Change	794,570	1,013,425		253,018	25,281

TABLE 4.12 CHANGE IN OUTPUT - TYPE I INPUT-OUTPUT MODEL (excluding households)

Sector	Projected Change In Regional Output ($1000)	Projected Change In Regional Final Demand ($1000)	Percent Change In Regional Final Demand (%)
1. All Crops	18,346	1,536	100
2. Dairy	75,750	53,342	100
3. Swine	12,200	11,464	100
4. Poultry	9,372	9,269	100
5. Forestry	79,904	77,068	100
6. Frt/Veg Processing	82,058	80,039	100
7. Food/Bev/Feed Proc.	90,335	58,498	100
8. Forest Prod. Manftg.	55,556	47,598	100
9. Other Manufacturing	34,829	25,254	100
10. Services/Trade	448,315	340,042	100
11. National Defence	63,297	63,082	100
12. Local Government	43,463	27,378	100
Total Change	1,013,425	794,570	

The amount of output going to final consumers rather than intermediate producers is listed in column 1. Column 3 indicates that the total (100%) impact of regional production is being assessed. Columns 4 and 5 indicate current regional (household) income and employment by sector. Current regional income is estimated at $253,018,000 and total regional employment is estimated at 25,281 persons. In section 5.0, this table will be used to assess the impact of future changes in the aggregated final demand of regional production.

Table 4.12 provides an analysis of regional output. The first two columns are the same as those of Table 4.11 only in reverse order. They list regional output by sector and the portion of output going to final demand. In section 5.0, this table will be used to estimate the changes in final demand required to bring about a specific change in output.

The above analysis deals with the Type I input-output model. Below are the corresponding tables for the Type II I-O model. The exact same procedure is repeated only the household sector is treated as a local economic sector.

Table 4.13 lists the Type II economic multipliers. The magnitude of these multipliers is larger than those of the Type I model because of the added effect of household spending. Moreover, the rank of the multipliers is considerably different than in the previous model. When household spending is also taken into account, the national defence sector has the largest output multiplier at 2.61. For every dollar injected into this sector by the federal government, overall regional output increases by $2.61. Also with large output multipliers are the local government and crops sectors. A primary reason why these sectors have larger output multipliers than other sectors is because they spend a

TABLE 4.13 ECONOMIC MULTIPLIERS - TYPE II INPUT-OUTPUT MODEL (including households)

Sector	Output Multiplier And Rank [a]	Income Multiplier And Rank [b]	Employment Multiplier And Rank [c]
1. All Crops	2.27 - 3	1.56 - 9	2.35 - 11
2. Dairy	2.03 - 7	1.66 - 8	3.18 - 6
3. Swine	2.06 - 6	3.63 - 2	3.22 - 5
4. Poultry	1.57 - 13	1.72 - 6	2.53 - 10
5. Forestry	2.08 - 5	1.67 - 7	3.62 - 4
6. Frt/Veg Processing	1.92 - 8	2.12 - 5	4.19 - 1
7. Food/Bev/Feed Proc.	1.64 - 12	2.24 - 4	2.81 - 8
8. Forest Prod. Manftg.	1.90 - 9	1.54 - 11	4.10 - 2
9. Other Manufacturing	1.82 - 11	1.56 - 9	3.90 - 3
10. Services/Trade	1.83 - 10	1.45 - 12	1.85 - 13
11. National Defence	2.61 - 1	1.34 - 13	2.66 - 9
12. Local Government	2.37 - 2	2.35 - 3	2.94 - 7
13. Households	2.11 - 4	44.16 - 1	1.87 - 12

a) Output multiplier = increase in total regional output resulting from a $1.00 increase in sectoral final demand.

b) Income multiplier = increase in total regional household income resulting from a $1.00 increase in a sector's direct labour expenditures.

c) Employment multiplier = increase in regional full-time equivalent employment positions for every job created in a sector.

high proportion of their total expenditures on the services of labour which, in turn, have one of the highest propensities to purchase local goods and services. In Table 4.5, the household sector was shown to have an import coefficient of 0.07, one of the lowest of any local economic sector (i.e., they spend a much larger proportion of their earnings within the region than do most producing sectors). Since over 90 percent of local household expenditures are made to the services and trade sector, almost all of the spin-off growth is centered in the services sector.

The manufacturing sectors, similarly, have lower output multipliers because they have lower labour/output ratios and because surveys indicated that they have higher import coefficients.

In addition to total regional output, local household income and employment are also primary concerns of government leaders and economic planners. Disregarding the household sector, the sector with the largest income multiplier is the swine sector. For every dollar increase in labour expenditures by this sector, total regional household income will increase by $3.63. The local government sector is a distant second with a multiplier of 2.35. The two agricultural processing sectors are ranked 3rd and 4th.

The fruit and vegetable sector again records the largest employment multiplier, primarily because of its strong backward linkages with more labour intensive enterprises. Forestry manufacturing and 'other' manufacturing also have high employment multipliers. It should be noted, however, that a low employment multiplier does not necessarily mean an economic sector has a low total employment impact. For instance, the national defence sector registers a relatively low employment multiplier but it has significant overall employment impact because it has a very high direct employment requirement which 'compensates' for lower spin-off employment effects (indirect and induced).

Tables 4.14 and 4.15 are expansions of Tables 4.11 and 4.12 - an additional row is included representing the household sector. They describe the 1984 distribution of output, final demand, income, and employment. Figures 3, 4, and 5 graphically illustrate the magnitude of the output, employment, and income multipliers for the Type I and II input-output models.

TABLE 4.14 AGGREGATED FINAL DEMAMD - TYPE II INPUT-OUTPUT MODEL (including households)

Sector	Projected Change In Final Demand ($1000)	Projected Change In Output ($1000)	Percent Change In Output (%)	Projected Change In Income ($1000)	Projected Change In Employment (No. FTE)
1. All Crops	1,536	18,346	100	6,228	624
2. Dairy	53,342	75,750	100	16,741	1,136
3. Swine	11,464	12,200	100	647	134
4. Poultry	9,269	9,372	100	1,068	113
5. Forestry	77,068	79,904	100	20,815	1,231
6. Frt/Veg Proc.	80,039	82,058	100	12,655	870
7. Food/Bev/Feed	54,267	90,335	100	7,823	958
8. Forestry Mnf.	46,702	55,556	100	14,195	589
9. Other Mnf.	25,254	34,829	100	7,867	369
10. Services/Trade	34,331	448,315	100	116,708	15,736
11. National Def.	57,170	63,297	100	40,394	2,405
12. Local Gov't.	12,319	43,463	100	7,877	1,117
13. Households	319,763	589,507	100	16,726	26,528
Total Change	782,524	1,602,932		269,744	51,809

TABLE 4.15 CHANGE IN OUTPUT - TYPE II INPUT-OUTPUT MODEL (including households)

Sector	Projected Change In Output ($1000)	Projected Change In Final Demand ($1000)	Percent Change In Final Demand (%)
1. All Crops	18,346	1,536	100
2. Dairy	75,750	53,342	100
3. Swine	12,200	11,464	100
4. Poultry	9,372	9,269	100
5. Forestry	79,904	77,068	100
6. Frt/Veg Processing	82,058	80,039	100
7. Food/Bev/Feed Proc.	90,335	54,267	100
8. Forest Prod. Manftg.	55,556	46,702	100
9. Other Manufacturing	34,829	25,254	100
10. Services/Trade	448,315	34,331	100
11. National Defence	63,297	57,170	100
12. Local Government	43,463	12,319	100
13. Households	589,507	319,763	100
Total Change	1,602,932	782,524	

FIGURE 4 CHILLIWACK REGIONAL OUTPUT MULTIPLIERS
TYPE I AND II

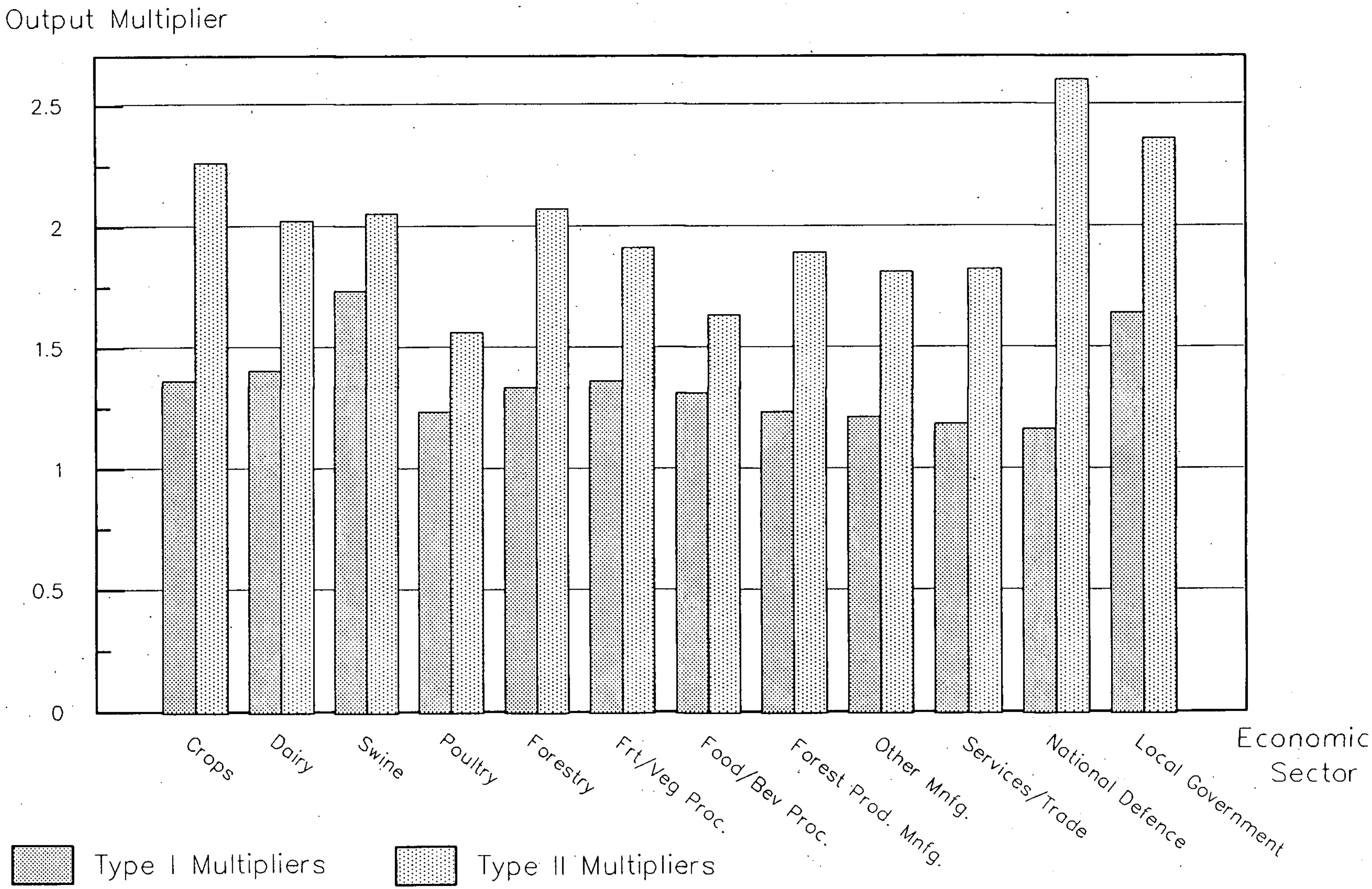


FIGURE 5 CHILLIWACK REGIONAL EMPLOYMENT MULTIPLIERS
TYPE I AND II

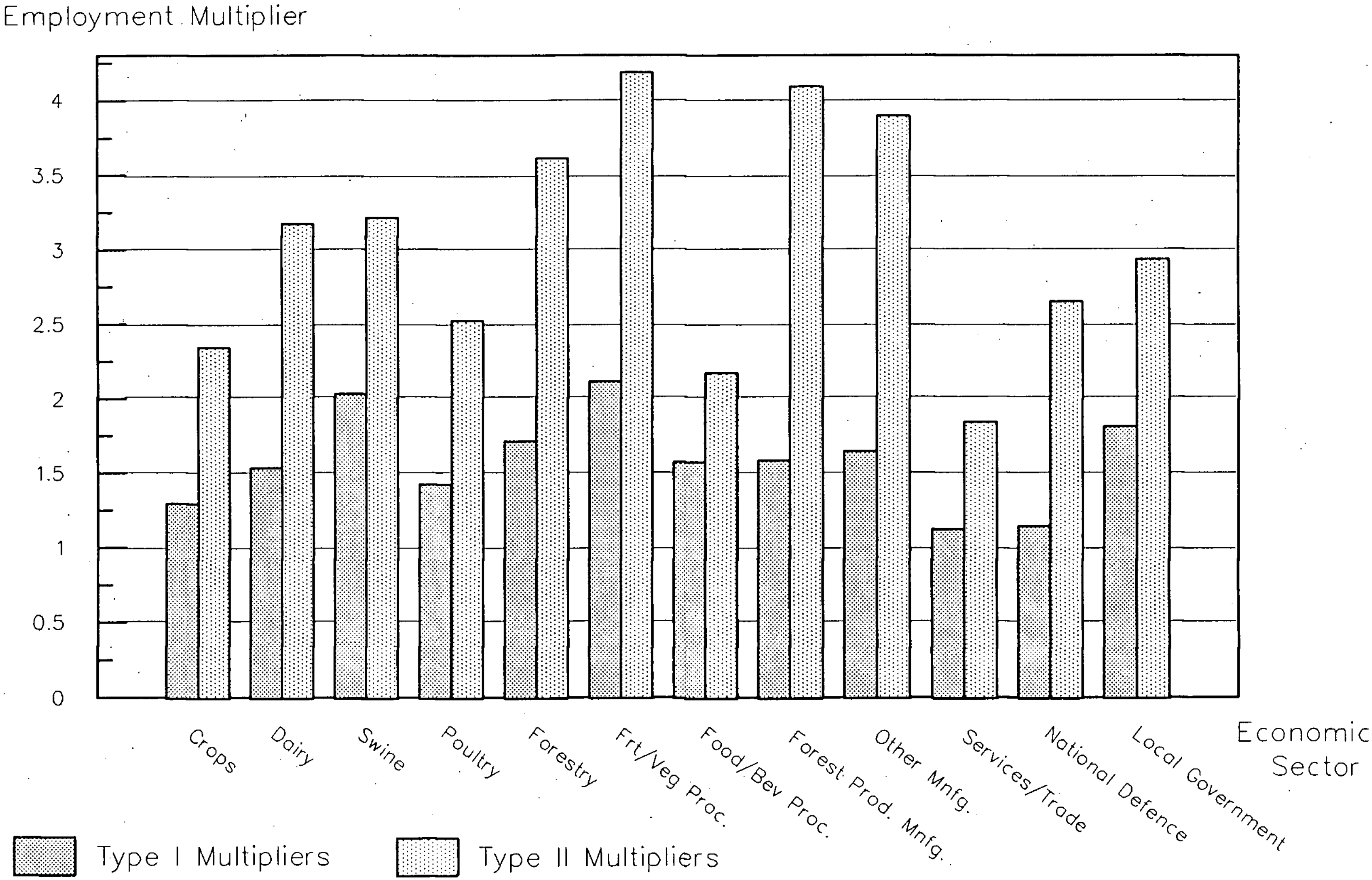
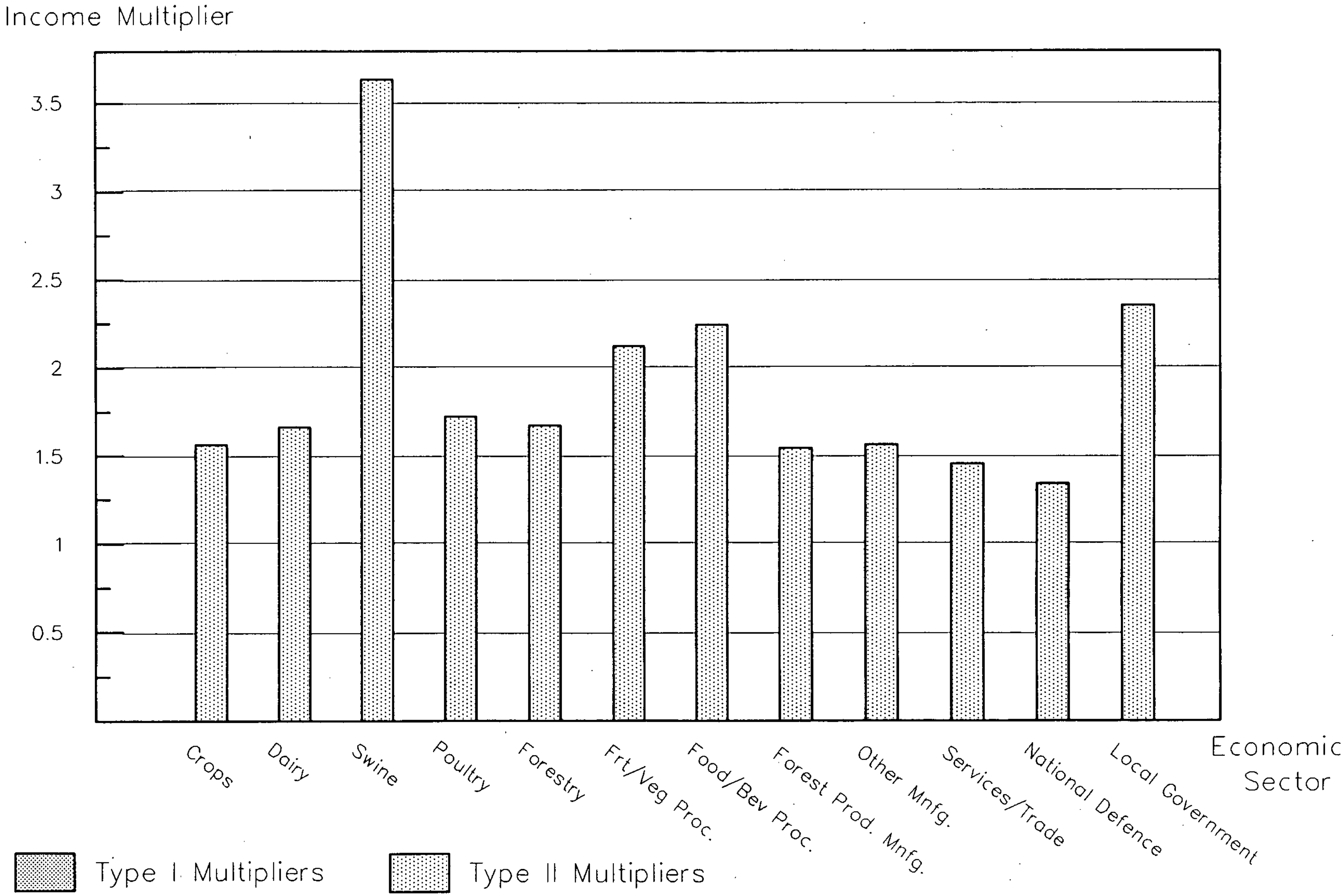


FIGURE 6 CHILLIWACK REGIONAL INCOME MULTIPLIERS
TYPE II



5.0 THE CHILLIWACK REGIONAL ECONOMIC IMPACT ANALYSIS

The economic multipliers described in section 4.4 provide an indication of the overall impact a dollar's worth of output in each sector has on the regional economy. Government leaders and economic planners will be able to use the multiplier estimates in formulating regional economic development strategies. The output multipliers illustrate which sectors contribute most to the economic base of the community. The income and employment multipliers illustrate which sectors contribute most to the well-being of the regional population. In order to derive the most benefit from I-O analysis and the greatest understanding of the information provided through impact analysis, planners should have a clear set of economic objectives.

5.1 Sectoral Economic Impact Analysis

The I-O model can also be used more directly to assess the impact of a specific expansion, or contraction, of a regional economic sector. For instance, regional planners could use the I-O model to compare the expected impact of two specific development projects to assess which would contribute most to regional growth, and, therefore, which should receive government incentives. The first step is to assign each project to the appropriate economic sector and to estimate the size of the projects in terms of sales to final demand. For example, the two development proposals could be 'export' oriented manufacturing firms, the first dealing in processed vegetables and the second in wooden cabinets. These two firms would be assigned to economic sectors 6 and 8 of the Chilliwack transactions matrix respectively - fruit and vegetable processors and forest product manufacturers. Since both of these regional economic sectors are export oriented, the increase in sales to final demand would simply be the projected sales of each plant. In other words, the revenue generated by each of these firms would be received almost entirely through sales recorded in the export column of the regional transactions matrix. And, as described in section 4.0, exports comprise one of the four categories of final demand in the Chilliwack regional transactions matrix.

If the two proposed developments are roughly the same size, a more detailed economic analysis beyond the project financial analysis stage is required to assess which project is more beneficial from an overall community perspective. Individual project assessments provide little basis for a meaningful comparison of developments. For example, the development proposals may indicate that project A will have a larger output but that project B will have a larger regional payroll. Furthermore, development proposals typically provide little information as to the amount of secondary local economic activity expected to be generated by the firm.

The input-output table provides the basis upon which to compare different development projects from a community perspective. Through I-O economic impact analysis, estimates are made of the economic ripple effect generated by each development proposal. These estimates of the 'indirect' and the 'induced' effects are added to the 'direct' economic effects of each development proposal (as outlined in the project proposal) to derive the overall economic effect to the community. Moreover, the I-O analysis explains this overall economic impact in terms of several specific criteria. In this study, we are concentrating on three criteria; a) total output, b) total regional income (household), and c) total regional employment.

In sections 5.1.1 and 5.1.2, we will examine in detail the impact of economic growth for the crops and the fruit/vegetable processing sectors. In each case, a hypothetical project in a specific economic sector will be examined. This exercise is to show how I-O analysis might be used in on-going economic development work. In the Appendix to the report, similar assessments are summarized in tables for seven additional regional economic sectors. The size of sectoral economic expansion chosen for this study is arbitrarily set at 20 percent growth for the crops, swine, and poultry sectors, and at five percent growth for the dairy, forestry, fruit and vegetable processing, other food, beverage, and feed processing, forest products manufacturing, and national defence sectors. Using two rates of growth leads to a similar absolute rate of growth across all nine sectors. This, in turn, allows a more meaningful comparison of the secondary economic benefits of the nine different sectors.

5.1.1 Crops Sector

In Tables 5.1 and 5.2, an impact assessment is presented for the case of economic expansion in the primary crop production sector. The expansion is arbitrarily set at 20 percent of the 1984 total sectoral output.

Table 5.1 lists the estimated impact based on the Type I I-O model which excludes the (induced) effect of increased household spending resulting from increased economic activity. Thus, households are treated as a category of final demand. The first column lists the projected change in final demand at $3,669,200. The cause of this increase in

TABLE 5.1 IMPACT OF INCREASED FINAL DEMAND - CROPS SECTOR
(Type I I-O Model - 20% increase in final demand)

Sector	Projected Change In Final Demand ($1000)	Projected Change In Output ($1000)	Percent Change In Output (%)	Projected Change In Income ($1000)	Projected Change In Employment (No. FTE)
1. All Crops	3,669.2	3,673.1	20.02	1,246.9	124.9
2. Dairy	0.0	50.5	0.07	11.2	0.8
3. Swine	0.0	1.1	0.01	0.1	0.0
4. Poultry	0.0	0.1	0.00	0.0	0.0
5. Forestry	0.0	0.7	0.00	0.2	0.0
6. Frt/Veg Proc.	0.0	4.1	0.00	0.6	0.0
7. Food/Bev/Feed	0.0	235.8	0.26	20.4	2.5
8. Forestry Mnf.	0.0	15.2	0.03	3.9	0.2
9. Other Mnf.	0.0	106.7	0.31	24.1	1.1
10. Services/Trade	0.0	910.2	0.20	236.9	31.9
11. National Def.	0.0	0.4	0.00	0.3	0.0
12. Local Gov't.	0.0	46.0	0.11	8.3	1.2
Total Change	3,669.2	5,043.9		1,552.9	162.6

sales to final demand, for example, might be a new contract for $3,699,200 worth of fruits/vegetables to a food processing firm outside of the Chilliwack area. This new demand might be met by an increase in output from existing regional farms or by the emergence of new crop farms with a similar method of production.

The second column lists the total projected change in regional output by sector once the regional multiplier effect is taken into account. Therefore, the original increase in exports by the crops sector of $3,669,200 is projected to lead to an overall increase in regional output of $5,043,900. Put differently, total regional output would need to increase by $5,043,900 in order to enable the crops sector to sell an additional $3,669,200 worth of goods to final consumers, such as exports.

As well, regional income would be expected to increase by $1,552,900 and 163 new jobs would be created.

The Table further illustrates to what extent each sector would be impacted by the increased production in the crops sector. The crops sector benefits the most registering a total expansion of $3,673,100 in order to meet the export order of $3,669,200. The service/trade sector also benefits immensely with sales increasing by $910,200. Other sectors to experience significant economic benefits from this increased export activity include food and beverage processing and 'other manufacturing'.

A similar analysis based on the Type II I-O model is presented in Table 5.2. In this assessment, the effect of increased household spending is also evaluated. Note that the projected change in final demand is the same as in Table 5.1 - the size of the new export order is not altered. The projected change in total regional output, however, increases to $8,320,000 (colummn 2). The difference between this figure and that of Table 5.1 reflects the induced effect of increased household spending. Similarly, the projected change in regional income and employment increase to $1,945,800 and 294 respectively. Generally, the Type I economic impact assessment tends to underestimate the actual economic effects of expansion while the Type II impact assessment tends to overestimate them. Consequently, both levels of assessment are usually reported in input-output analyses.

5.1.2 Fruit and Vegetable Processing Sector

As another example, consider Table 5.3. If final demand for processed fruits and vegetables were to increase by $4,102,900 (i.e., if export orders were to increase), then total regional output would

TABLE 5.2 IMPACT OF INCREASED FINAL DEMAND - CROPS SECTOR
(Type II I-O Model - 20% increase in final demand)

Sector	Projected Change In Final Demand ($1000)	Projected Change In Output ($1000)	Percent Change In Output (%)	Projected Change In Income ($1000)	Projected Change In Employment (No. FTE)
1. All Crops	3,669.2	3,677.8	20.05	1,248.5	125.0
2. Dairy	0.0	65.9	0.09	14.6	1.0
3. Swine	0.0	2.4	0.02	0.1	0.0
4. Poultry	0.0	0.2	0.00	0.0	0.0
5. Forestry	0.0	1.5	0.00	0.4	0.0
6. Frt/Veg Proc.	0.0	9.1	0.01	1.4	0.1
7. Food/Bev/Feed	0.0	281.6	0.31	24.4	3.0
8. Forestry Mnf.	0.0	35.9	0.06	9.2	0.4
9. Other Mnf.	0.0	123.4	0.35	27.9	1.3
10. Services/Trade	0.0	2,027.1	0.45	527.7	71.2
11. National Def.	0.0	20.5	0.03	13.1	0.8
12. Local Gov't.	0.0	128.8	0.30	23.3	3.3
13. Households	0.0	1,945.8	0.33	55.2	87.6
Total Change	3,669.2	8,320.0		1,945.8	293.7

increase by $5,612,300 solely through the effect of local inter-industry trade. Regional income and employment would also be expected to increase by $1,068,300 and 92 jobs. In keeping with the assumption of constant trade coefficients, the proportion of regional crop purchases is assumed to remain constant. Therefore, crop production would be expected to rise by $766,200. The services/trade sector would also experience a healthy increase in sales of around $574,000.

With the Type II model, the projected change in total output increases to $7,866,200. Note that the projected increase in sales of the crop sector does not increase much because the household sector does not deal extensively with that sector but the projected sales of the services/trade sector increases substantially because of its strong

TABLE 5.3 IMPACT OF INCREASED FINAL DEMAND - FRUIT/VEGETABLE PROCESSING (Type I I-O Model - 5% increase in final demand)

Sector	Projected Change In Final Demand ($1000)	Projected Change In Output ($1000)	Percent Change In Output (%)	Projected Change In Income ($1000)	Projected Change In Employment (No. FTE)
1. All Crops	0.0	766.2	4.18	260.1	26.1
2. Dairy	0.0	15.6	0.02	3.5	0.2
3. Swine	0.0	8.5	0.07	0.5	0.1
4. Poultry	0.0	2.7	0.03	0.3	0.0
5. Forestry	0.0	0.4	0.00	0.1	0.0
6. Frt/Veg Proc.	4,102.9	4,105.5	5.00	633.1	43.6
7. Food/Bev/Feed	0.0	64.0	0.07	5.5	0.7
8. Forestry Mnf.	0.0	9.3	0.02	2.4	0.1
9. Other Mnf.	0.0	28.0	0.08	6.3	0.3
10. Services/Trade	0.0	574.3	0.13	149.5	20.2
11. National Def.	0.0	0.3	0.00	0.2	0.0
12. Local Gov't.	0.0	37.5	0.09	6.8	1.0
Total Change	4,102.9	5,612.3		1,068.3	92.3

TABLE 5.4 IMPACT OF INCREASED FINAL DEMAND - FRUIT/VEGETABLE PROCESSING (Type II I-O Model - 5% increase in final demand)

Sector	Projected Change In Final Demand ($1000)	Projected Change In Output ($1000)	Percent Change In Output (%)	Projected Change In Income ($1000)	Projected Change In Employment (No. FTE)
1. All Crops	0.0	769.5	4.19	261.2	26.2
2. Dairy	0.0	26.2	0.03	5.8	0.4
3. Swine	0.0	9.4	0.08	0.5	0.1
4. Poultry	0.0	2.8	0.03	0.3	0.0
5. Forestry	0.0	1.0	0.00	0.3	0.0
6. Frt/Veg Proc.	4,102.9	4,108.9	5.01	633.7	43.6
7. Food/Bev/Feed	0.0	95.5	0.11	8.3	1.0
8. Forestry Mnf.	0.0	23.5	0.04	6.0	0.2
9. Other Mnf.	0.0	39.5	0.11	8.9	0.4
10. Services/Trade	0.0	1,342.7	0.30	349.5	47.1
11. National Def.	0.0	14.1	0.02	9.0	0.5
12. Local Gov't.	0.0	94.5	0.22	17.1	2.4
13. Households	0.0	1,338.6	0.23	38.0	60.2
Total Change	4,102.9	7,866.2		1,338.6	182.1

economic ties with the household sector. Also, when including the household effect, the projected change in income increases to $1,338,600 and the projected change in employment doubles to 182 jobs.

5.1.3 Impact Analysis Overview

The impact assessments presented above illustrate with hard numbers the effect of economic multipliers listed in section 4.6. The initial development constitutes the direct effect. The spin-off effects of this expansion in each sector are described by the multiplier effect. Only when both effects are considered is the true importance of economic expansion to a community fully understood.

While multipliers describe the cummulative effect of the backward economic linkages, the analysis presented above shows, in addition, the sectors which could be expected to benefit from these increased regional trade flows and to what extent. With this type of analysis, economic sectors can be targeted for growth which will best meet the needs of the local community.

In each case presented, the Type II multipliers are larger than those of the Type I model. As explained in previous sections, this is because the induced effect of increased household spending is added to the direct and indirect multiplier effects. The different categories of multipliers, however, respond differently to this additional spin-off effect. The overall impact in terms of regional employment is considerably larger with the Type II model than when only the inter-industry trade effect is considered. The differences in the magnitude of regional output and income multipliers, though less stark, are still significant. Again, the reason why employment is impacted the most between the two model types is because the household sector makes most of its purchases from the services/trade sector which is much more labour intensive.

5.1.4 Final Demand Requirements for Output Targets

In economic development work, it is also useful to be able to estimate what level of final demand is required to support a new business. Since each sector makes purchases from other local firms, the effect of the increase in final demand is amplified. This type of impact analysis is illustrated in Tables 5.5 - 5.8. For example, in Table 5.7 total regional final demand need only increase by $722,500 to support a new fruit and vegetable processing business with projected output of $1,000,000. When the effect of increased household spending is included, total regional final demand need only increase by $568,300 to support the new business (Table 5.8).

5.2 Economic Impact of a Reduction in the Agricultural Land Base

Input-output analysis examines the economic impact of changes to the level of final demand on an economy. It is also beneficial to assess the potential impact of reducing (increasing) the size of the agricultural land base. Since this study identifies only two broad categories of land extensive agricultural industries, the following discussion will deal only with these two sectors.

The first is the dairy sector. To make an estimate of the economic impact of removing land from the dairy sector, we have to make two broad and rather indefensible assumptions. The first is that the region's dairy farms are absolutely dependent on their farmland acreages to produce forage for their dairy herds. This is not true as forage could

TABLE 5.5 TYPE I OUTPUT MODEL - SWINE SECTOR

Sector	Projected Change In Output ($1000)	Projected Change In Final Demand ($1000)	Percent Change In Final Demand (%)
1. All Crops	0.0	0.0	0.00
2. Dairy	0.0	0.0	0.00
3. Swine	500.0	497.8	4.34
4. Poultry	0.0	0.0	0.00
5. Forestry	0.0	0.0	0.00
6. Frt/Veg Processing	0.0	0.0	0.00
7. Food/Bev/Feed Proc.	0.0	234.6	0.40
8. Forest Prod. Manftg.	0.0	0.0	0.00
9. Other Manufacturing	0.0	2.2	0.01
10. Services/Trade	0.0	40.3	0.01
11. National Defence	0.0	0.0	0.00
12. Local Government	0.0	2.5	0.01
Total Change	500.0	218.2	

TABLE 5.6 TYPE II OUTPUT MODEL - SWINE SECTOR

Sector	Projected Change In Output ($1000)	Projected Change In Final Demand ($1000)	Percent Change In Final Demand (%)
1. All Crops	0.0	0.0	0.00
2. Dairy	0.0	0.0	0.00
3. Swine	500.0	497.8	4.34
4. Poultry	0.0	0.0	0.00
5. Forestry	0.0	0.0	0.00
6. Frt/Veg Processing	0.0	0.0	0.00
7. Food/Bev/Feed Proc.	0.0	234.6	0.43
8. Forest Prod. Manftg.	0.0	0.0	0.00
9. Other Manufacturing	0.0	2.2	0.01
10. Services/Trade	0.0	40.3	0.12
11. National Defence	0.0	0.0	0.00
12. Local Government	0.0	2.5	0.02
13. Households	0.0	26.5	0.01
Total Change	500.0	191.7	

TABLE 5.7 TYPE I OUTPUT MODEL - FRUIT AND VEG. PROCESSING SECTOR

Sector	Projected Change In Output ($1000)	Projected Change In Final Demand ($1000)	Percent Change In Final Demand (%)
1. All Crops	0.0	186.1	12.12
2. Dairy	0.0	0.0	0.00
3. Swine	0.0	1.9	0.02
4. Poultry	0.0	0.6	0.01
5. Forestry	0.0	0.0	0.00
6. Frt/Veg Processing	1,000.0	1,000.0	1.25
7. Food/Bev/Feed Proc.	0.0	0.0	0.00
8. Forest Prod. Manftg.	0.0	0.0	0.00
9. Other Manufacturing	0.0	0.0	0.00
10. Services/Trade	0.0	84.9	0.02
11. National Defence	0.0	0.0	0.00
12. Local Government	0.0	4.0	0.01
Total Change	1,000.0	722.5	

TABLE 5.8 TYPE II OUTPUT MODEL - FRUIT AND VEG. PROCESSING SECTOR

Sector	Projected Change In Output ($1000)	Projected Change In Final Demand ($1000)	Percent Change In Final Demand (%)
1. All Crops	0.0	186.1	12.12
2. Dairy	0.0	0.0	0.00
3. Swine	0.0	1.9	0.02
4. Poultry	0.0	0.6	0.01
5. Forestry	0.0	0.0	0.00
6. Frt/Veg Processing	1,000.0	1,000.0	1.25
7. Food/Bev/Feed Proc.	0.0	0.0	0.00
8. Forest Prod. Manftg.	0.0	0.0	0.00
9. Other Manufacturing	0.0	0.0	0.00
10. Services/Trade	0.0	84.9	0.25
11. National Defence	0.0	0.0	0.00
12. Local Government	0.0	4.0	0.03
13. Households	0.0	154.2	0.05
Total Change	1,000.0	568.3	

be purchased from outside the region. If this route proves to be too costly, then the removal of land from this sector would have a significant impact on over- all production.

The second assumption is that the dairy sector has a single production function; that even in the short run, it cannot substitute inputs to maintain, or increase, production. This stringent constaint of the input-output model is clearly incorrect as technological advances continually improve the productive capabilities of dairy cows. For many industries, this may not be overly restrictive for short-term economic analysis. However, it is a significant limitation for economic forecasts of dairy production. The following analysis of the impact of reduced forage land base must therefore be viewed with caution as it is likely to be biased upwards.

Based on 1983 land utilization estimates for grass and silage corn of the Ministry of Agriculture and Food and the 1984 dairy sector output estimates of this study, the per acre value of dairy farmland in terms of potential output is about $4,500 per hectare. As an example, assume 1,000 hectares of dairy land is converted to a non-productive land use such as residential housing. The direct economic losses each year to the local economy would be about $4,500,000 worth of dairy sector output. The total economic impact to the community is determined by applying economic multipliers to this direct losses figure. The total decrease in community output would range between 6.3 and 9.1 million dollars (the Type I and II impact estimates). Assuming a total dairy farm labour force of about 1,140, the direct employment losses would be about 68 people and the total community losses would range between 105 and 216 positions.

It is important to keep in mind that these are rough estimates and they represent only one aspect of the economy. Although new jobs will likely be created in other sectors, it would be imprudent to needlessly sacrifice existing jobs without just cause. Also, this analysis can only be applied to a reduction in the agricultural land base in the Chilliwack region, and not an increase, as it is presently fully utilized.

The second land extensive agricultural sector assessed in this study is 'all crops'. The economic impact of this sector is an average of all the individual crops grown within the region. Total crop hectarage and crop value is estimated for 1983 and 1984 respectively at 3063 hectares and $18.35 million. If the crop pattern in 1984 was roughly the same as in 1983, the average potential output of cropland in 1984 was about $5,990 per hectare.

As an example, we shall consider the economic impact of removing 500 hectares of cropland from production in favor of a non-productive land use. The direct losses would amount to about $3 million. The total economic impact in terms of regional output as determined through I-O impact analysis ranges between 4.1 and 6.8 million dollars, depending whether the induced spin-off effect of decreased household spending is included in the assessment (Type I and II economic multipliers). Assuming a total sector labour force (full time equivalents) of about 624 people, the direct employment losses would be about 102 people and the total community losses would range between 133 and 240 positions. Again, the general nature of these estimates should be kept in mind.

The economic impact of removing cropland from production varies quite substantially over the various crops grown in the region. For instance, the 1984 potential crop output per acre for peas, cole crops, hops, raspberries, and strawberries was $1,400, $4,200, $8,200, $12,100, and $15,900 respectively.[22] In addition, the crops with the highest output value per hectare, and thus the highest direct impact on regional output, also are expected to have a greater intensity of inputs, both material and labour. This will further the overall community impact of removing from production cropland devoted to these more intensively managed crops.

As with the dairy sector, the assumption inherent in I-O analysis concerning fixed input ratios should be viewed with caution for the crops sector. Alternate forms of production are currently available for many crops, such as greenhouses and hydroponic production. Consequently, a decrease in the crop land base may not necessarily lead to these forecasted decreases in production.

5.3 Impact Analysis of Changes in Technology

A more complicated method of impact analysis is to alter the original transactions matrix to reflect some change in regional production and/or trade. For instance, new technologies will result in new production functions for firms. The resulting changes in input expenditures could lead to significantly different multiplier effects. Price changes will also lead to input substitution. As well, trade patterns among small regions frequently change. These changes can be incorporated into the model by transferring accounts between local sectors and import/export categories.

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22 Based on estimates of the District Agriculturalists, Ministry of Agriculture and Food, Chilliwack as reported in Economic Development Commission, Economic Profile, 1984.

Developing a new transactions matrix is beyond the scope of this study. However, to show how this might be done, an example is provided with rough alterations to reflect the closure of the Fraser Valley Milk Producers' plant in Sardis.

The impact of this plant closure is mitigated somewhat since most of the local dairy inputs to the plant are now exported to other company processing plants outside of the region. Thus, the Chilliwack regional economy does not lose all of the business represented by 'backward linkages', or input purchases, of the Sardis milk processing plant. The largest input to the plant, unprocessed milk, continued to be purchased from local producers, but was 'exported' to other regions. It is the cancelled purchases of the other inputs, notably labour, which represent real losses to the Chilliwack regional economy.

The first step in this type of impact analysis is to adjust the transactions matrix. In the simple example provided, only the most obvious direct changes are estimated - the indirect and induced effects were not estimated, i.e., the effects of decreased household spending were ignored. The resulting impact estimates will therefore be biased downwards.

Table 5.9 provides the adjusted transactions matrix. Entries with asterisks mark accounts which have been altered. Table 5.10 provides the new regional output, income, and employment figures. Total regional output decreases by $23,126,000. Total regional income likewise decreases by $1,722,000 and regional employment decreases by 277 persons.

The new Type I output and employment multipliers are listed in Table 5.11. Since only the most obvious changes in trade were accounted for, only a few sectors experience reduced multipliers. The sector which

TABLE 5.9 TRANSACTIONS TABLE-DAIRY PROCESSING PLANT CLOSURE ($1,000)

Purchasing Sector / Producing Sector	1 All crops	2 Dairy	3 Swine	4 Poultry	5 Forestry	6 Fruit & veg. proc.	7 Food bev/feed proc.	8 Manuftd forest prod.	9 Other primary & mnfg.	10 All services & trade
1. All crops	0	0	0	0	0	15,275	0	0	0	1,535
2. Dairy	0	3,356	0	0	0	0	4,703*	0	0	2,522
3. Swine	0	0	54	0	0	156	0	0	0	526
4. Poultry	0	0	0	0	0	52	0	0	0	51
5. Forestry	0	0	0	0	456	0	0	2,380	0	0
6. Fruit/vegetable proc.	0	0	0	0	0	0	0	0	0	2,019
7. Food/bev/feed proc.	1,018	12,541	5,725	986	0	0	0	0	0	11,387
8. Mnfd forest prod.	0	0	0	0	0	0	0	715	272	6,971
9. Other manufacturing	459	184	53	0	684	0	0	1,299	438	6,368
10. All services/trade	4,036	7,029	983	747	21,347	6,964	2,798*	6,007	5,609	22.804
11. National defence	0	0	0	0	0	0	0	0	0	215
12. Local government	94	841	62	47	322	331	224*	224	141	11,035
Total Intermediate	5,607	23,951	6,877	1,780	22,809	22,778	7,745	10,625	6,460	64,167
13. Households	6,228	16,741	647	1,068	20,815	12,655	6,101*	14,195	7,867	116,708
14. Prov. & fed. gov't	74	303	0	37	8,469	740	373*	458	565	10,621
15. Other value added	4,470	23,786	2,354	1,659	12,105	6,367	3,887*	4,759	3,129	83,217
16. Imports	1,967	10,969	2,322	4,828	15,706	39,518	50,430*	25,519	16,808	172,336
Total Primary Inputs	12,739	51,799	5,323	7,592	57,095	59,280	60,791	44,931	28,369	382,882
17. Total	18,346	75,750	12,200	9,372	79,904	82,058	68,536	55,556	34,829	448,315

* Indicates values that were changed.

TABLE 5.9 (cont.) TRANSACTIONS TABLE-DAIRY PROCESSING PLANT CLOSURE ($1,000)

Purchasing Sector / Producing Sector	11 Nat'l defence	12 Local gov't	Total Inter-mediate	13 House-holds	14 Prov. & fed. gov't	15 Other final demand	16 Exports	Total Final Demand	17 Total
1. All crops	0	0	16,810	0	0	0	1,536*	1,536	18,346
2. Dairy	0	0	10,581	0	0	1,440	63,729	65,169	75,750
3. Swine	0	0	736	0	1,106	0	10,358	11,464	12,200
4. Poultry	0	0	103	0	66	0	9,203	9,269	9,372
5. Forestry	0	0	2,836	0	0	6,712	70,356	77,068	79,904
6. Fruit/vegetable proc.	0	0	2,019	0	0	574	79,465*	80,039	82,058
7. Food/bev/feed proc.	180	0	30,571	4,231	0	915	32,819	37,965	68,536
8. Mnfd forest prod.	0	0	7,958	896	174	1,462	45,066	47,598	55,556
9. Other manufacturing	90	0	9,575	0	0	877	24,377	25,254	34,829
10. All services/trade	8,748	19,996	107,007	305,711	10,000	4,000	20,331	340,042	447,049
11. National defence	0	0	215	5,912	57,170*	0	0	63,082	63,297
12. Local government	0	2,623	15,694	15,059	8,639	1,951	1,769	27,438	43,402
Total Intermediate	9,018	22,558	204,375	331,829	77,155	17,931	359,009	785,924	990,299
13. Households	40,394	7,877	251,296	16,726	153,579	84,011	82,173	336,489	587,785
14. Prov. & fed. gov't	0	6,923	28,563	111,236				111,236	139,799
15. Other value added	98	3,608	149,439	84,317				84,317	233,756
16. Imports -	13,787	2,436	356,626	43,677				43,677	400,303
Total Primary Inputs	54,279	20,844	785,924	255,956	153,579	84,011	82,173	575,719	1,361,643
17. Total	63,297	43,402	990,299	587,785	230,734	101,942	441,182	1,361,643	2,351,942

TABLE 5.10 AGGREGATE FINAL DEMAND (TYPE I) - DAIRY PLANT CLOSURE (excluding households)

Sector	Projected Change In Final Demand ($1000)	Projected Change In Output ($1000)	Percent Change In Output (%)	Projected Change In Income ($1000)	Projected Change In Employment (No. FTE)
1. All Crops	1,536*	18,346	100	6,228	623.8
2. Dairy	65,169	75,750	100	16,741	1,136.3
3. Swine	11,464	12,200	100	647	134.2
4. Poultry	9,269	9,372	100	1,068	112.5
5. Forestry	77,068	79,904	100	20,815	1,230.5
6. Frt/Veg Proc.	80,039*	82,058*	100	12,655*	869.8*
7. Food/Bev/Feed	37,965	68,536	100	6,101	726.5
8. Forestry Mnf.	47,598	55,556	100	14,195	588.9
9. Other Mnf.	25,254	34,829*	100	7,867	369.2*
10. Services/Trade	340,042	447,049	100	116,708	15,691.4
11. National Def.	63,082*	63,297*	100	40,394	2,405.3*
12. Local Gov't.	27,438	43,402	100	7,877	1,115.4
Total Change	785,924	990,299		251,296	25,003.7

TABLE 5.11 ECONOMIC MULTIPLIERS (TYPE I) - DAIRY PLANT CLOSURE (excluding households)

Sector	Output Multiplier And Rank	Labour/output Ratio	Employment Multiplier And Rank
1. All Crops	1.36 - 4	0.0340	1.30 - 10
2. Dairy	1.38 - 3	0.0150	1.50 - 7
3. Swine	1.66 - 1	0.0110	1.92 - 2
4. Poultry	1.22 - 8	0.0120	1.40 - 8
5. Forestry	1.34 - 6	0.0154	1.72 - 4
6. Frt/Veg Processing	1.36 - 4	0.0106	2.11 - 1
7. Food/Bev/Feed Proc.	1.15 - 12	0.0106	1.31 - 9
8. Forest Prod. Manftg.	1.24 - 7	0.0106	1.59 - 6
9. Other Manufacturing	1.22 - 8	0.0106	1.65 - 5
10. Services/Trade	1.19 - 10	0.0351	1.13 - 12
11. National Defence	1.17 - 11	0.0380	1.15- 11
12. Local Government	1.64 - 2	0.0257	1.82 - 3

includes dairy processing (other food/beverage/feed processing) experiences the biggest drop from 1.32 to 1.15. The Table also shows that the output multiplier of the swine sector also decreases. This is a model error resulting from grouping feed processors and dairy processors into one economic sector. The employment multipliers experience similar adjustments.

6.0 SUMMARY AND CONCLUSIONS

6.1 Summary

6.1.1 Applications of Input-Output Analysis

Input-output analysis is a powerful tool that can assist economic analysis in numerous ways, given that the assumptions, particularly with regard to fixed production functions, are not overbearing. The primary uses of I-O analysis are:

1. to provide a structural account of a regional economy;
2. to provide an estimate of the multiplier effect - the total effect, in terms of output, income, value added, employment, resource use, environmental degradation, etc., attributable to an exogenous increase in final demand for output from a given sector; and
3. to provide an indication as to the distribution backward linkages (spin-off benefits), either geographically or amongst categories of primary inputs (e.g., labour versus capital, income classes, etc.).

These are all examples of positive economics, analysis which describes a situation but does not prescribe a course of action. Though I-O analysis can be used in normative economic analysis, the researcher must be very cautious not to incorrectly apply the model or to misinterpret the results.

> Input-output models are undoubtedly useful in 'impact analysis,' such as forecasting short-run impacts of resource development projects (an example of positive economics). However, these methods must be used with great care in evaluative (normative) contexts. (Young and Grey, 1985, p. 1823)

Unfortunately, I-O analysis is often embroiled in controversy because, in the view of some researchers, it is frequently misused. This is perhaps most evident with rural development evaluations, particularly those involving irrigation projects. While I-O analysis can have a legitimate role in evaluating the relative merit of different projects, it can also easily be misused. Firstly, it is suggested that the I-O methodology used to estimate the unit price (value) of water imparts a substantial upwards bias to these benefit estimates. Secondly, I-O analysis has the controversial tendency to list some costs of a development project as benefits. Thirdly, the impact multipliers of I-O analysis are frequently inappropriately used to justify a particular project in isolation rather than to compare the total benefits of various project alternatives.

Young and Grey (1985) contend that economic evaluations based on I-O analysis frequently overestimate the value of water as an input to industrial production. Consequently, the value of water development projects, such as irrigation, is also misrepresented. Assuming fixed prices, Young and Grey demonstrate that the value added attributable to water for a specific sector can be calculated as a residual element of an I-O table:

$$P_{wj}Q_{wj} = V_j - P_{sj}Q_{sj} - P_{rj}Q_{rj} - P_{kj}Q_{kj} \tag{65}$$

where V_j is the total value added of sector j and the remaining terms represent the value added components (price times quantity) of water, salaries, other resources (including profit), and capital. The per unit value attributable to water is therefore:

$$P_{wj} = (V_j - P_{sj}Q_{sj} - P_{rj}Q_{rj} - P_{kj}Q_{kj})Q_{wj}^{-1} \qquad (66)$$

Though it seems incredible, Young and Grey claim that numerous reports concerning irrigation development in the United States estimate the value of water from I-O tables as:

$$P_{wj} = V_j/Q_{wj} \qquad (67)$$

In other words, the residual value for water is not calculated; rather, the contribution of all primary inputs is attributed to water.[23] If this is true, it represents a serious misuse of I-O tables.

The second criticism relates to the use of I-O analysis to evaluate the merit of development projects. The most widely accepted method to evaluate the worthiness of a project is to assess its total welfare effect through an assessment of economic surplus (consumer plus producer). If the contribution is positive, then the project is deemed worthy based on the 'potential Pareto' principle. If we can assume that the project will have no effect on general price levels, then we can adopt the less complicated form of economic surplus analysis known as benefit-cost analysis. Since prices are constant, the effect on producer surplus represents the total change in economic surplus (Young and Grey, 1985, p. 1821). Total benefits are compared to total costs incurred by the project. The project is acceptable if total benefits exceed total

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23 A more appropriate method to calculate the (marginal) value of water would be to apply differential calculus to a total revenue function for irrigation production, or to use linear programming as per Long (1972b).

costs. In mathematical terms, the project is accepted if:

$$\Sigma \frac{B_t}{(1 + r)^t} - \Sigma \frac{C_t}{(1 + r)^t} \geq 0 \tag{68}$$

In many studies which use I-O analysis to evaluate a proposed project, it is often implicitly or explicitly suggested that the project is beneficial, and therefore worthy, if the total effect on regional income (or value-added) is positive. Alternately, indirect benefits as computed by an I-O model are added to the direct benefits of a benefit-cost assessment. Either approach redefines transactions which are costs as benefits. Young and Grey agree that this is inappropriate; "The GRP (and I-O) conceptual framework was not designed to distinguish between cost and benefits. This is well recognized as a serious shortcoming in using (these) accounts as indicators of social well-being ... Indeed, a curious reversal of the meaning of costs and benefits in the value-added approach is observed." (p. 1822)

To understand the mechanics further, the value-added function illustrated above (equation 65) is expanded below to represent total value of output:

$$\begin{aligned} TVP_j &= P_{ij}Q_{ij} + P_{kj}Q_{kj} + P_{lj}Q_{lj} + P_{wj}Q_{wj} + P_{rj}Q_{rj} + R \\ &= TC_j + R \end{aligned} \tag{69}$$

where TVP is total value of the output of sector j, i is intermediate inputs of materials and supplies, k is capital (depreciation allowance), l is labour, w is water, r is other resources, R is the residual profit, and TC is total cost. According to benefit-cost evaluation, the project is accepted if total revenue (TVP) exceeds total costs, or if R 0.

The value-added approach described above compares the value added generated by the project with the investment costs (money diverted from GRP to initiate the project). The approach suggests that the project should be accepted if:

$$P_{lj}Q_{lj} \geq I \qquad (70)$$

or,

$$(P_{kj}Q_{kj} + P_{lj}Q_{lj} + P_{wj}Q_{wj} + P_{rj}Q_{rj} + R) \geq I$$

where I is the initial investment cost. The first part of equation 70 designates the increase in regional labour income as the objective of regional development projects. The second part sets the objective to be an increase in regional value added.

Although these are worthwhile objectives, they should not be the sole basis of project evaluation. Economic efficiency as determined through welfare economics should be the primary consideration. A project may lead to an increase in GRP, but per capita consumer purchasing power (consumer surplus) could still decrease.

The alternate approach, to include multiplier value-added 'benefits' in the direct benefit-cost ratio, serves the same purpose and suffers even further criticisms. As long as the import propensities are relatively low (i.e., the study region relatively large and economically diversified), the directly generated value added plus the indirect value added generated through additional rounds of spending in the local community for most 'investments' will be larger than the original investment.

To illustrate this, consider an extreme case; a 'project' involving the transfer of $1,000 dollars of government funds to an individual. A financial evaluation would indicate that costs exceed benefits with costs equal to $1,000 and benefits equal to $0 (i.e., no new production). Clearly, from this perspective, the 'investment' is not worthwhile. However, the entire $1,000 represents new value added for the lucky individual since no direct production costs are incurred (i.e., it is a transfer payment which is a component of GNP). As long as this individual spends any of the money locally, total regional income would increase due to the multiplier effect. However, this assessment provides no indication whether the investment funds were wisely spent, whether the project in question created the highest returns of all feasible investments.

In this extreme context, it is easy to see that the justification for assessing total increases to GRP in isolation is clearly erroneous; while total GRP in fact increases, the 'project' is clearly a poor use of limited government investment capital. Indeed, it is difficult to imagine a project which would fail these criteria. Yet, even with including the multiplier value-added benefits, many irrigation projects barely achieve a positive benefit-cost ratio. This means that the economic inefficiency of the project is of the same magnitude as the total change in regional income arising from the project.

A dominant argument for including multiplier benefits in benefit-cost assessments is that in an economy where primary resources are under-utilized, increased expenditures for these resources are indeed benefits rather than costs. This arguement is partially correct. The main point is that the problem of under-utilized resources should be addressed through the imputation of shadow prices rather than through the inclusion of multiplier benefits. In other words, if market prices do not reflect the true costs of using inputs in production, then the prices should be adjusted accordingly. Several techniques can be employed to estimate true economic prices, or shadow prices, including regression based general equilibrium modelling and linear programming.

The underlying concept of shadow prices is that if a resource can be used elsewhere in the economy, then it has an opportunity cost. As long as there are more than one possibility for utilizing these resources, then the indirect and induced (multiplier) effects identified in I-O analysis will be fulfilled regardless of the investment choise. Input-output analysis illustrates the possible magnitude of multiplier benefits for all regional economic sectors. The difference between the highest multiplier and the next best alternative may represent true economic gains for the region if investments are made in that sector. Alternatively, if investments are made in the sector with the second highest multiplier, then the difference reflects an opportunity cost.

> The (multiplier) effects for a project are of no special interest in themselves. What is important to know is that they are more important with one project than with another. It must therefore be possible to prove that with an investment I in an irrigation project A producing given direct effects, the (multiplier) advantages obtained will be greater than those produced by the same investment I in another project B, which may be industrial or agricultural, and produces the same direct effects. (Bergman and Boussard, 1976, p. 96)

Stated differently, it would be legitimate to include some multiplier benefits in the efficiency evaluation of a proposed project. However, it would have to be demonstrated that the resources used in round two and on would not be utilized as greatly by the next most attractive investment alternative. The difficulty is to identify which resources would be utilized less effectively, and to what extent.

> ...if it is impossible to consider the opportunity costs of the production factors used in the backward or forward-linked sectors (or in the sectors affected by the income distribution effects) as zero, and if, in particular, these opportunity costs are not less than those in other regions or other sectors of the economy, then it is impossible to say that the project has produced the (true multiplier) benefits. (Bergmen and Boussard, 1976, p. 96)

Though it is clearly incorrect, many studies attempt to justify a project, or to suggest that it is economically efficient, by introducing the multiplier effects imputed through I-O analysis as economic benefits. This is not always suggested outright: often it is an implicit argument. For example, Kulshrestha et al. (1985) go to great lengths to describe the multiplier effects of irrigation development and rehabilitation. While these effects are described repeatedly as benefits resulting from irrigation, and that they are greater in magnitude than development costs, they do not suggest outright that the inclusion of multiplier benefits demonstrates economic efficiency until the final sentence; "Based on the distribution of the benefits this study has presented a case for a continued public support of irrigation development activities." (p. 10) But in the previous sentence they admit that opportunity costs are not considered; "This study has concentrated on the benefits of continued investment in irrigation, but has not presented a benefit-cost analysis of irrigation vis-a-vis other alternative uses of public funds." In many cases, the adoption of the incorrect evaluation procedures outlined above are no doubt due to honest misconceptions. In many other cases, though, incorrect methods are knowingly adopted to arrive at the numbers the particular interest group is after.

An appropriate use of I-O analysis is to demonstrate the distributional effects of a project. If a project is shown not to be cost-effective, then the income distributional effects can be highlighted. The decision-maker must then evaluate the trade-offs of efficiency versus improved equity.

An example of how I-O analysis can be used to examine the income distributional effects of a project is the paper by Bell and Hazell (1980). The objective of the paper was to measure the indirect effects of an irrigation investment project in Malaysia on the surrounding region. The empirical analysis was based on a semi-input-output model with adaptations from a social accounting matrix (SAM). Briefly, a semi-input-output model differs from an input-output model in that for each sector the choice is afforded to either hold final demand or total regional output as exogenous variables. The social accounting matrix is essentialy an input-output matrix with a more highly dissagregated primary inputs submatrix. That is, the labour category is further categorized by income level, by occupation, or by region.

The paper illustrates the effect of the project by comparing the income totals and distributions after the project was developed to the conditions expected for that year had the project not gone ahead. The analysis does not suggest that the project was justified because total regional income increased due to the project. However, Young and Grey point out that the economic evaluation of an accompanying paper (Bell and Davarajan, 1980) has as its objective an increase in total regional wage payments rather than economic surplus. This was criticized by

Kuyvenhoven (1980), and subsequently Bell evaluated the Malaysian project based on the economic surplus criteria rather than the total wage payments (Bell and Slade, 1982).

6.1.2 Interpretation of Study Results

The Chilliwack regional transactions matrix (Table 4.4) demonstrates the importance of agriculture to the regional economy in terms of sectoral output. Primary agriculture accounts for 11.4 per cent of total regional output. Agricultural processing sectors account for a further 17 per cent. Together, agricultural sectors comprise over 28 per cent of regional output.

These figures demonstrate that agriculture is an important component of the regional economy. Agricultural output, both primary and secondary, is over three times that of regional non-agricultural manufacturing output. As well, primary and manufactured agricultural output is over 20 per cent higher than all other regional primary and manufactured output plus the output (i.e., revenue) of the National Defence Base.

These figures, however, illustrate only a portion of the economic impact of agriculture to the regional economy. As was shown in preceding chapters, the direct economic effect of an industry is complemented by additional indirect and induced economic effects. These additional economic benefits are defined by the inter-regional trade characteristics of regional businesses as well as individual households. Trade between local sectors represents new revenue for the suppliers of goods and services, and new income for regional residents.

The magnitude of the spin-off economic trade is a function of the import coefficient of each local business and household. These coefficients, which are listed in Table 4.5, are the main source of leakage of monies outside of the regional trading economy. While other sources, such as taxes and savings, draw monies out of the local economy, their combined impact is much smaller than that of imports for goods and services. Moreover, the import coefficient is a much more significant factor because it can be substantially altered leading to either greater or smaller local economic diversity or well-being.

The import coefficients demonstrate some interesting trends. The sector which has the lowest import coefficient is local government (0.06). This is not surprising as "buy local products and services" is an integral part of their mandates. Households also predictably demonstrate low import coefficients (0.07). Factors which lead to this low value include the inconvenience of doing the weekly shopping far away from home and the desire to support the local community.

As a group, primary industries (agriculture and forestry) have the next lowest import coefficients in the range of 0.11 to 0.20. This, too, is predictable. Since primary industries comprise such a large part of the local economy and because their input needs of supplies and services are well defined, a local service sector developed. The poultry sector diverges from this trend (0.52) because its largest input, that of feed, is not supplied by local feed producers due to the limited local market. It must be emphasized, however, that the accuracy of these import propensities is dependent on the accuracy of the survey responses and of the expert, unbiased judgement of local agricultural representatives.

The National Defence Base has a slightly higher import coefficient (0.22). Although many of their inputs are purchased through national supply pools to realize economies of scale, considerable effort is made to support local enterprises.

At the top of the list are the manufacturing sectors. Their import coefficients range from 0.46 to 0.62. The inputs required by manufacturing are often very specialized. Consequently, suppliers for manufacturing firms usually have very large market areas and are located in major trading centers. Rules of the marketplace make it difficult to establish service enterprises in the Chilliwack area.

Although import coefficients are important factors to consider, they can also be very misleading economic indicators when examined in isolation. The leakage of monies out of the economy due to imports is only one aspect of a complex local economy. They do not provide, by themselves, an accurate representation of the impact of local economic sectors on the well-being of the community. Primary concerns of local economic planners are, of course, the overall level of economic activity, regional employment, and household income. To get an idea as to how each local sector contributes to regional production, employment, and income, a multiplier estimate must be derived which is based on all aspects of local trade in addition to the first-round import coefficient.

The output multiplier is a measure of the local economy's state of health. The production/sales of local sectors fuels consumption by local residents. The Type I output multiplier considers only the spin-off effect of inter-industry trade while the Type II multiplier also considers the economic spin-off effect of increased household spending.

Local government performs very well under both measures. This shows that local governments are doing a good job of rechannelling resources within the local economy.

Other sectors which rate well under both output multipliers are the primary agricultural sectors 'all crops', dairy, and swine. These figures show that an increase in agricultural output has a significant impact on the overall level of business in the Chilliwack area.

The two sectors which have the lowest impact on the level of output of other local businesses are the 'other manufacturing' and the services/trade sectors. This implies that both of these sectors buy many of their material inputs and services from outside of the local area. Again, these multipliers may be biased downwards due to the collection of less detailed survey data compared to other sectors.

The National Defence Base performs quite differently under the two types of output multipliers. The Base generates comparatively little growth in output amongst other sectors. However, when household expenditures are considered, the impact of the Base grows substantially. Again, it is the low import coefficient of the household sector which contributes most of the economic impact of the Base.

Among the manufacturing sectors, the fruit and vegetable sector generally performs the best. Its spin-off effect on other businesses is tied for fourth. When households are included, its relative effect decreases somewhat. The output mulitiplier effects of the food, beverage, and feed processing sector and the forest product manufacturing sector are somewhat lower than average.

In addition to the level of production, economic planners are also concerned with the well-being of local residents. The income multiplier shows how changes in the level of demand by final users for local output affects the overall level of income of area households (in relation to the change in income of households in the affected economic sector). The swine sector proves to be best in this category. A distant second is local government. The large income multiplier of the swine sector compared to all other sectors suggests that survey data errors may have been encountered.

The impact of the remaining sectors is categorized quite neatly. The agricultural manufacturing sectors have the highest income multipliers. As the level of wages in these sectors increases due to a growth in business, the overall income of area residents increases quite substantially due to the pattern of spin-off economic activity. The next most important category of economic activity in terms of the income multiplier is the primary sectors. With the exception of the swine sector, they are all grouped together with multipliers in the range of 1.56 to 1.72.

The next category is that of non-agricultural manufacturing firms; forest products and 'other' manufacturing. These two sectors have slightly lower income multipliers - 1.54 and 1.56 respectively. The lowest income multiplier category includes the services/trade and National Defence sectors at 1.45 and 1.34 respectively.

The final multiplier is that for employment. As stated earlier, these multipliers are less reliable because they are based on general estimates of labour/output ratios.

The fruit and vegetable processing sector has the highest employment multiplier in both models because of its strong backward linkages to the relatively labour intensive 'all crops' sector. For every job created in this sector, regional employment increases by 4.2 jobs. When only inter-industry trade is considered (Type I model), the swine and local government sectors have the next highest multipliers. When the induced effect of increased household spending is included in the model, forest products and 'other' manufacturing rate the next highest. Other sectors which have relatively large employment multipliers under both models are the primary forest and dairy sectors.

In section 5.1, the effects of an arbitrary growth in sales to final users is illustrated in more detail. Comparing the resulting totals reinforces the above analysis. The tables further illustrate the effect of growth in one sector on each of the remaining regional sectors. Consequently, these tables can assist economic planners in targeting specific sectors for growth.

The overall economic effect of contracting the primary agricultural land base is demonstrated in section 5.2. While this analysis is based on potentially unrealistic assumptions inherent in I-O analysis concerning fixed input ratios (i.e., no input substitution allowed) which may result in high forecasts, it nevertheless provides insights into the type of consequences likely to occur due to land conversions. A decrease of 1,000 hectares in the dairy sector's land base could result in a reduction of dairy sector output of $4.5 million and an overall reduction in community output of $9.1 million (of which $2.7 is due to a decrease in local household spending). Direct dairy sector and overall community employment losses could amount to 68 and 105 to 216 positions respectively. A decrease of 500 hectares in the 'all crops' sector's land base could result in a reduction of crop production of $3 million and an overall community output reduction of between 4.1 and 6.8 million dollars. Employment losses to the community could be up to 240 positions.

Finally, section 5.3 provides a demonstration of the effects of reducing the activity of a local economic sector. The effect on the community is dramatic. With the loss of the dairy processor, millions of dollars of production were lost from the region resulting in an estimated loss of $1.7 million in household income and a loss of 277 full time equivalent positions.[24]

6.1.3 Comparison with Other Regional Input-Output Studies

Results from three comparable regional input-output studies were presented in section 3.4.3. The Type I output multipliers estimated in the Blaine County study ranged between 1.1 and 1.7. The range in this study was very similar, between 1.2 and 1.7. The livestock sector in Blaine County registered the highest multiplier, just as in the Chilliwack region. Manufacturing in both regions demonstrated low multipliers. The multipliers of the service sector divisions in Blaine County covered a wide range whereas in Chilliwack the single service sector was estimated to have a low multiplier. Interestingly, the local government sector in Blaine County was shown to have a low multiplier.

Type II output multipliers for the three studies are listed in Tables 3.5 - 3.8. The range of each is summarized below:

24 Actual employment losses are likely to be even larger when part-time positions are considered.

1. Chilliwack Region 1.6 - 2.6
2. Clatsop County 1.5 - 3.2
3. Colorado Counties 1.1 - 2.2
4. Blaine County 1.5 - 2.7

The Type II output multipliers for the Chilliwack region are in the middle of the ranges of the U.S. studies. Once again, Blaine County and the Chilliwack region demonstrate very similar ranges. The ranges for the Clatsop and three Colorado counties are respectively higher and lower. The Colorado study area was much larger in area and had a significanlty lower population. These factors can explain the lower range in multipliers. Each is a constraint to local trading of goods and services. The Clatsop County suprisingly demonstrates a higher range despite having a smaller trading market.

Output multipliers for agriculture sectors in the four studies ranged from medium to high. Government sectors also consistantly demonstrate above average multipliers. Other trends in ranking of multipliers between the four studies are conspicuous by their absence.

6.2 Conclusions

6.2.1 Study Results

Input-output analysis can be used to better understand the workings of an economy, be it national or regional. With the information provided, community leaders and local planners will be able to make more informed decisions.

The first part of this study describes the theoretical and mathematical frameworks of I-O analysis as well as its main limitations and assumptions. As well, a detailed review of a broad range of technical issues dealing with model formulation and construction is presented. Researchers must have an in-depth understanding of the many options and issues to ensure that the model best reflects the regional economy and the effective use of resources to construct the model. An effort was made to describe I-O analysis in terms accessible to all readers and not just to economists and professional planners.

In the second part of the study, an economic impact assessment is conducted for the Chilliwack regional economy. The Chilliwack region is a small economy heavily dependent on trade with the rest of the lower Fraser Valley economy as well more distant markets in Canada, the U.S., and overseas. The economic assessment shows that agricultural industries, both primary and secondary processing, are an important components of the regional economy. The direct impact of agricultural industries in terms of value of output, income for regional residents, and employment is significant. The impact of the agricultural sector is further demonstrated through the identification of spin-off economic activity attributable to activity in agricultural sectors.

Through the development of a regional input-output model, three categories of multiplier estimates, one each for value of output, income, and employment, are estimated for twelve regional economic sectors. When all of the different measures (multipliers) are considered, the local government, fruit and beverage processing, and swine sectors are shown to have the largest all-round positive impact on the regional economy. The results for the swine sector, though, may be biased upwards due to inaccurate survey data. In terms of local government, these findings are reassuring - tax dollars are being successfully rechannelled throughout the community; however, this sector is viewed by society as a necessary service to be restricted in size, and not as an 'investment' sector.

The export dollars earned by the fruit and beverage processing and swine sectors generate the highest degree of spin-off economic benefits to other local sectors and to local households. The reason these sectors have the largest impact on the regional economy in terms of spin-off activity is because they have the most well defined and extensive backward linkages throughout the local economy. These sectors purchase a relatively high degree of their inputs from local suppliers of goods and services. Furthermore, the suppliers of the fruit and vegetable processing sector's primary inputs, namely primary agricultural enterprises, also spend a relatively high proportion of their expenditures within the local economy. Together, the spending pattern of fruit and vegetable processing firms and the swine producers along with that of their suppliers lead to the strong impact of these sectors on the local economy.

Other sectors which are identified to have relatively large output multipliers are 'all crops', dairy, and primary forestry. Sectors with large income multipliers are food/beverage/feed processing, poultry, primary forestry, and dairy. Finally, sectors with large employment multipliers are forest products manufacturing, 'other manufacturing', primary forestry, dairy, and food/beverage/feed processing. It should be noted, however, that employment multiplier estimates generated in this report are not as reliable as other multiplier estimates due to limited employment data.

In view of these findings, we conclude that; a) agricultural sectors are currently a very important component of the Chilliwack regional economy, and b) growth in these sectors, particularly in the fruit and vegetable processing and swine sectors, may achieve the highest overall impact on the Chilliwack regional economy through their strong economic ties with regional businesses.

The flip side of the coin involves the contraction of agricultural industries. Reduction in the activity of either primary or secondary agricultural enterprises could result in a significant economic impact to many local non-agricultural businesses, and thus to the community at large. Specifically, this study has illustrated the negative effect in real economic terms of both a reduction in the agricultural land base and in the amount of local secondary processing.

The economic multiplier estimates calculated in this study should be fairly representative of the regional economy for a number of years, depending on the rate of change of industrial composition, technical production functions, and trading patterns. An update of the study may be worthwhile at a future date though this would require almost an equal amount of preparation as the original study.

6.2.2 Input-Output Analysis

Input-output analysis is a useful tool available to economic planners to gain further insight into the structure and inter-sectoral flows of regional economies. Though it is subject to a number of constraints, in some situations I-O analysis can be effectively used to address specific issues. Admittedly, I-O analysis has been criticized because of its strict assumptions, particularly of fixed input ratios. However, the real problems are that I-O models often poorly represent the study area economy because of too heavy a reliance on 'borrowed' technical coefficients and that I-O analysis is often applied beyond its practical scope.

Studies have shown that regional I-O models which rely too heavily on national technical coefficients subsequently adjusted by various means to reflect regional characteristics are likely to be subject to considerable error. Yet, it has also been shown that regional I-O models based on considerable amount of regionally specific primary and secondary data are likely to be fairly good representations of the economy. Therefore, a basic conclusion is that regional I-O models should be undertaken only if a sufficient amount of resources can be committed to primary data collection.

A more serious problem is that I-O models are often used as the basis for 'normative' analysis for which they simply are not capable of supporting. That is, the results of the modelling process are routinely inappropriately applied as indications of the best course of action. In the basic Leontief format, they are more apt as simple descriptions of an economy to be used in 'positive' economic analysis. The most common example of inappropriate applications are studies which use the multiplier estimates derived from I-O analysis as the basis of arguements to justify specific projects. As discussed in section 6.1.1, adding the 'secondary' benefits (i.e., the indirect effect) as identified in I-O analysis to the direct benefits portion of a benefit-cost ration is an indefensible procedure from an economic efficiency point of view. And if regional disparities are the issue, then an altogether different approach is warrented; specifically, to identify the trade-offs involved up front by listing for the decision-maker the gains in regional employment and income expected from the project and the direct cost of the project in terms of economic efficiency.

Too much emphasis is given to the multiplier estimates derived from I-O analysis and too little is given to the structural information provided or to the macro-level planning opportunities it offers. Wassily Leontief developed the model primarily as an aid to assess structural change and technical transformation. It was developed as a system to collect data to be used in further economic analysis so that economists could shift their reliance away from speculations and assumptions concerning the structure and behaviour of the economy (Leontief, 1985, 29). The country which is perhaps most committed to the development and application of I-O analysis is Japan. "As an indication of Japanese interest and committment to this kind of work, thirteen of their ministries are engaged together to produce an I-O table under the direction of a cabinet committee." (p. 27) The I-O model is actively engaged to assess the effects of alternate technologies, possible areas of shortfalls or bottlenecks, and the effect of alternate government policies. Ironically, the other organization renowned for its effective use of I-O models is the U.S. pentagon.

A major factor in the misuse/under-utilization of I-O models is that those involved in the construction of the models cannot devote the time necessary to see that they are applied effectively. The constructors of the models are often too far removed from those who would apply the model. If the application of I-O models to assess the ramifications of technical change were simply the matter of setting parameters to a 'user-friendly' software package, then this might not be so critical. However, this is not the case. To assess the effects of structural change, the I-O model must be altered, as in section 5.3. The users of the model are likely not capable of making these alterations.

Consequently, a more common course of action is for an I-O model to be constructed and a list of economic/resource multipliers supplied to be applied at the discretion of the clients. This study is no exception. If I-O modelling is to continue, more effort should be made to see that a system is in place to identify relevant research issues and to operationalize the model on an on-going basis.

Input-output analysis is a macro-economic planning tool that maintains a perspective on micro-economic relationships. Therefore, the model is best applied to large regions, such as nations or provinces. It is at this level that macro-economic policy evaluation can be conducted effectively using this method. As the region becomes smaller, the opportunity to use the model for macro-economic policy evaluation becomes more restricted. For instance, the inter-regional trading relationships may be less stable, or the regional sectors less responsive to fluctuations in final demand levels. Another difficulty associated with small region I-O models is that opportunities for growth may be extremely limited. The need to construct a detailed economic model in this case is questionable. Efforts may be better directed towards simply attracting new investment to the region, although the I-O model could assist in identifying which sectors to concentrate on.

Though many circumstances lend themselves to economic analysis through I-O modelling, the strict assumptions nevertheless limit its application. The combination of I-O modelling with other forms of analysis, including regression based general equilibrium modelling and linear/quadratic programming, has great potential to reduce these limitations. Though beyond the scope of this study, some of these applications were briefly reviewed in this text (Long, 1972; Bell and

Hazell, 1980; Penson and Fulton, 1980). Efforts should continue in these areas.

Another short-coming is that standard I-O analysis only considers the backward-linked spin-off effects. However, forward-linked spin-off effects are equally important. Henry and Schluter (1985) provide an example of the magnitude and impact of both sources of indirect effects as they relate to the food and fiber system in the U.S. They also bring to attention several studies which have examined means of assessing forward- linked relationships through I-O modelling.

A final point concerns the objectives of regional development. A 'common sense' philosophy is that increases in regional output, income, and employment are desirable. I-O analysis identifies the expected changes in those variables in response to an exogenous increase in final demand. If an economic sector can finance its own expansion to meet this new demand, and the residual profit component is positive (after deductions for depreciation and expansion financing), then the expansion is identified by the I-O analysis as cost-effective. This information is drawn from the budgets of the transactions table and not from the multiplier analysis.

It becomes more difficult to properly construct, operationalize, and interpret I-O analysis when the source of the capital investment and financing funds is different from the economic sector which is using the capital to create new production. If the capital investment costs are not properly accounted for, then the I-O model cannot identify whether the investment is cost-effective. A conflict thereby arises between the objectives of increases in regional income and economic efficiency. Publicly financed projects invariably spawn two camps of economists for and against the project. The former base their arguement on gains in regional income or employment while the latter base their's on economic efficiency criteria.

The conflict could be reduced by two possible courses of action. Firstly, results from both assessments could be presented. The decision-maker would be left to evaluate the trade-offs between economic efficiency and regional equity. Secondly, the I-O model could be constructed to explicitly demonstrate the economic efficiency of the project. Two adaptations would be required. The first is to add a sector to represent the government agency responsible for the capital investment. The second is to disaggregate the primary inputs further to separately list 'profits' as defined in a benefit-cost account. The profits for the government agency would likely be negative. For example, profits for an irrigation agency would be water usage fees less capital investment costs. Since water fees are usually a small fraction of investment costs, profits would be negative. The economic efficiency of the project could be determined by summing the profit levels of the government agency and the users of the capital investment. This model format would likely reduce the tendency to misuse I-O models. Though a simple procedure, the author has not seen any examples which incorporate these features.

A common misuse of I-O analysis is to model two changes in final demand resulting from a single development project; firstly, the government investment (from outside the region) for capital works, and secondly, the exports of the production which stems from the investment. It is this procedure which masks the true costs, and therefore the economic efficiency, of the project. In addition, it leads to double-counting of project indirect effects (or 'secondary benefits'). Either increased demand for exports or the investment should be interpreted as the initial shock, but not both. The above procedure would prevent this error. With the government agency endogenized into the model, exports are the only final demand component that can be used to initiate the multiplier assessment.

6.3 Recommendations

This study used I-O modelling to illustrate the importance of the agricultural sectors, primary and secondary, to the Chilliwack regional economy. Agriculture was shown to be a mainstay of the local economy with backward-linked effects felt throughout the local economy. In view of these observations, it is recommended that:

a) that the development of agriculture and its downstream manufacturing enterprises remain a focal point of regional economic development strategies;

b) non-agricultural development be carried out in a manner as to minimize impacts upon the agricultural land base; and

c) efforts continue to ensure a healthy environment for agricultural processing within the region.

The model constructed herein will reflect regional conditions for a relatively short period due to shifts in economic activity and technological processes. It may be desired to update the model at a future date. Because of the resource demands of constructing regional I-O models, it is recommended that an update of this study or any regional input-output study strive to:

a) obtain a high degree of local understanding and support;

b) consider at an early stage one of several short-cut modelling approaches which offer comparable reliability in multiplier estimates at substantially reduced costs in terms of data collection; and

c) commit sufficient resources to the project to ensure an adequate pool of surveyors and data analysts.

Input-output analysis has much to offer in terms of policy evaluation; however, a high degree of technical knowledge, as well as additional data collection, is necessary to properly apply the model. Because the technical knowledge is often lacking, I-O models are often incorrectly applied. It is therefore recommended that:

a) more emphasis be placed on supporting the application of I-O modelling and not only on their construction;

b) more emphasis be placed on the use of I-O analysis to assess issues relating to the structure of the economy, changes in technology, and the impacts of government policies, and less on the simple presentation of multipliers;

c) more effort be made, in regional development studies, to separately illustrate the cost-effectiveness of the project and the impact on regional incomes for the consideration by decision-makers;

d) future regional I-O models include government investment agencies as an endogenous sector and disaggregate profits separately within primary inputs so that the cost-effectiveness of public projects are clearly evident from the regional transactions table; and

e) more research be conducted to demonstrate the relationship/conflicts between I-O assessments of indirect effects and benefit-cost assessments of economic efficiency.

SELECTED REFERENCES

Anderson, A.W. and T.W. Manning. "The Use of Input-Output Analysis in Evaluating Water Resource Development." Can. J. of Agr. Econ., March 1983, pp. 15-26.

Bell, C. and S. Devarajan. "Semi-Input-Output and Shadow Prices: A Critical Note." Oxford Bull. Econ. Stat., 42(3), 1980, pp. 251-56.

Bell, C.L.G. and P.B.R. Hazell. "Measuring the Indirect Effects of an Agricultural Investment Project on its Surrounding Regions." Amer. J. of Agr. Econ., 62(1), Feb. 1980, pp. 75-86.

Bell, C., P. Hazell, and R. Slade. Project Evaluation in Regional Perspective. John Hopkins University Press, Baltimore, Md., 1982.

Bergman, Hellmuth and Jean-Marc Boussard. Guide to Economic Evaluation of Irrigation Projects. Organization of Economic Cooperation and Development, Paris, 1976.

Billings, R.B. "The Mathematical Identity of the Multipliers Derived from the Economic Base Model and the Input-Output Model", J. of Reg. Sci., 9(3), 1969, pp. 471-73.

Bonner, Ernest R. and Vernon L. Fable. Techniques for Area Planning. Pittsburgh: Regional Economic Developemnt Institute, 1967.

Bradley, I.E. and J.P. Gander. "Input-Output Multipliers: Some Theoretical Comments." J. of Reg. Sci., 9(2), 1969, pp. 309-17.

Bromley, Daniel W. "An Alternative to Input-Output Models: A Methodological Hypothesis." Land Econ., 48, May 1972, pp. 125-33.

Burford, Roger L. and Joseph L. Katz. "A Method for the Estimation of Input-Output-Type Output Multipliers When No I-O Model Exists." J. of Reg. Sci., 21(2), 1981, pp. 151-61

______. "Regional Input-Output Multipliers Without a Full I O Table." Annals of Reg. Sci., 11(3), Nov. 1977, pp. 21-38.

Carroll, Thomas M. and Herbert H. Stoevener. A 1977 Input-Output Model for Clatsop County, Oregon. Agricultural Experiment Station, Oregon State University, Corvallis, Special Report 525, December, 1978

Chenery, Hollis B. "Regional Analysis." The Structure and Growth of the Italian Economy, ed. Hollis B. Chenery, Paul G. Clarck, and Vera Cao Pinna, U.S. Mutual Security Agency: Rome, 1953, pp. 97-129.

Chossudousky, Michel. Input-Output Analysis. Research Paper No. 7708, University of Ottawa, March 1977.

Conrad, Klaus and Iris Henseler-Unger. "Applied General Equilibrium Modeling for Long-Term Energy Policy in Germany." J. of Policy Modeling, 8(4), Winter 1986, pp. 531-49.

CONSAD Research Corporation. Regional Federal Procurement Study. Prepared for the Office of Economic Research, U.S. Dept. of Commerce Contract 7-35211, Oct. 1967.

Crown, William H. "An Approach to Estimating a Consistant Aggregate Input-Output Model." Growth and Change, 18(4), Fall 1987, pp. 1-9

Cumberland, John H. "A Regional Interindustry Study of Maryland." Studies in Bus. and Econ., 8, Sept. 1954.

Czamanski, S. and E.E. Malizia. "Applicability and Limitations in the Use of National Input-Output Tables for Regional Studies." Papers of the Reg. Sci. Asso., 23, 1969, pp. 65-77.

Davis, H.C. "Economic Base and Input-Output Multipliers: A Comparison for Vancouver, B.C." Annals of Reg. Sci., 9, 1975, pp. 1-8.

______. "Regional Sectoral Multipliers with Reduced Data Requirements." Inter. Reg. Sci. Rev., 1(2), Fall 1976, pp. 18-29.

______. "A Synthesis of Two Methods of Estimating Regional Sectoral Multipliers." Growth and Change, April 1978, pp. 9-13.

Diamond, Joseph and Daniel Chappelle. Application of an Input-Output Model Based on Secondary Data in Local Planning: The Case of Manis tee County. Michigan State University, Agricultural Experiment Station, Research Report 409, 19??.

DiPasquale, D. and R. Polenske. "Output, Income, Employment Input-Output Multipliers," in Economic Impact Analysis: Methodology and Applications, ed. Saul Pleeter. M. Nijhoff Pub.: Boston, 1977.

DiPietre, D., R.L. Walker, and D.R. Martella. "Developing Regional Input-Output Models from the U.N. Format Adopted by the U.S. in the New 1972 Input-Output Model." Southern J. of Agr. Econ., 12(1), July 1980, pp. 143-49.

Doekson, G.A. and C.H. Little. "Effect of Size of the Input-Output Model on the Results of an Impact Analysis." Agr. Econ. Research, 20(4), 1968, pp. 134-38.

Drake, R.L. "A Short-Cut to Estimates of Regional Input-Output Multipliers: Methodology and Evaluation." Inter. Reg. Sci. Rev., 1(2), Fall 1976, pp. 1-17.

Erickson, R.A. "Purchasing Patterns and the Regional Trade Multiplier." Growth and Change, April 1978, pp. 49-51.

Eskelinen, H. and M. Suorsa. "Note on Estimating Interindustry Flows." J. of Reg. Sci., 20(2), 1980, pp. 261-66.

Garnick, D.H. "Differential Regional Multiplier Models." J. of Reg. Sci., 10(1), 1970, pp. 35-47.

Gerking, Shelby D. "Input-Output as a Simple Econometric Model." The Rev. of Econ. and Stats., LVIII(3), 1976a, pp. 274-83.

______. "Reconciling 'Rows Only' and 'Columns Only' Coefficients in an Input-Output Model." Inter. Reg. Sci. Rev., 1(2), 1976b, pp. 30-46.

Gerking, Shelby D. and Saul Pleeter. "Minimum Variance Sampling in Input-Output Analysis." Rev. of Reg. Studies, 7(1), 1978, pp. 59-80.

Goldman, George E. Explanation and Application of County Input-Output Models. Division of Agricultural Sciences, University of California, Special Publication 3013, March 1974.

Gould, Brian W. "The Impacts of Prairie Branch Line Rehabilitation: An Application of Inter-Regional Input-Output Analysis." Can. J. of Agr. Econ., 34(3), Nov. 1986, pp. 313-31.

Gould, B.W. and S.N. Kulsheshtha. "An Input-Output Analysis of the Impacts of Increased Export Demand for Saskatchewan Products." Can. J. of Agr. Econ., 33(2), July 1985, pp. 127-149.

Gould, B.W., J.A. Sampson, and S.N. Kulsheshtha. Application of Non-Survey Updating Procedures to a Rectangular Input-Output Model: A Documentation of the "RAS" and "H-M" Updating Algorithms. Dept. of Agricultural Economics, University of Saskatchewan, Technical Bulletin: 83-07, Dec. 1983a.

Gould, B.W., J.A. Sampson, and S.N. Kulsheshtha. The Saskatchewan Rectangular Input-Output Model: A Documentation of the Computer Programs. Dept. of Agricultural Economics, University of Saskatchewan, Technical Bulletin: 83-06, Dec. 1983b.

Harrigan, F.J. "The Estimation of Input-Output Type Output Multipliers When No Input-Output Model Exists: A Comment." J. of Reg. Sci., 22(3), 1982, pp. 375-81.

Harris, T.R. and C.T.K. Ching. "Economic Resource Multipliers for Regional Impact Analysis." Water Resources Bulletin, American Water Resources Association, 19(2), April 1983, pp. 205-10.

Harris, Thomas R. and Bradley S. Pierce. Final Demand and Output Multiplier Analysis: Humboldt and Landover Counties Interindustry Study: Part I and II. Division of Agricultural and Resource Economics, University of Nevada, Reno, M.S. 142 and 143, Sept. 1981.

Henry, M.S. "A Cost Effective Approach to Primary Input-Output Data Collection: Reply." Rev. of Public Data Use, 11, 1983, pp. 193-95.

Henry, M.S., A. Leholm, G. Schaible, and J. Haskins. "A Cost-Effective Approach to Primary Input-Output Data Collection." Rev. of Public Data Use, 9, 1981, pp. 331-36.

Henry, M.S. and T.L. Martin. "Rural Area Consumer Demand and Regional Input-Output Analysis: Reply." Australian J. of Agr. Econ., 66(2), May 1984, pp. 177-79.

Henry, Mark and Gerald Schluter. "Measuring Backward and Forward Linkages in the U.S. Food and Fiber System." Agr. Econ. Res., 37(4), Fall 1985, pp. 33-39.

Hewings, G.J.D. "Aggregation for Regional Impact Analysis." Growth and Change, Jan. 1972, pp. 15-19.

______. "A Cost Effective Approach to Primary Input-Output Data Collection: Comment." Rev. of Public Data Use, 11, 1983, pp. 197-99.

Hope, Robert. Building a Non-Metropolitan Input-Output Model: Minnesota's Region Six East. University of Minnesota Technical Bulletin No. 313, 1978.

Hushak, L.J., Y.K. Ro, and Z.Y. Hussain. An Input-Output Analysis of Regional Economic Development. The Ohio State University, Research and Development Center, Wooster, Ohio, Research Bulletin No. 1155, Sept. 1983.

Isard, Walter. "Interregional and Regional Input-Output Analysis: A Model of a Space Economy." The Rev. of Econ. and Stats., 33, Nov. 1951, pp. 318-28.

Isserman, A.M.J. "A Bracketing Approach for Estimating Regional Impact Multipliers and a Procedure for Assessing their Accuracy." Env. and Plan. A, Vol. 9, 1977, pp. 1003-1011.

Jensen, R.C. "The Concept of Accuracy in Regional Input-Output Models." Inter. Reg. Sci. Rev., 5(2), 1980, pp. 139-54.

______. "Some Accounting Procedures and their Effects on Input-Output Models." Annals of Reg. Sci., 15(3), 1981, pp. 21-38.

Jensen, R.C., T.D. Mandeville, and N.D. Karunaratne. Regional Economic Planning: Generation of Regional Input-Output Analysis. Croom Helm Ltd.: London, 1979.

Jensen, R.C. and D. McGraurr. "Reconciliation of Purchases and Sales Estimates in an Input-Output Table." Urban Studies, 13, 1976, pp. 59-65.

______. "Reconciliation Techniques in Input-Output Analysis: Some Comparisons and Implications." Urban Studies, 14, 1977, pp. 327-37.

Johnson, Thomas G. and O. Capps, Jr. "Rural Area Consumer Demand and Regional Input-Output Analysis: Comment." Australian J. of Agr. Econ., 66(2), May 1984, pp. 173-76.

Johnson, Thomas G. and Surendra N. Kulshreshtha. "Exogenizing Agriculture in an Input-Output Model to Estimate Relative Impacts of Different Farm Types." Western J. of Agr. Econ., 7(2), Dec. 1982, pp. 187-98.

Johnson, Thomas G. and Surendra N. Kulshreshtha. Nature of Intersectoral Relations of Saskatchewan Agriculture: An Input-Output Analysis. Department of Agricultural Economics, University of Saskatchewan, Research Report 81-06, November 1981.

Jordan, Jeffrey L. and Rusty Brooks. IO/EAM: An Input-Output Economic Assessment Model. Southern J. Agr. Econ., 16(2), Dec. 1984, pp. 145-49.

Jordan, Jeffrey L., Rusty Brooks, and J. Michael Lee. A User's Guide to IO/EAM: An Input-Output Economic Assessment Model. University of Georgia, College of Agriculture Experiment Station, Research Report 468, Aug. 1985.

Kaneko, Yukio. "An Empirical Study on Non-Survey Forecasting of the Input Coefficient Matrix." Econ. Modelling, 5(1), Jan. 1988, pp. 41-48.

Katz, Joseph and Roger L. Burford. "A Comparison of Estimators of Output Multipliers from Incomplete Input-Output Data." Annals of Reg. Sci., 15(2), July 1981a, pp. 39-54.

_______. "The Effect of Aggregation on the Output Multipliers in Input-Output Models." Annals of Reg. Sci., 15(3), Nov. 1981b, pp. 46-54.

_______. "The Estimation of Input-Output Type Output Multipliers When No Input-Output Model Exists: A Reply." J. of Reg. Sci., 22(3), 1982, pp. 383-87.

Kulshreshtha, Surendra N., K. Dale Russell, Gorden Ayers, and Byron C. Palmer. "Economic Impacts of Irrigation Development in Alberta Upon the Provincial and Canadian Economy." Can. Water Res. J., 10(2), 1985, pp. 1-10.

Kulshreshtha, S.N. and M.T. Yap. The Prairie Regional Input-Output and Employment Model (Prairie Model): A User's Handbook. Report No. 1, Prairie Farm Rehabilitation Administration, Regina, Saskatchewan, August, 1985.

Kuyvenhoven, A. "Semi-Input-Output and Shadow Prices: A Reply." Oxford Bull. Econ. Stat., 42(3), 1980, pp. 257-58.

Lal, Kishori. "Compilation of Input-Output Tables: Canada." Rev. of Income and Wealth, No. 4, Dec. 1982, pp. 411-30.

Latham III, W.R. and M. Montgomery. "Methods for Calculating Regional Industry Impact Multipliers." Growth and Change, Oct. 1979, pp. 2-9.

Lee, Gene K., Leroy L. Blakeslee, and Walter R. Butcher. "Effects of Exogenous Price Changes on a Regional Economy: An Input-Output Analysis." Inter. Reg. Sci. Rev., 2(1), 1977, 15-27.

Lewis, W.C. "Export Base Theory and Multiplier Estimation: A Critique." Annals of Reg. Sci., 10(2), 1976, pp. 58-70.

Leontief, Wassily. "Quantitative Input-Output Relations in the Economic System of the United States." Rev. of Econ. and Stats., 18(3), Aug. 1936, pp. 105-25.

______. The Structure of the American Economy: 1919-29. Oxford University Press: New York, 1941. 2nd ed., rev. and en., 1951. Reprint International Arts and Sciences Press: White Plains, 1976.

______. "Why Economics Needs Input-Output Analysis." Interview in Challenge, 28(1), March/April 1985, pp. 27-35.

Long, Roger B. An Economic Input-Output Study of the South Saskatchewan River Basin of Alberta in 1969: Phase I. University of Alberta, Feb. 1972.

Long, Roger B. An Income-Maximizing Model for the South Saskatchewan River Basin of Alberta: Phase III. University of Alberta, May 1972.

Long, Roger B. and Neil L. Meyer. The Economic Structure of Blaine County, Idaho: 1979. Agricultural Experiment Station, University of Idaho, Bulletin No. 613, Jan. 1982.

Mather, V.K. and H.S. Rosen. "Regional Employment Multiplier: A New Approach." Land Econ., Vol. 50, 1974, pp. 93-96.

MacMillan, J.A., C. Lu, and C.F. Framingham. Manitoba Interlake Area: A Regional Development Evaluation. The Iowa State University Press: Ames, Iowa, 1975.

McKean, John R. and Joseph C. Weber. The Economy of Moffat, Routt, and Rio Blanco Counties, Colorado: Descriptions and Analysis. Colorado Water Resources Research Institute, Colorado State University, Fort Collins, Colorado, Tech. Report 23, Jan. 1981.

McMwnamin, D.G. and J.E. Haring. "An Appraisal of Nonsurvey Techniques for Estimating Regional Input-Output Models." J. of Reg. Sci., 14(2), 1974, pp. 191-205.

Miernyk, William H. "Comments on Recent Developments in Regional Input-Output Analysis." Inter. Reg. Sci. Rev., 1(2), 1976, pp. 47-56.

______. Elements of Input-Output Analysis. Random House: New York, 1965.

Miller, B.R. and L.H. Langley. "Suggested Sectors for Input-Output Models of Rural Areas." Amer. J. of Agr. Econ., 56(2), May 1974, pp. 450-52.

Miller, Ronald E. and Peter Blair. "Estimating State Level Input-Output Relationships from U.S. Multiregional Data." Inter. Reg. Sci. Rev., 8(3), 1983, pp. 233-54.

______. Input-Output Analysis: Foundations and Extentions. Prentice Hall: Englewood Cliffs, N.J., 1985.

Moore, Frederick T. and James Peterson. "Regional Analysis: An Inter-industry Model of Utah." Rev. of Econ. and Stats., 37(4), Nov. 1955, pp. 368-83.

Morrison, W.I. and P. Smith. Input-Output Methods in Urban and Regional Planning: A Practical Guide. Vol. 7, Part 2, Progress in Planning, Perganmon Press: Oxford, England, 1977.

______. "Nonsurvey Input-Output Techniques at the Small Area Level: An Evaluation." J. of Reg. Sci., 14(1), 1974, pp. 1-13.

Moses, Leon N. "The Stability of Interregional Trading Patterns and Input-Output Analysis." Amer. Econ. Rev., 45(5), Dec. 1955, pp. 803-32.

Nelson, P.E. Jr. and J.S. Perrin. "A Short Cut for Computing Final Demand Multipliers: Some Empirical Results." Land Econ., 54(1), 1978, pp. 82-91.

Ong, K.T. An Agriculturally Oriented Input-Output Analysis of the Ontario Economy. Ontario Min. of Agriculture and Food, Province of Ontario, April 1977.

Pasurka, Carl A. "The Short-Run Impact of Environmental Protection Costs on U.S. Product Prices." J. of Env. Econ. and Manag., 11, 1984, pp. 380-390.

Penson, J.B. Jr. and M.E. Fulton. "The Impact of Localized Cutbacks in Agricultural Production on a State Economy." Western J. Agr. Econ., 5(2), Dec. 1980, pp. 107-22.

Petkovich, M.D. and C.T.K. Ching. "Modifying a One Region Leontief Input-Output Model to Show Sector Capacity Constraints." Western J. of Agr. Econ., 3, 1978, pp. 173-79.

Phibbs, Peter J. and Andrew Holsman. "An Evaluation of the Burford-Katz Short Cut Technique for Deriving Input-Output Multipliers." Annals of Reg. Sci., 15(3), Nov. 1981, pp. 11-19.

Pleeter, Saul, ed. Economic Impact Analysis: Methodology and Applications. Papers presented at a workshop held in Oxford, Ohio, April 1977. M. Nijhoff Pub.: Boston, 1980.

Polenske, Karen R. The U.S. Multiregional Input-Output Accounts and Model. Vol 6, Multiregional Input-Output Analysis. Lexington Books, D.C. Heath and Co.: Lexington, Massachusetts, 1980.

Postner, Harry H. Canadian Productivity Growth: An Alternative (Input-Output) Analysis. Prepared for the Economic Council of Canada. Supply and Services Canada, 1983.

Regional District of Frase-Cheam. Economic Profile. Economic Development Commission, Feb. 1984.

Round, Jeffery I. "On Estimating Trade Flows in Interregional Input-Output Models." Reg. Sci. and Urban Econ., Vol. 8, 1978a, pp. 289-302.

______. "An Interregional Input-Output Approach to the Evaluation of Nonsurvey Methods." J. of Reg. Sci., 18(2), 1978b, pp. 179-94.

______. "Nonsurvey Techniques: A Critical Review of the Theory and the Evidence." Inter. Reg. Sci. Rev., 8(3), 1983, pp. 189-212.

Salcedo, David. A Short-Cut Method for Determining the Impact of an Economic Activity on an Entire Economy. Unpubliched report, Division of Planning Coordination, Office of the Governor, Austin, Texas.

Schaffer, W.A. "Constructing the Nova Scotia Input-Output System." Can. J. Reg. Sci., I, Spring 1978, pp. 1-11.

______. "Testing Regional Impact Analysis in Nova Scotia." Can. J. Reg. Sci., II(2), Spring 1979, pp. 1-10.

Schaffer, W.A. and K. Chu. "Nonsurvey Techniques for Constructing Regional Interindustry Models." Papers of the Reg. Sci. Asso., 23, 1969, pp. 83-101.

Silvers, A.L. "The Structure of Community Income Circulation in an Incidence Multiplier for Development Planning." J. of Reg. Sci., 10(2), pp. 175-190.

Stager, David. Economic Analysis and Canadian Policy. Butterworth and Co.: Toronto, 1973.

Statistics Canada. The Input-Output Structure of the Canadian Economy in Constant Prices: 1961-1974. Cat. 15-509 E Occasional, May 1979.

Statistics Canada. Census of Canada. 1981, several volumes.

Statistics Canada. Various monthly and annual statistical publications.

Stevens, B.H. and G.A. Trainer. "Error Generation in Regional Input-Output Analysis and its Implication for Nonsurvey Models," in Economic Impact Analysis: Methodology and Applications, ed. Saul Pleeter. M. Nijhoff Pub.: Boston, 1977.

Stevens, B.H., G.I. Treyz, D.J. Ehrlich, and J.R. Bower. "A New Technique for the Construction of Non-survey Regional Input-Output Models." Inter. Reg. Sci. Rev., 8(3), 1983, pp. 271-86.

Stone, R. and G. Brown. "Behavioral and Technical Change in Economic Models." Paper presented at the Second Congress of the International Economic Association, Vienna, 1962.

Syed, A.A. "The Input-Output Structure of Agriculture in Canada," in Agricultural Sector Models for Policy Analysis, ed. Z.A. Hassan and H. Bruce Huff, Agriculture Canada, Ottawa, 1985.

Thomassin, Paul and Allan Andison. Agriculture Canada's Input-Output Model, Part I: Disaggregation of the Agricultural Sector. Agriculture Canada, Policy Branch, Working Paper 6/87, April 1987.

Thomassin, Paul J. and Harold L. Baker. Estimating the Impacts of Increased Forest Industry Outputs on the Hawaiian Economy by Using Input-Output Analysis. Collage of Tropical Agricultural and Human Resources, University of Hawaii, Research Series 019.

United Nations Industrial Development Organization. Proceedings of the Seventh International Conference on Input-Output Techniques. New York, 1984.

U.S. Dept. of Agriculture. Regional Development and Plan Evaluation: The Use of Input-Output Analysis, Agricultural Handbook No. 530, May 1978.

U.S.S.R. Central Statistics Board. Transactions of the U.S.S.R. Central Statistics Board. Vol. 29, 1926.

Weiss, Steven J. and Edwin C. Gooding. "Estimation of Differential Employment Multipliers in a Small Regional Economy." Land Econ., 44(1), 1968, pp. 235-44.

West, G.R. "An Efficient Approach to the Estimation of Regional Input-Output Multipliers." Env. and Plan., 13(7), 1981, pp. 857-867.

Williamson, R.B. "Aggregation for Regional Impact Analysis: Comment." Growth and Change, Jan. 1972, p. 20.

Williamson, R.B. "Simple Input-Output Models for Economic Analysis." Land Econ., 46, 1970, pp. 333-38.

Wilson, J.H. "Impact Analysis and Multiplier Specification." Growth and Change, July 1977, pp. 42-46.

Wilson T. "The Regional Multiplier - A Critique." Oxford Econ. Papers, 20, 1968, pp. 374-93.

Young, Robert A. and S. Lee Gray. "Input-Output Models, Economic Surplus, and the Evaluation of State or Regional Water Plans." Water Resources Research, 21(12), Dec. 1985, pp. 1819-23.

APPENDIX

TABLE A.1 IMPACT OF INCREASED FINAL DEMAND - DAIRY SECTOR
(Type I I-O Model - 5% increase in final demand)

Sector	Projected Change In Final Demand ($1000)	Projected Change In Output ($1000)	Percent Change In Output (%)	Projected Change In Income ($1000)	Projected Change In Employment (No. FTE)
1. All Crops	0.0	2.0	0.01	0.7	0.1
2. Dairy	3,787.5	4,098.1	5.41	905.7	61.5
3. Swine	0.0	0.6	0.00	0.0	0.0
4. Poultry	0.0	0.1	0.00	0.0	0.0
5. Forestry	0.0	0.3	0.00	0.1	0.0
6. Frt/Veg Proc.	0.0	2.1	0.00	0.3	0.0
7. Food/Bev/Feed	0.0	690.7	0.76	59.8	7.3
8. Forestry Mnf.	0.0	7.5	0.01	1.9	0.1
9. Other Mnf.	0.0	17.1	0.05	3.9	0.2
10. Services/Trade	0.0	468.4	0.10	121.9	16.4
11. National Def.	0.0	0.2	0.00	0.1	0.0
12. Local Gov't.	0.0	63.8	0.15	11.6	1.6
Total Change	3,787.5	5,350.9		1,106.0	87.2

TABLE A.2 IMPACT OF INCREASED FINAL DEMAND - DAIRY SECTOR
(Type II I-O Model - 5% increase in final demand)

Sector	Projected Change In Final Demand ($1000)	Projected Change In Output ($1000)	Percent Change In Output (%)	Projected Change In Income ($1000)	Projected Change In Employment (No. FTE)
1. All Crops	0.0	5.4	0.03	1.8	0.2
2. Dairy	3,787.5	4,109.0	5.42	908.1	61.6
3. Swine	0.0	1.5	0.01	0.0	0.0
4. Poultry	0.0	0.1	0.00	0.0	0.0
5. Forestry	0.0	1.0	0.00	0.3	0.0
6. Frt/Veg Proc.	0.0	5.7	0.01	0.9	0.1
7. Food/Bev/Feed	0.0	723.4	0.80	62.6	7.7
8. Forestry Mnf.	0.0	22.3	0.04	5.7	0.2
9. Other Mnf.	0.0	29.0	0.08	6.5	0.3
10. Services/Trade	0.0	1,264.0	0.28	329.0	44.4
11. National Def.	0.0	14.5	0.02	9.3	0.6
12. Local Gov't.	0.0	122.7	0.28	22.2	3.2
13. Households	0.0	1,385.9	0.24	39.3	62.4
Total Change	3,787.5	7,684.5		1,385.7	180.7

TABLE A.3 IMPACT OF INCREASED FINAL DEMAND - SWINE SECTOR
(Type I I-O Model - 20% increase in final demand)

Sector	Projected Change In Final Demand ($1000)	Projected Change In Output ($1000)	Percent Change In Output (%)	Projected Change In Income ($1000)	Projected Change In Employment (No. FTE)
1. All Crops	0.0	1.3	0.01	0.4	0.0
2. Dairy	0.0	230.8	0.30	51.0	3.5
3. Swine	2,440.0	2,451.2	20.09	130.0	27.0
4. Poultry	0.0	0.0	0.00	0.0	0.0
5. Forestry	0.0	0.2	0.00	0.1	0.0
6. Frt/Veg Proc.	0.0	1.4	0.00	0.2	0.0
7. Food/Bev/Feed	0.0	1,196.3	1.32	103.6	12.7
8. Forestry Mnf.	0.0	4.9	0.01	1.3	0.1
9. Other Mnf.	0.0	15.9	0.05	3.6	0.2
10. Services/Trade	0.0	304.4	0.07	79.3	10.7
11. National Def.	0.0	0.1	0.00	0.1	0.0
12. Local Gov't.	0.0	29.2	0.07	52.9	0.8
Total Change	2,440.0	4,235.7		422.5	55.0

TABLE A.4 IMPACT OF INCREASED FINAL DEMAND - SWINE SECTOR
(Type II I-O Model - 20% increase in final demand)

Sector	Projected Change In Final Demand ($1000)	Projected Change In Output ($1000)	Percent Change In Output (%)	Projected Change In Income ($1000)	Projected Change In Employment (No. FTE)
1. All Crops	0.0	2.4	0.01	0.8	0.1
2. Dairy	0.0	234.5	0.31	51.8	3.5
3. Swine	2,440.0	2,451.5	20.09	130.0	27.0
4. Poultry	0.0	0.1	0.00	0.0	0.0
5. Forestry	0.0	0.4	0.00	0.1	0.0
6. Frt/Veg Proc.	0.0	2.6	0.00	0.4	0.0
7. Food/Bev/Feed	0.0	1,207.3	1.34	104.6	12.8
8. Forestry Mnf.	0.0	9.9	0.02	2.5	0.1
9. Other Mnf.	0.0	19.9	0.06	4.5	0.2
10. Services/Trade	0.0	574.0	0.13	149.4	20.1
11. National Def.	0.0	5.0	0.01	3.2	0.2
12. Local Gov't.	0.0	49.2	0.11	8.9	1.3
13. Households	0.0	469.6	0.08	13.3	21.1
Total Change	2,440.0	5,026.4		469.5	86.4

TABLE A.5 IMPACT OF INCREASED FINAL DEMAND - POULTRY SECTOR
(Type I I-O Model - 20% increase in final demand)

Sector	Projected Change In Final Demand ($1000)	Projected Change In Output ($1000)	Percent Change In Output (%)	Projected Change In Income ($1000)	Projected Change In Employment (No. FTE)
1. All Crops	0.0	0.8	0.00	0.3	0.0
2. Dairy	0.0	41.0	0.05	9.1	0.6
3. Swine	0.0	0.2	0.00	0.0	0.0
4. Poultry	1,874.4	1,874.4	20.00	213.6	22.5
5. Forestry	0.0	0.1	0.00	0.0	0.0
6. Frt/Veg Proc.	0.0	0.8	0.00	0.1	0.0
7. Food/Bev/Feed	0.0	208.7	0.23	18.1	2.2
8. Forestry Mnf.	0.0	2.9	0.01	0.7	0.0
9. Other Mnf.	0.0	2.8	0.01	0.6	0.0
10. Services/Trade	0.0	180.1	0.04	46.9	6.3
11. National Def.	0.0	0.1	0.00	0.1	0.0
12. Local Gov't.	0.0	16.1	0.04	2.9	0.4
Total Change	1,874.4	2,328.0		292.4	32.0

TABLE A.6 IMPACT OF INCREASED FINAL DEMAND - POULTRY SECTOR
(Type II I-O Model - 20% increase in final demand)

Sector	Projected Change In Final Demand ($1000)	Projected Change In Output ($1000)	Percent Change In Output (%)	Projected Change In Income ($1000)	Projected Change In Employment (No. FTE)
1. All Crops	0.0	1.7	0.01	0.6	0.1
2. Dairy	0.0	43.9	0.06	9.7	0.7
3. Swine	0.0	0.5	0.00	0.0	0.0
4. Poultry	1,874.4	1,874.4	20.00	213.6	22.5
5. Forestry	0.0	0.3	0.00	0.0	0.0
6. Frt/Veg Proc.	0.0	1.8	0.00	0.3	0.0
7. Food/Bev/Feed	0.0	217.3	0.24	18.8	2.3
8. Forestry Mnf.	0.0	6.8	0.01	1.7	0.1
9. Other Mnf.	0.0	5.9	0.02	1.3	0.1
10. Services/Trade	0.0	390.4	0.09	101.6	13.7
11. National Def.	0.0	3.9	0.01	2.5	0.1
12. Local Gov't.	0.0	31.7	0.07	5.7	0.8
13. Households	0.0	366.4	0.06	10.4	16.5
Total Change	1,874.4	2,945.0		366.2	56.9

TABLE A.7 IMPACT OF INCREASED FINAL DEMAND - FORESTRY SECTOR
(Type I I-O Model - 5% increase in final demand)

Sector	Projected Change In Final Demand ($1000)	Projected Change In Output ($1000)	Percent Change In Output (%)	Projected Change In Income ($1000)	Projected Change In Employment (No. FTE)
1. All Crops	0.0	5.0	0.03	1.7	0.2
2. Dairy	0.0	13.2	0.02	2.9	0.2
3. Swine	0.0	1.4	0.01	0.1	0.0
4. Poultry	0.0	0.1	0.00	0.0	0.0
5. Forestry	3,995.2	4,018.9	5.03	1,046.9	61.9
6. Frt/Veg Proc.	0.0	5.3	0.01	0.8	0.1
7. Food/Bev/Feed	0.0	32.9	0.04	2.8	0.3
8. Forestry Mnf.	0.0	18.9	0.03	4.8	0.2
9. Other Mnf.	0.0	52.3	0.15	11.8	0.6
10. Services/Trade	0.0	1,170.5	0.26	304.7	41.1
11. National Def.	0.0	0.6	0.00	0.4	0.0
12. Local Gov't.	0.0	48.6	0.11	8.8	1.2
Total Change	3,995.2	5,367.7		1,385.7	105.8

TABLE A.8 IMPACT OF INCREASED FINAL DEMAND - FORESTRY SECTOR
(Type II I-O Model - 5% increase in final demand)

Sector	Projected Change In Final Demand ($1000)	Projected Change In Output ($1000)	Percent Change In Output (%)	Projected Change In Income ($1000)	Projected Change In Employment (No. FTE)
1. All Crops	0.0	9.2	0.05	3.1	0.3
2. Dairy	0.0	26.9	0.04	5.9	0.4
3. Swine	0.0	2.6	0.02	0.1	0.0
4. Poultry	0.0	0.3	0.00	0.0	0.0
5. Forestry	3,995.2	4,019.7	5.03	1,047.1	61.9
6. Frt/Veg Proc.	0.0	9.8	0.01	1.5	0.1
7. Food/Bev/Feed	0.0	73.8	0.08	6.4	0.8
8. Forestry Mnf.	0.0	37.3	0.07	9.5	0.4
9. Other Mnf.	0.0	67.2	0.19	15.2	0.7
10. Services/Trade	0.0	2,167.2	0.48	564.2	76.1
11. National Def.	0.0	18.5	0.03	11.8	0.7
12. Local Gov't.	0.0	122.4	0.28	22.1	3.1
13. Households	0.0	1,736.4	0.29	49.3	78.1
Total Change	3,995.2	8,291.3		1,736.2	222.6

TABLE A.9 IMPACT OF INCREASED FINAL DEMAND - FOOD/BEV/FEED PROCESSING (Type I I-O Model - 5% increase in final demand)

Sector	Projected Change In Final Demand ($1000)	Projected Change In Output ($1000)	Percent Change In Output (%)	Projected Change In Income ($1000)	Projected Change In Employment (No. FTE)
1. All Crops	0.0	1.4	0.01	0.5	0.0
2. Dairy	0.0	896.8	1.18	198.2	13.5
3. Swine	0.0	0.4	0.00	0.0	0.0
4. Poultry	0.0	0.0	0.00	0.0	0.0
5. Forestry	0.0	0.2	0.00	0.1	0.0
6. Frt/Veg Proc.	0.0	1.5	0.00	0.2	0.0
7. Food/Bev/Feed	4,516.8	4,673.9	5.17	404.8	49.5
8. Forestry Mnf.	0.0	5.2	0.01	1.3	0.1
9. Other Mnf.	0.0	7.1	0.02	1.6	0.1
10. Services/Trade	0.0	327.3	0.07	85.2	11.5
11. National Def.	0.0	0.2	0.00	0.1	0.0
12. Local Gov't.	0.0	39.3	0.09	7.1	1.0
Total Change	4,516.8	5,953.3		699.1	75.7

TABLE A.10 IMPACT OF INCREASED FINAL DEMAND - FOOD/BEV/FEED PROCESSING (Type II I-O Model - 5% increase in final demand)

Sector	Projected Change In Final Demand ($1000)	Projected Change In Output ($1000)	Percent Change In Output (%)	Projected Change In Income ($1000)	Projected Change In Employment (No. FTE)
1. All Crops	0.0	3.5	0.02	1.2	0.1
2. Dairy	0.0	903.7	1.19	199.7	13.6
3. Swine	0.0	1.0	0.01	0.1	0.0
4. Poultry	0.0	0.1	0.00	0.0	0.0
5. Forestry	0.0	0.6	0.00	0.2	0.0
6. Frt/Veg Proc.	0.0	3.7	0.00	0.6	0.0
7. Food/Bev/Feed	4,516.8	4,694.5	5.20	406.5	49.8
8. Forestry Mnf.	0.0	14.5	0.03	3.7	0.2
9. Other Mnf.	0.0	14.6	0.04	3.3	0.2
10. Services/Trade	0.0	830.2	0.19	216.1	29.1
11. National Def.	0.0	9.2	0.01	5.9	0.3
12. Local Gov't.	0.0	76.6	0.18	13.9	2.0
13. Households	0.0	876.0	0.15	24.9	39.4
Total Change	4,516.8	7,428.2		876.1	134.7

TABLE A.11 IMPACT OF INCREASED FINAL DEMAND - FOREST PRODUCTS MNFTG.
(Type I I-O Model - 5% increase in final demand)

Sector	Projected Change In Final Demand ($1000)	Projected Change In Output ($1000)	Percent Change In Output (%)	Projected Change In Income ($1000)	Projected Change In Employment (No. FTE)
1. All Crops	0.0	1.6	0.01	0.6	0.1
2. Dairy	0.0	4.3	0.01	0.9	0.1
3. Swine	0.0	0.5	0.00	0.0	0.0
4. Poultry	0.0	0.0	0.00	0.0	0.0
5. Forestry	0.0	121.5	0.15	31.7	1.9
6. Frt/Veg Proc.	0.0	1.7	0.00	0.3	0.0
7. Food/Bev/Feed	0.0	10.7	0.01	0.9	0.1
8. Forestry Mnf.	2,777.8	2,820.6	5.08	720.7	29.9
9. Other Mnf.	0.0	73.4	0.21	16.6	0.8
10. Services/Trade	0.0	380.7	0.08	99.1	13.4
11. National Def.	0.0	0.2	0.00	0.1	0.0
12. Local Gov't.	0.0	23.0	0.05	4.2	0.6
Total Change	2,777.8	3,438.2		875.1	46.9

TABLE A.12 IMPACT OF INCREASED FINAL DEMAND - FOREST PRODUCTS MNFTG.
(Type II I-O Model - 5% increase in final demand)

Sector	Projected Change In Final Demand ($1000)	Projected Change In Output ($1000)	Percent Change In Output (%)	Projected Change In Income ($1000)	Projected Change In Employment (No. FTE)
1. All Crops	0.0	4.3	0.02	1.5	0.1
2. Dairy	0.0	12.9	0.02	2.9	0.2
3. Swine	0.0	1.2	0.01	0.1	0.0
4. Poultry	0.0	0.1	0.00	0.0	0.0
5. Forestry	0.0	122.0	0.15	31.8	1.9
6. Frt/Veg Proc.	0.0	4.5	0.01	0.7	0.0
7. Food/Bev/Feed	0.0	36.5	0.04	3.2	0.4
8. Forestry Mnf.	2,777.8	2,832.3	5.10	723.7	30.0
9. Other Mnf.	0.0	82.8	0.24	18.7	0.9
10. Services/Trade	0.0	1,010.0	0.23	262.9	35.5
11. National Def.	0.0	11.5	0.02	7.3	0.4
12. Local Gov't.	0.0	69.7	0.16	12.6	1.8
13. Households	0.0	1,096.4	0.19	31.1	49.3
Total Change	2,777.8	5,284.2		1,065.4	120.5

TABLE A.13 IMPACT OF INCREASED FINAL DEMAND - NATIONAL DEFENCE (Type I I-O Model - 5% increase in final demand)

Sector	Projected Change In Final Demand ($1000)	Projected Change In Output ($1000)	Percent Change In Output (%)	Projected Change In Income ($1000)	Projected Change In Employment (No. FTE)
1. All Crops	0.0	2.0	0.01	0.7	0.1
2. Dairy	0.0	7.1	0.01	1.6	0.1
3. Swine	0.0	0.6	0.00	0.0	0.0
4. Poultry	0.0	0.1	0.00	0.0	0.0
5. Forestry	0.0	0.3	0.00	0.1	0.0
6. Frt/Veg Proc.	0.0	2.1	0.00	0.3	0.0
7. Food/Bev/Feed	0.0	22.6	0.02	2.0	0.2
8. Forestry Mnf.	0.0	7.5	0.01	1.9	0.1
9. Other Mnf.	0.0	11.6	0.03	2.6	0.1
10. Services/Trade	0.0	472.4	0.11	123.0	16.6
11. National Def.	3,164.9	3,165.1	5.00	2,020.0	120.3
12. Local Gov't.	0.0	12.7	0.03	2.3	0.3
Total Change	3,164.9	3,704.1		2,154.5	137.8

TABLE A.14 IMPACT OF INCREASED FINAL DEMAND - NATIONAL DEFENCE (Type II I-O Model - 5% increase in final demand)

Sector	Projected Change In Final Demand ($1000)	Projected Change In Output ($1000)	Percent Change In Output (%)	Projected Change In Income ($1000)	Projected Change In Employment (No. FTE)
1. All Crops	0.0	8.6	0.05	2.9	0.3
2. Dairy	0.0	28.4	0.04	6.3	0.4
3. Swine	0.0	2.4	0.02	0.1	0.0
4. Poultry	0.0	0.2	0.00	0.0	0.0
5. Forestry	0.0	1.6	0.00	0.4	0.0
6. Frt/Veg Proc.	0.0	9.1	0.01	1.4	0.1
7. Food/Bev/Feed	0.0	86.1	0.10	7.5	0.9
8. Forestry Mnf.	0.0	36.3	0.07	9.3	0.4
9. Other Mnf.	0.0	34.9	0.10	7.9	0.4
10. Services/Trade	0.0	2,022.0	0.45	526.4	71.0
11. National Def.	3,164.9	3,192.9	5.04	2,037.6	121.3
12. Local Gov't.	0.0	127.5	0.29	23.1	3.3
13. Households	0.0	2,699.5	0.46	76.6	121.5
Total Change	3,164.9	8,249.5		2,699.5	319.6