EMPLOYMENT IN CANADIAN AGRICULTURE

A REGIONAL ANALYSIS OF EMPLOYMENT CHANGES IN CANADIAN AGRICULTURE

By

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A Thesis

Submitted to the School of Graduate Studies

in Partial Fulfilment of the Requirements

for the Degree

Doctor of Philosophy

McMaster University

March, 1977

DOCTOR OF PHILOSOPHY (1977)
(Geography)

McMASTER UNIVERSITY
Hamilton, Ontario

TITLE: A Regional Analysis of Employment Changes in Canadian Agriculture

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NUMBER OF PAGES: 214

ABSTRACT

The study investigates changes in the size and composition of the farm labour force in the regions of Canada over the period 1946 to 1973. The analysis of changes in farm employment is based upon an econometric model of the market for agricultural labour. The study departs from previous econometric analyses of the farm labour market in several respects. The model is disaggregated into three submodels, each pertaining to a distinct component of the farm workforce. Unlike other disaggregated models, the fundamental processes that determine levels of employment are not assumed to be the same for all types of farm labour. Instead, the submodels for farm operator employment, unpaid family employment, and hired farm labour have different conceptual bases and different structural forms, thus incorporating important elements of the heterogeneity of the farm labour force within the model. The derivation procedures also result in particular interdependencies being specified among the components, a further extension of previous models.

Empirical estimation of the farm employment model is undertaken at both the national and regional levels, and regional differences in the parameter estimates are analyzed using covariance procedures. This investigation of regional variation in the

estimated employment relationships represents a notable development in the analysis of the market for agricultural labour.

The results attest to the efficacy of using econometric models to analyze changes in farm employment, and demonstrate that such models also lend themselves to statistical examination of regional variation in the determinants of employment changes. The regional analysis shows that the effects of changes in economic variables on farm employment differ significantly among the regions of Canada. However, these differences are most frequently differences in the magnitude and speed of employment responses to changing economic stimuli, and several of the empirical relationships are relatively consistent among groups of regions.

Changes in farm operator numbers are shown to be related to changes in agricultural technology and nonfarm income opportunities, though changes in the relative price of farm products seem to have little effect on operator employment in agriculture. In all regions, the number of unpaid family workers in agriculture is related to the number of farmers, but in Quebec, Ontario and the Prairies, unpaid family employment also varies with changes in the cost of hired labour. In these regions, the results imply that increases in farm wage rates encourage farm operators to employ available members of their families on the farm rather than hire additional paid labour. The results also indicate that in Quebec, Ontario, and the Prairies, the supply of hired farm workers would increase if returns to hired labour in agriculture were raised, as long as operators are willing and able to offer such increases. In these regions also, employment in all components of the farm workforce are shown to be related to wage levels and the availability of jobs in the nonfarm sector. In periods when the nonfarm economy is depressed, agriculture tends to retain surplus labour.

It is suggested that the regional differences in the parameter estimates might reflect differences in the structure of agriculture, especially the relative importance of commercial family farms, or they may be related to differences in the degree of urban-industrial development among the regions. In any event, the farm employment model generally fits the data well in Ontario, has minor limitations in the Prairie region and Quebec, but performs poorly in the Atlantic region and British Columbia.

ACKNOWLEDGEMENTS

I am greatly indebted to the members of my supervisory committee for their contribution to the preparation of this dissertation; a special obligation is felt towards Michael Webber for his continued stimulus and guidance, and Lloyd Reeds and Leslie Robb were particularly generous in their encouragement and advice. The Geography department at McMaster provided financial support and a stimulating research environment. I am grateful to the many faculty members, fellow graduate students, and staff from the Geography department who provided help or advice. The typing of the final draft was graciously undertaken by Becky Nixon, and cartographic assistance was provided by Margo Adamson. I also wish to thank my wife, Ruthanne, for the many ways in which she has contributed to the completion of this thesis.

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CHAPTER 1

INTRODUCTION

1.1 Nature of the Problem

The number of people employed in the agricultural sector of advanced western economies has substantially declined over recent decades. For instance, between 1940 and 1970 in Great Britain, the United States, and Canada, the agricultural labour force declined by more than 50 percent. In the 1950's, the farm workforce declined on average by 200,000 each year in the United States, and by 26,000 each year in Canada. Such large movements of people out of the farm sector stimulated the analysis of farm labour markets and of the forces which influence the movement of workers between farm and nonfarm occupations. The magnitude of the changes and the associated problems of low rural incomes and adjustments to urban living prompted many studies, particularly in the 1950's and 1960's, by agricultural economists, geographers, rural sociologists, demographers, and regional development analysts.

However, by the late 1960's, a relative dearth of literature on farm labour and off-farm mobility reflected reduced interest in this phenomenon, despite continued reductions in agricultural employment. Between 1960 and 1970 the farm work-force declined on average by 180,000 each year in the United States, and by 17,000 each year in Canada. However, by this time mobility from agriculture was less notable relative to other shifts of occupation or residence.

By contrast, analyses of urban labour markets, and intraurban and interregional migration continued to be popular. It is unlikely that interest in farm labour waned because the farm labour market and farm labour mobility were by then clearly understood. Certainly, considerable insight has been gained into the processes which have influenced changes in agricultural employment, but a perusal of the literature reveals that many fundamental questions, both theoretical and empirical, remain unsolved.

Theory developed specifically for farm labour markets is meagre. For example, most studies draw upon general theories of labour supply and demand for their conceptual base. The inadequacy of the current theory is readily apparent when it is observed that most of the theoretical treatment is concerned with hired farm labour, while in the agricultural sector, hired workers constitute only a small proportion of the labour force. The bulk of the farm labour force is either self-employed or unpaid family help.

The empirical studies, conducted mainly in the United States, have concentrated on the farm labour market at the national level, or have examined aspects of farm labour and labour mobility in small areas. Little attention has been given to the regional pattern of employment change and its determinants. Our understanding of the farm labour force and the processes which influence changes in its size and composition is rather limited. Our knowledge of the regional variation in these changes and processes is even more scanty.

In Canada, the inadequacy of the theory and the paucity of the empirical work is especially noticeable. Despite shifts of large numbers of people out of agriculture, our knowledge of the patterns of change in the farm labour force and of the forces that govern such adjustments is minimal. This study represents an attempt to increase our knowledge of the Canadian farm labour force and the changes that have occurred since 1946 in agricultural employment among the regions of Canada.

1.2 Objectives of the Study

The general aim of this study is to describe and account for changes in the size and composition of the farm labour force in the regions of Canada. While the empirical investigation is emphasized, the study also offers an opportunity to present some theoretical developments, a methodological procedure which has wider application, and some implications for rural manpower policy.

The first specific objective is to describe the main characteristics of the farm labour force in Canada, and outline some of the more fundamental changes that have taken place in the employment of labour in agriculture at both the national and regional levels. This background information is presented in Chapter 2.

Secondly, the study devises a method of analysing regional differences in the determinants of change in the size and composition of the farm labour force. The strategy adopted in this investigation is outlined after existing approaches to the analysis of farm labour adjustments and off-farm mobility are reviewed in Chapter 3. Essentially, the design involves applying a model, developed to account for year to year changes in the numbers employed in the major categories of farm labour, to each of the regions of Canada, then testing for regional differences in the model results.

The third objective is to develop a model of employment in agriculture that recognises three distinct components of farm labour (farm operators, unpaid family workers, and hired labour), and allows for interdependence among the components. This theoretical model, in which particular attention is given to the family labour components and to the aggregation question, is developed in Chapter 4.

The final objective is the empirical implementation of the model and the interpretation of the results. The properties of the statistical model and the estimation procedures used in the empirical analysis are described in Chapter 5. The model is tested at both the national and regional levels, and the regional differences in the statistical results are analysed in Chapter 6. The study concludes with a discussion of the implications of the results.

CHAPTER 2

BACKGROUND TO THE ANALYSIS

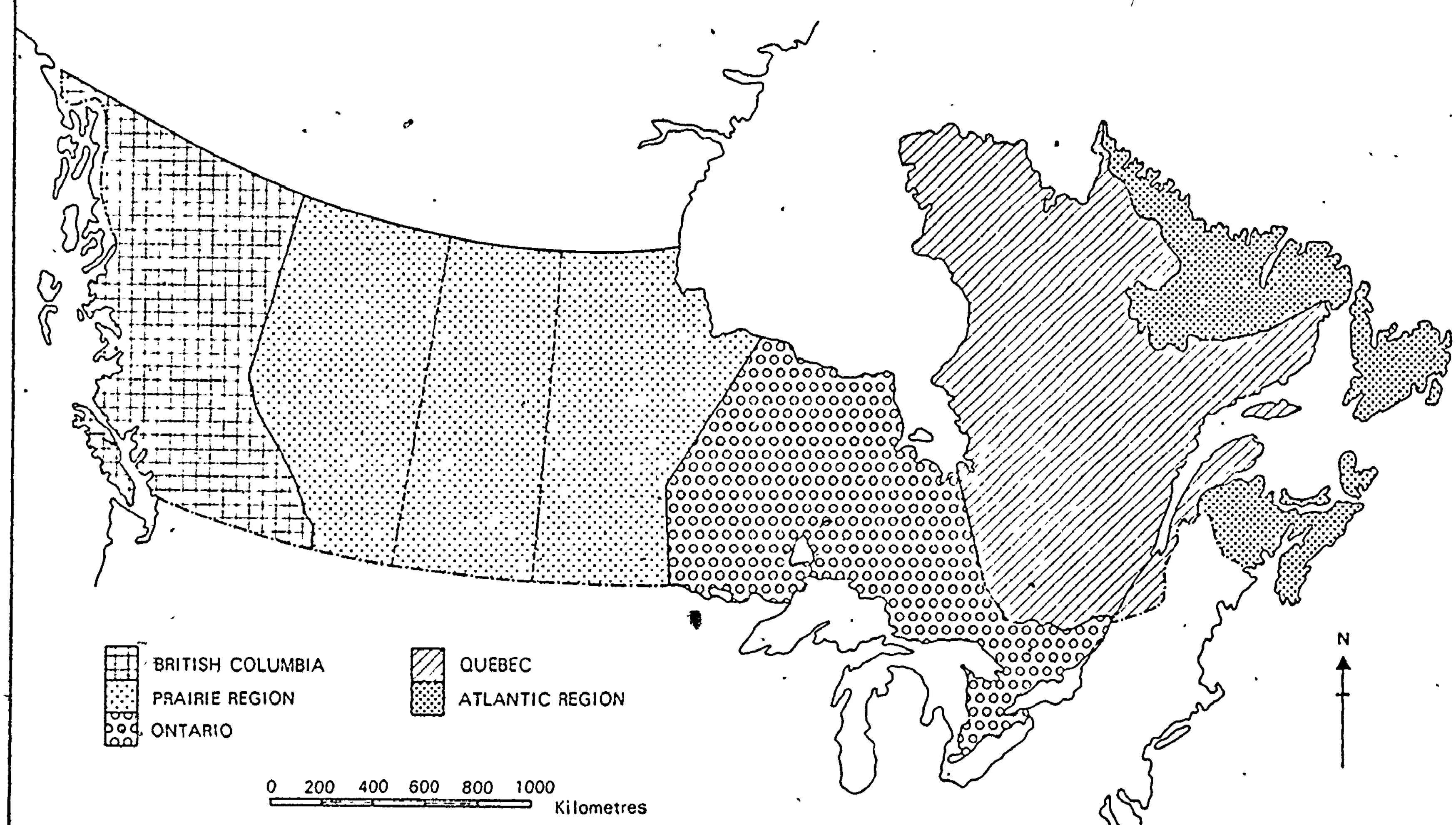
This chapter describes recent trends in the size, composition and distribution of the Canadian agricultural labour force. The regions of Canada used in this study are delimited, and changes in the numbers and characteristics of the farm workforce are described at the national and regional levels. A summary of adjustments in the structure and organization of Canadian agricultural production is also given. This background information provides a basis for understanding and interpreting the theoretical and statistical results that follow in later chapters.

2.1 Regions of Canada

An important focus of this thesis is the analysis of regional differences in the patterns of farm labour force adjustment and the consideration of regional differences in the determinants of farm labour changes. For the purposes of the study, the following regions of Canada are defined: the Atlantic region, Quebec, Ontario, the Prairies, and British Columbia (Figure 2.1).

FIGURE 2.1

REGIONS OF CANADA



These regions are chosen largely because the data required in the empirical analyses are usually available only for these regions or for the provinces. Nevertheless, the regions represent a traditional demarcation of Canada (see Putnam and Putnam, 1970). The regions delimit broad areas, based on political units, that exhibit some homogeneity in agriculture and general economic organization. A brief description of the nature of agricultural production in each of the regions follows.

Atlantic region. Agriculture in New Brunswick and Nova Scotia is largely restricted to the coastal lands and valleys, most of Prince Edward Island is farmland, while very little of Newfoundland supports any agriculture. Although the Maritime provinces have long been known for their traditional cash crops such as potatoes, apples, and hay, since the early 1960's more than half of the commercial farmers have received the bulk of their incomes from the sale of livestock and livestock products. Modern techniques and mechanization have not had a great impact on the organization of agriculture in the Atlantic provinces, largely because of the relatively low proportion of full-time operations, the small size of farms, the high proportion of farmers in the older age groups, the limited resource base, and the general lack of prosperity among the farm enterprises (Putnam and Putnam, 1970). The role of agriculture in the economy of the region has been studied by Fletcher (1966), who argues that although agriculture plays a significant role in the total regional economy, this is largely a reflection of the comparative underdevelopment of regional manufacturing, and agriculture is not a significant employer of labour. Many farms are not economically viable, and land abandonment has proceeded rapidly. In 1961 it was estimated that more than 30 percent of farms were operating at a subsistence level, and more than 50 percent of farmers reported doing "off-the-farm" work (Fletcher, 1966). In both 1966 and 1971, very high proportions (61 and 52 percent, respectively) of census farms in the Atlantic provinces fell in the non-commercial (less than $2500 gross sales) classes (Canada Yearbook, 1974).

Quebec. Mixed crop and livestock farming is characteristic of most of rural Quebec. A majority of its farmers derive the bulk of their income from the sale of dairy products: in 1971, more than 70 percent of census farms with annual sales of $2,500 or more were classified as dairy operations (Canada Yearbook, 1974). The provincial government has actively encouraged land settlement on the Canadian Shield, resulting in an agricultural fringe area, in which most of the farms are small scale operations which earn less than $2,500 annually, with operators also working "off-the-farm" (Putnam and Putnam, 1970). Quebec as a whole has a considerable proportion of farms in the non-commercial category (47 percent in 1966 and 34 percent in 1971).

Ontario. Dairying, livestock raising, and the growing of fruits, vegetables and tobacco are the dominant agricultural activities in Ontario. The livestock industry, accounting for about 70 percent of commercial operations, is supported by farms producing grain and fodder crops. A noticeable change in Ontario agriculture in the post-war period is the steady decline of the old "mixed" or general farm as farm operations have become more specialized. Technological advances in dairying, such as bulk cooling, have forced dairy farmers into heavy new capital expenses. Many small herds have been forced out of the industry and their contracts awarded to the operators of larger farms. The rising demand for beef during the 1950's and 1960's stimulated the increase in steer feeder operations and the establishment of fairly large feeder lots (Putnam and Putnam, 1970). Intensification of agricultural practices is particularly noticeable in the more favourably endowed areas of Ontario, while elsewhere many farms are going out of production (ARDA, 1972). Farms are becoming fewer, larger and more highly mechanized, more efficient, and capable of greater production. Non-commercial enterprises accounted for 35 percent of all farms in 1966 and less than 30 percent in 1971 (Canada Yearbook, 1974).

Prairie region. Agriculture plays an important role in the economy of the Prairie provinces, accounting in 1971 for 25 percent of the annual net income of the Prairie population and

16 percent of the Prairie's labour force. Commercial grain farming is still the dominant type of enterprise, with large and highly mechanized operations, a pattern which was already well established by the mid-1940's. Farm enterprises have since diversified in some areas of the Prairies, most notably as meat production has increased in importance, especially in the mixed farming areas of Alberta and Manitoba. The raising of beef cattle tends to be specialized into cow-calf enterprises, wintering farms, and feedlots for finishing (Putnam and Putnam, 1970). More than any other region, the farms of the Prairies are operated as business enterprises, with only a small proportion of farms in the non-commercial class (24 percent in 1966 and 22 percent in 1971), and only a small proportion of the operators reporting "off-the farm" work (Canada Yearbook, 1974).

British Columbia. Compared with the other regions, agriculture is a relatively unimportant primary industry in British Columbia. The agriculture is highly diversified: specialized fruit growing is found in the Okanagan Valley, dairying and truck-farming occur in the southwestern lowlands, grain and livestock are produced in the Peace River area, and the natural grasslands of the interior support grazing operations. The degree of commercialization among British Columbia farms is also varied, with half the census farms falling in the less than $2500 sales category in 1966 and 1971 (Canada Yearbook, 1974).

Clearly, significant differences exist among the regions in the relative importance of agriculture to the regional economies, in the products of the agricultural sector, and in the structure and organization of the industry. Agriculture in the Atlantic region is diversified, small scale, and largely non-commercial. At the other extreme, Prairie agriculture is characterised by a high degree of specialization, large operations, and a higher proportion of commercial farms than in any other region.

2.2 Rural and Farm Population

The rural-urban distribution of the Canadian population has changed markedly during the last five decades. Whilst total population has increased from 8.8 million in 1921 to 21.6 million in 1971, that portion living in rural areas was estimated at 4.4 million in 1921, 6.0 million in 1951, but only 5.1 million in 1971 (Table 2.1). As a percentage of total population, rural dwellers declined steadily from 50.5 percent in 1921 to 23.9 percent in 1971.

The Canadian farm population, that is persons residing on farms, declined even more rapidly, from 3.2 million in 1931 to 1.5 million in 1971. Farm dwellers constituted 32 percent of the total population and 68 percent of the rural population in 1931, but by 1971, only 6.9 percent of the total population and

TABLE 2.1

POPULATION OF CANADA: TOTAL, RURAL AND FARM, 1921 to 1971

	1921	1931	1941	1951	1961	1971
Numbers (thousands):						
Total population	8,788	10,377	11,507	14,009	18,236	21,568
Rural population	4,436	4,805	5,254	6,068	5,538	5,154
Farm population	--	3,289	3,152	2,912	2,128	1,489
Percentages:						
Rural of total	50.5	46.3	45.6	43.3	30.4	23.9
Farm of total	--	31.7	27.4	20.8	11.7	6.9
Farm of rural	--	68.4	60.0	48.0	37.4	28.9

Source: Statistics Canada, Census of Canada, Population, 1961, 1971.

28.9 percent of the rural population resided on farms. Thus, between 1931 and 1971, the Canadian population became predominantly urban, with the rural population declining proportionately and absolutely. Within the rural community, the farm population declined in importance, coincident with the growth of a rural non-farm population.

2.3 The Agricultural Labour Force

The two main sources of data on the Canadian labour force are The Labour Force[1] and Census of Canada[2]. There are differences in the data from these two sources because of the different concepts used (Denton and Ostry, 1967). The Labour Force defines labour force as "those persons, 14 years of age and over, who are not members of the armed forces, Indians living on reserves, or inmates of institutions". The labour force thus consists of employed and unemployed. The Census of Canada, for the 1941 Census and in earlier years, used the concept "gainfully employed" to count people working. Since 1951, the Census has used the labour force concept. The main conceptual differences between the 1951 Census and The Labour Force of the

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[1] Statistics Canada, The Labour Force, monthly.

[2] Statistics Canada, Census of Canada, Labour Force, Population, Agriculture, various years.

same time are in the classification of Indians living on reserves and members of the armed forces. The two sources also differ in their frequency and method of data collection: the Census figures are based on 5 yearly census returns from all households, whereas The Labour Force estimates are derived from monthly sample surveys.

The following sections used data both from The Labour Force, which is available from 1946, and from the Censuses. In addition, extensive use is made of monographs published by public agencies such as Statistics Canada (Ostry, 1968), and the Economics Branch, Canada Department of Agriculture (Andarawewa, 1970).

The Canadian civilian labour force has shown a steady increase from 3.1 million in 1921 to 8.1 million in 1971 as a result of immigration, natural increase, and increased participation (Table 2.2). Employment in agriculture increased to 1,224,000 in 1941, then declined to 509,000 in 1971. In proportion to total employment, agricultural employment decreased from 37.3 percent in 1921 to 6.3 percent in 1971. This decline in the relative position of agriculture as a source of employment has not been constant, however, for it was particularly marked during the years since World War II (Table 2.2), which coincides with the focus of this thesis. Labour force trends in the pre-war period are discussed in Buchanan (1960) and Andarawewa (1970).

The decline in agricultural employment, both absolutely

TABLE 2.2

LABOUR FORCE: TOTAL, AGRICULTURAL AND NON-AGRICULTURAL, CANADA, 1921 TO 1971

	Total Employed	Employed in Agriculture	Employed in Non-Agriculture	Percentage of Total: Agriculture	Percentage of Total: Non-Agriculture
	thousands			percent	
1921	3,121	1,165	1,956	37.3	62.7
1931	3,670	1,216	2,454	33.1	66.9
1941	4,271	1,224	3,047	28.6	71.4
1951	5,097	939	4,158	18.4	81.6
1961	6,055	681	5,374	11.2	88.8
1971	8,079	509	7,570	6.3	93.7

Sources: Andarawewa (1970);
Statistics Canada, Census of Canada, Population, 1971.

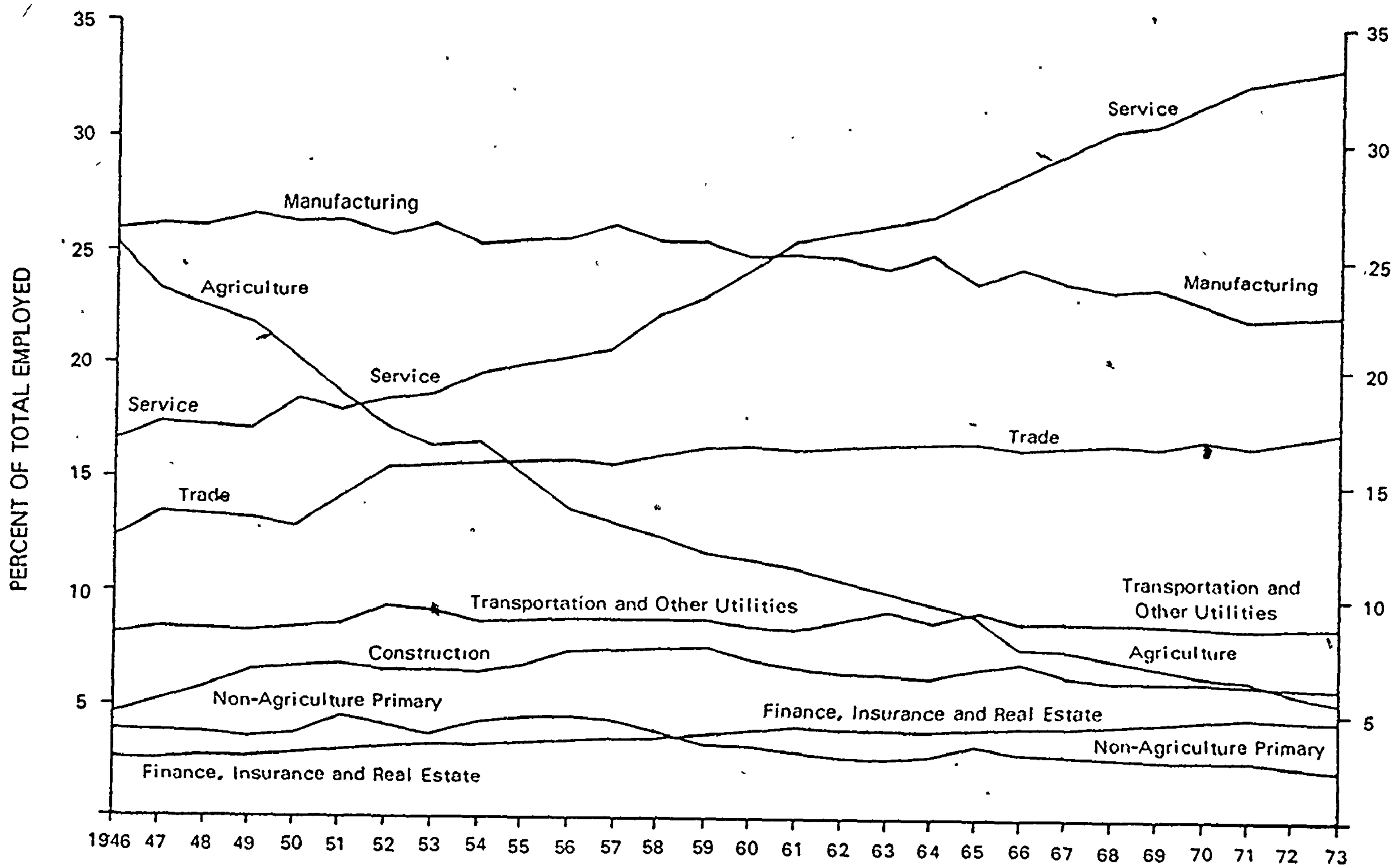
and relative to that in other industries, manifests a transition from an economy relying on agriculture to one based on manufacturing, services, and trade. In 1946, employment in agriculture accounted for 25.5 percent of total employment, ranking second to manufacturing with 26 percent (Figure 2.2). The rapid decline in agricultural employment meant that by 1973 more people were employed in each of manufacturing services, trade, transportation and utilities, and construction than in agriculture.

2.3.1 Regional Trends

The regional trends in agricultural employment during the period 1946-1973 generally reflect the national pattern. Employment in agriculture declined after 1946 in all regions, although both the magnitude of change and the annual rates of change differ among the regions (Figure 2.3). In the Atlantic region, farm employment declined by almost 80 percent between 1946 and 1973, despite a period of relative stability during the decade 1951 to 1961. In Quebec, the rate of change in agricultural employment varied greatly from year to year, although by 1973 the workforce in agriculture was only 32 percent of that in 1946. Farm employment also fluctuated over the years in Ontario, declining by 62 percent between 1946 and 1973. The greatest absolute loss in farm labour over the period occurred in the Prairie region, although the proportionate loss, 54 percent, was less than that

FIGURE 2.2

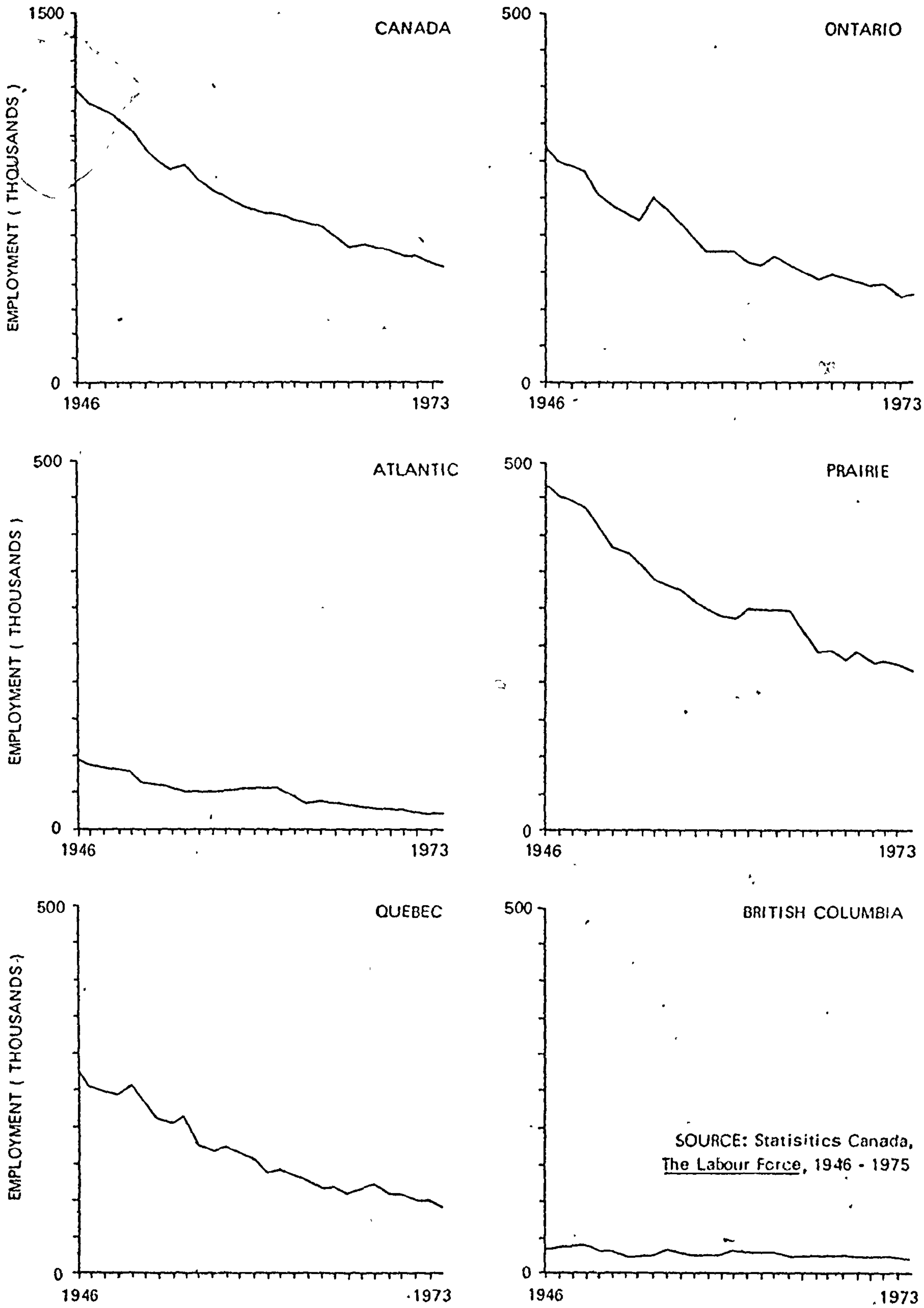
DISTRIBUTION OF THE EMPLOYED BY INDUSTRIAL GROUP, CANADA, 1946 - 1973



SOURCE: Statistics Canada, Canada Yearbook, 1962, 1973.

FIGURE 2.3

AGRICULTURAL EMPLOYMENT, CANADA AND REGIONS, 1946 - 1973



in the Atlantic region, Quebec and Ontario. In British Columbia, farm employment fluctuated annually, but did not decrease substantially over the period 1946 to 1973.

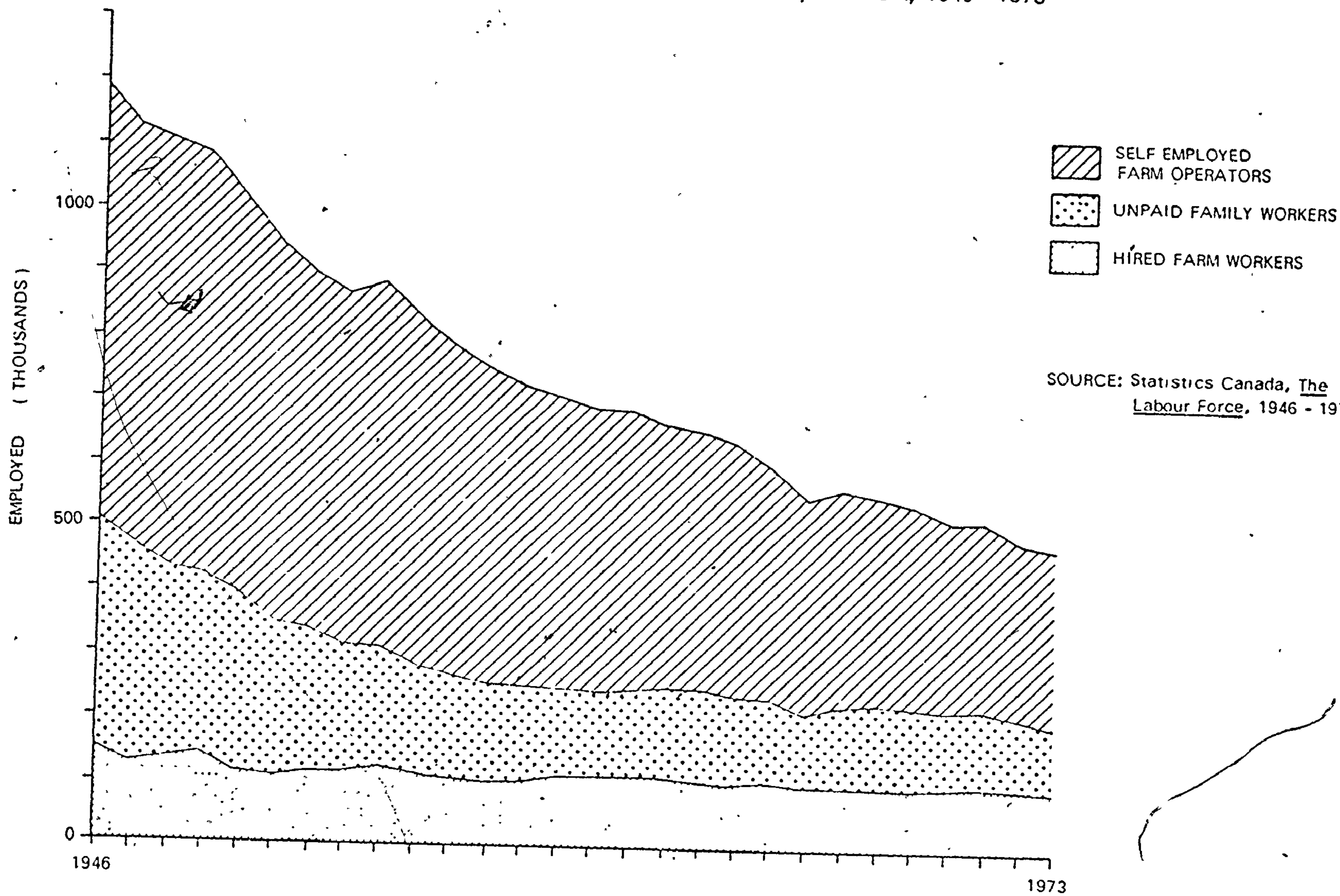
As a percentage of the total labour force, agricultural labour has declined in all regions. In the Atlantic region, Quebec and Ontario, agriculture's proportion of the total labour force decreased steadily from a little more than 20 percent in 1946 to less than 5 percent in 1973. In the Prairie region, the proportion of the labour force in agriculture has always been higher than in other regions but it also declined steadily from 48 percent to 16 percent over the period. The general reduction is also evident in British Columbia, where agriculture has accounted for a very small proportion of the total labour force.

2.3.2 Type of Worker

Total farm employment is comprised of several types or classes of farm workers. A distinction is commonly made between hired workers and family labour (Heady and Tweeten, 1963; Yeh and Li, 1966), though in Canada since 1946, three categories of agricultural workers have been identified and enumerated. These are paid workers, unpaid family members, and self-employed farm operators. The self-employed farm operators constitute the largest component of the total agricultural employment (Figure 2.4). While declining in absolute numbers throughout the period 1946 to

FIGURE 2.4

AGRICULTURAL EMPLOYMENT BY COMPONENT, CANADA, 1946 - 1973



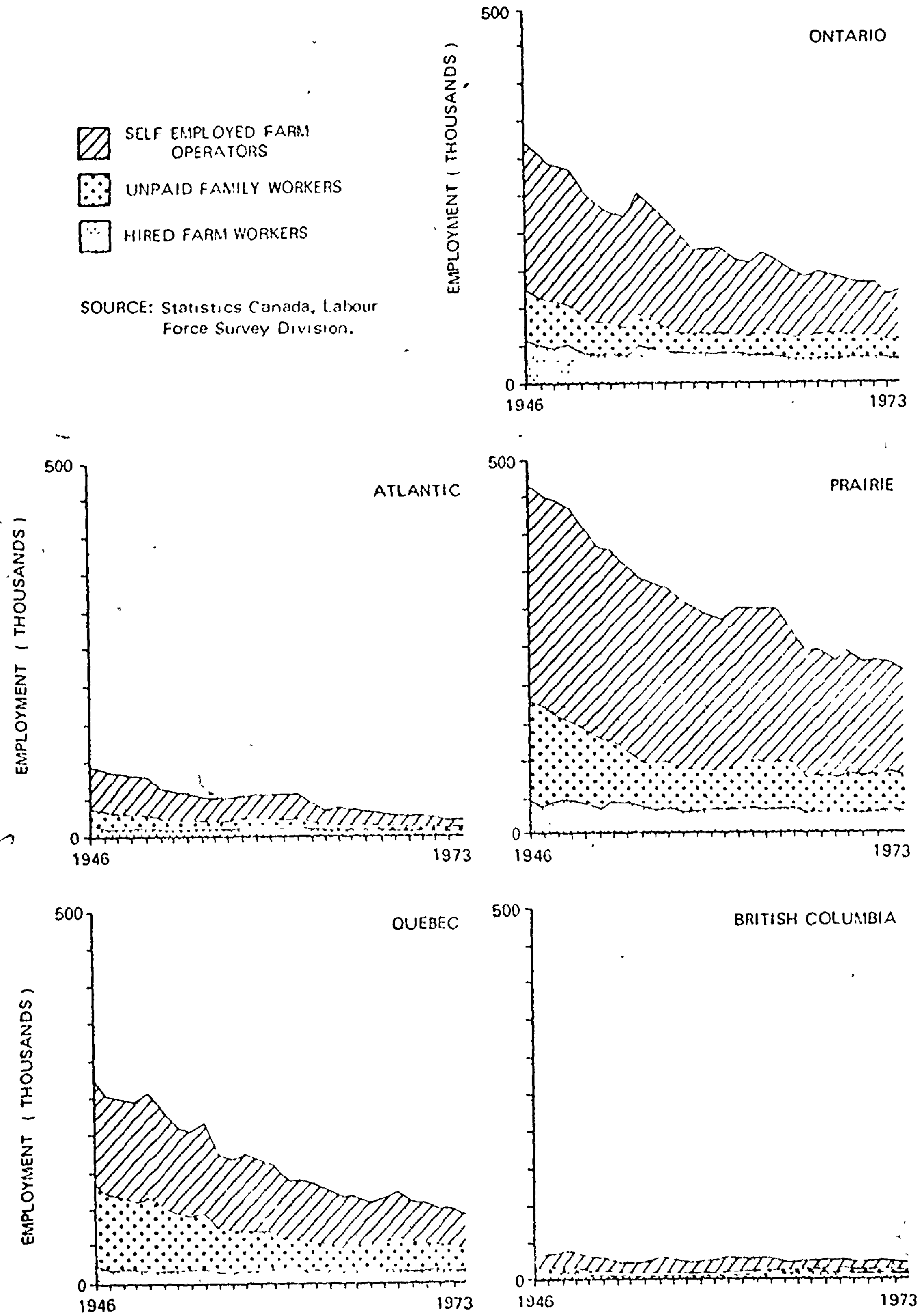
SOURCE: Statistics Canada, <u>The Labour Force</u>, 1946 - 1975

1973, the farm operator component has consistently accounted for approximately 60 percent of the total agricultural employment. Unpaid family workers experienced the greatest proportionate decline in numbers, especially in the period up to 1960. The smallest decline was among paid workers, whose numbers fluctuated from 146,000 in 1946 to a little under 100,000 by 1973. The major change in the relative proportions of workers among the three categories was the increase in the proportion of paid workers, largely at the expense of unpaid family members, from about 10 percent at the beginning of the period to more than 20 percent in 1973.

Among the regions, the three categories showed similar trends in absolute numbers: the number of farm operators and, in particular, of unpaid family workers declined, while paid workers fluctuated in number without experiencing substantial changes over the period (Figure 2.5). However, considerable differences existed among the regions with respect to both the proportion of the labour force in each category, and the changes in this composition between 1946 and 1973. Self-employed farm operators constituted the largest component in all regions, accounting for 50 to 70 percent of agricultural employment. Operators dominated the farm employment structure in the Prairies more than in any other region. The proportion of operators remained relatively constant over the period in all regions, with slight increases

FIGURE 2.5

AGRICULTURAL EMPLOYMENT BY COMPONENT, REGIONS OF CANADA, 1946 - 1973



apparent up to the late 1950's, followed by slight declines since that time.

The relative importance of the other categories varied significantly among the regions. In Quebec and the Prairie region, the unpaid family worker component has been significantly larger than the hired worker category since 1946. In both regions, the proportion of unpaid family workers declined for most of the period, but increased over recent years. In the Atlantic region, unpaid family workers accounted for almost twice the paid worker contribution in 1946. However, the unpaid family proportion has steadily declined whereas the proportion of paid workers has shown an equally steady increase. As a result, by 1960 there were more paid workers than unpaid family workers in the Atlantic region, and by 1973 paid workers represented almost 40 percent of the total workforce in agriculture while unpaid family workers accounted for only 10 percent. In Ontario, the proportion of unpaid family workers has fluctuated about 20 percent, while the paid worker component has shown a steady increase from 17 percent of farm employment in 1946 to almost 30 percent in 1973. In British Columbia, paid workers outnumbered unpaid family workers throughout the period, and accounted for almost 40 percent of the region's agricultural employment in 1973.

Clearly, the patterns of change in the size and composition of the farm workforce differ quite markedly from one region to another in Canada. The family labour component has persisted in importance in Quebec and Prairie agriculture, while in the Atlantic region the number and relative importance of unpaid family labour had declined steadily over the years. In British Columbia, hired labour contributed a considerable proportion to total agricultural employment throughout the period, whereas in Ontario the hired labour component has become relatively more important, particularly as the number of farm operators has declined. These adjustments in the size and composition of the farm workforce, and the regional differences in these patterns of change are the subject of the theoretical and statistical analyses that follow in Chapters 4 through 7.

2.3.3 Seasonality and Age-Sex Characteristics

The descriptions of employment in agriculture in the preceding sections are based on annual average data from monthly estimates of employment. However, within each year, marked patterns of seasonality in agricultural employment are apparent. For Canada as a whole over the period 1970 to 1973, average employment in agriculture in February was only 70 percent that in August. The greatest degree of seasonality is found amongst the hired farm workers, while little seasonal variation is apparent in farm operator employment (Andarawewa, 1970). Nevertheless, off-farm work by farm operators is common throughout

Canada. In 1970, more than a third of all farm operators reported working off the farm, although the duration of this employment varied considerably, as did the type of off-farm work undertaken.

The seasonal patterns of employment differ among the regions of Canada, reflecting the different physical environments, systems of farming, and compositions of farm labour in these regions. Seasonal variations in employment are most notable in British Columbia and the Atlantic region, and are of least magnitude in the Prairie region; January to July employment ratios for these regions are 0.49, 0.64 and 0.72 respectively (Statistics Canada, 1973). In all regions, paid worker employment exhibits the greatest seasonal variation, and farm operator employment the least. Furthermore, in each region, the seasonal employment pattern for each of the components is relatively stable over the period for which data are available, 1953 to 1973 (Andarawewa, 1970).

The Canadian agricultural labour force has been, and continues to be predominantly male. The proportion of females has increased from a low of 5 percent in 1956 to 15 percent in 1973, largely due to increases in the proportion of females in the unpaid family labour category. This predominance of male labour and the tendency for the proportion of females to increase after 1956 is also apparent in the regions.

Data on the age distribution of farmers and farm workers indicate that the proportion of the workforce in the older age categories has increased over time. Not only is the agricultural labour force aging over time, but agricultural workers are older than workers in other occupations. The median age of workers in agriculture and all occupations respectively was 39 years and 35 years in 1951, 41 years and 37 years in 1961, and 42 years and 38 years in 1971. In large part, this aging of the farm workforce reflects changes that have occurred in the age distribution of farm operators. Since 1951, there has been a proportionate shift in farm operators from the lower to the higher age brackets, a pattern that is evident in all regions.

2.4 Changes in the Organization of Canadian Agriculture

In the period since World War II, Canadian agriculture has undergone significant changes in its structure and organization. These changes have influenced and include those in the agricultural labour force.

The number of farms, as enumerated by successive censuses, has shown a consistent decline since 1941. The number of census farms in Canada declined from 732,832 in 1941 to 366,128 in 1971 (Table 2.3). Most of the decreases occurred in the lower economic classes of farms, as defined in terms of the value of products sold during the year. Small scale farms, those with less than $2,500 annual sales, constituted 62 percent of all farms in 1951,

TABLE 2.3

NUMBERS OF FARMS BY ECONOMIC CLASS, CANADA, 1951 TO 1971

Economic Class	1951			1961			1971		
	Number	Percent of farms	Percent of sales	Number	Percent of farms	Percent of sales	Number	Percent of farms	Percent of sales
All farms	623,091	100	100	480,903	100	100	366,128	100	100
Annual Sales									
less than $2,500	387,309	62	22	221,052	46	10	107,869	29	3
$2,500 to $4,999	144,828	23	29	118,777	25	18	62,954	17	6
$5,000 to $9,999	69,019	11	27	90,419	19	27	82,113	23	14
$10,000 and over	21,243	4	22	49,841	10	45	113,192	31	77

Source: Statistics Canada, Census of Canada, Agriculture, 1951, 1961, 1971.

46 percent in 1961, and 29 percent in 1971.[1] Amongst the commercial farms, those with more than $2,500 annual sales, the greatest proportionate increases occurred in the economic class with more than $10,000 annual sales. Associated with the decrease in the number of farms was an increase in the average area of farms, from 237 acres in 1941 to 463 acres in 1971. The average size of commercial farms was 562 acres in 1971, whereas the average size of small-scale farms was 267 acres in 1971. The trend, therefore, has been for a decline in farm numbers, especially in the non-commercial class, and an increase in the size of commercial farms. At the same time, the larger commercial farms have accounted for an increasing proportion of the total output from agriculture.

These changes in farm size and commercialization have been accompanied by increases in all farm input categories, with the exception of labour. In particular, machinery investment and capital inputs, partial substitutes for labour, increased notably over the period 1941 to 1971. These changes have resulted in marked shifts in the proportional distribution of inputs used in Canadian agriculture (Table 2.4). The major shift over the period 1941 to 1971 has been the substitution of capital inputs for labour. The decline in the labour proportion of inputs has

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[1] This trend towards fewer non-commercial farms is exaggerated, however, by the decreasing value of a constant $2,500.

TABLE 2.4

DISTRIBUTION OF FARM INPUTS[1] BY CATEGORIES,

CANADA, 1941 TO 1971

	1941	1951	1961	1971
		percent of total		
Labour	57	45	33	21
Land and buildings	22	20	23	25
Machinery and equipment	11	18	20	23
Purchased feed and seed	6	9	13	17
Fertilizer and limestone	--	1	2	4
Other inputs	4	7	9	10
Total	100	100	100	100

Source: Statistics Canada, Census of Canada, Agriculture, 1941 to 1971.

[1]By value, in 1949 dollars.

been offset by increases in the proportionate shares of the various categories of capital inputs, in particular, machinery. Land and buildings have remained more or less constant in proportion of total inputs.

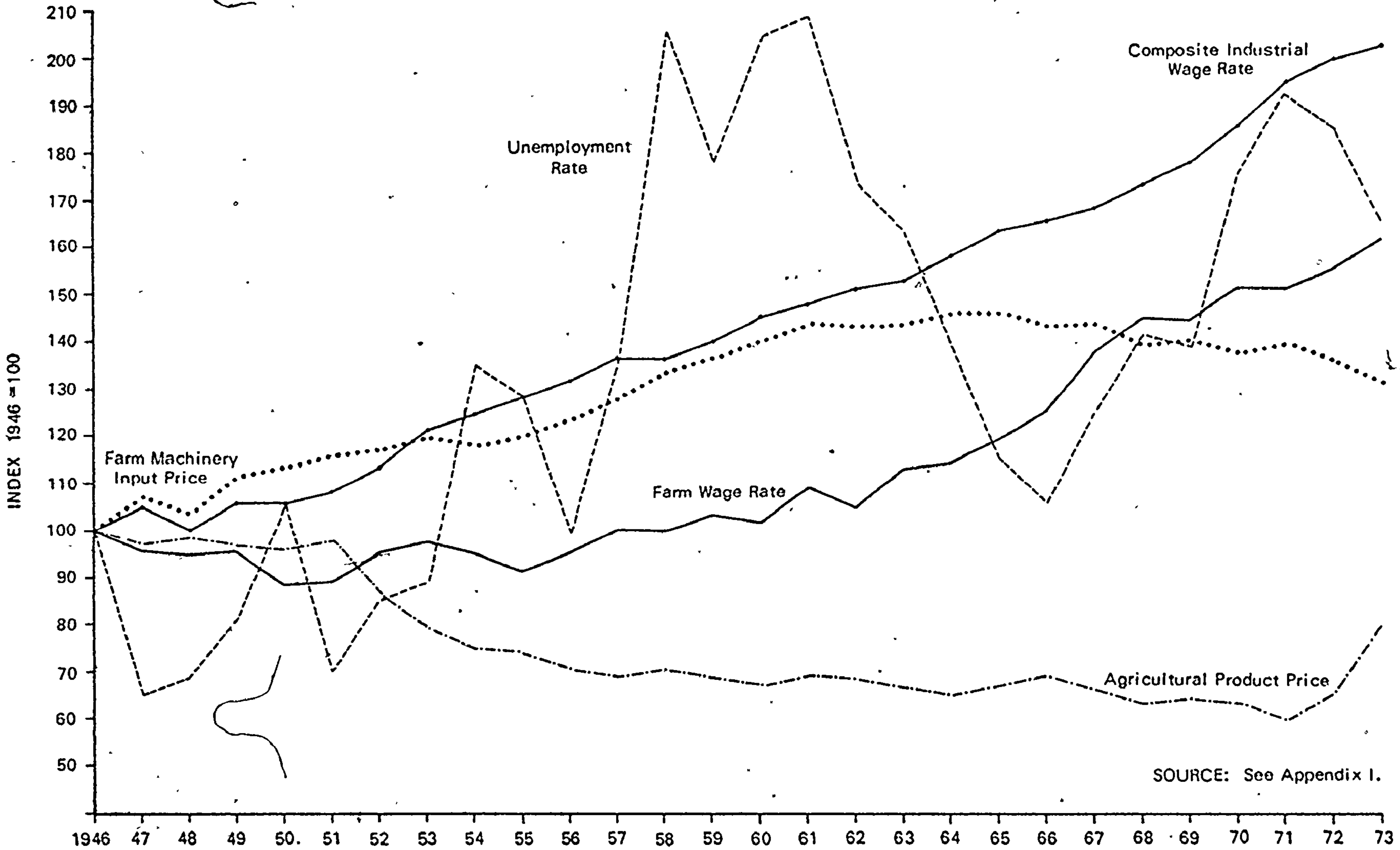
Prices of inputs and products have also changed over time (Figure 2.6). The cost of hired farm labour increased gradually relative to farm product prices to the early 1960's, after which time substantial relative increases in farm wages are apparent. At the same time, the increases in the farm wage rate have been more than matched by gains in the industrial composite nonfarm wage. Since the early 1960's, the price of farm machinery has not increased relative to farm product prices, and machinery has become cheaper relative to the farm wage rate. Further evidence for changes in the nonfarm economy over the period is given by the fluctuations in the unemployment rate (Figure 2.6).

2.5 Summary

The preceding information on the farm workforce and organization of agriculture serves two purposes. Firstly, general information on the nature of agriculture in the regions of Canada and data on changes in the organization of Canadian agriculture are provided as background to the analysis that follows. Secondly, the changes in the size, composition, and distribution of the Canadian agricultural labour force, which

FIGURE 2.6

RELATIVE CHANGES IN SELECTED ECONOMIC INDEXES, CANADA (1946=100)



SOURCE: See Appendix I.

represent the basic issues in this study, are described. It is clear that the numbers of people employed in agriculture in Canada have varied from year to year, and that the composition of this workforce, in terms of type of worker, has also changed through time. Furthermore, employment in agriculture and patterns of change in the size and composition of the farm workforce are shown to differ from one region of the country to another. This investigation is thus concerned both with changes through time in farm employment and with differences in these changes over space.

CHAPTER 3

APPROACHES TO THE ANALYSIS OF FARM LABOUR

The recent history of changes in the Canadian farm labour force is described in Chapter 2. There are few investigations of the determinants of such changes in Canada, although general theories of the labour market are well established, and many empirical analyses of farm labour have been undertaken in the United States. This chapter reviews approaches to the analysis of farm labour, and describes the major types of models of farm labour change. The general review is followed by more detailed discussion of two aspects of model specification and application, namely the problem of aggregation and the question of variations in employment over space and through time. The chapter summarises the current state of conceptual and empirical investigations of labour in agriculture, and thus serves as a basis for the model of farm labour adjustments which is later used in the empirical analysis of farm labour in Canada.

3.1 Labour Mobility

The analysis of adjustments in the farm labour force is frequently viewed as a question of labour mobility. It is possible to distinguish several types of labour mobility. 'Occupational mobility' involves a move to another job classification, either within the same industry or associated with a change of industries. 'Industrial mobility' involves the crossing of industry lines, for example, from agriculture to manufacturing. 'Geographical mobility' represents a relocation from one area or region to another. In addition to these types of mobility, there is the movement of workers into and out of the ranks of the unemployed and the movement into and out of the labour force, particularly by new entrants and retirements respectively. The significance of recognising these forms of worker mobility lies in the fact that changes in the size and structure of the workforce may result from any or all of these types of shift.

'Off-farm mobility' is used as a general term encompassing several of the types of mobility noted above. A shift from employment in the agricultural industry to employment to some other sector of the economy (industrial mobility) is invariably accompanied by a change in type of job (occupational mobility), and is frequently associated with a relocation from a rural area to an urban area (geographical mobility or migration), or from a 'farm' residence to a 'nonfarm' residence (residential mobility).

The frequent simultaneity of these types of mobility enables the phenomenon of off-farm mobility to be studied in a variety of ways. However, each type of study is concerned with a different problem. For instance, analysis of occupational (or industrial) mobility is concerned with the movement of workers between farm and nonfarm occupations, and thus refers only to the employed members of the population. Investigations of rural-urban migration and off-farm residential mobility, on the other hand, are concerned with the entire population, since all persons can be classified as living in a rural or urban area, or in a farm or nonfarm residence. Clearly, the problem of rural-urban migration is more general than that of off-farm occupational mobility.

The importance of distinguishing these types of off-farm mobility becomes apparent when an attempt is made to compare the results from several empirical analyses in which different measures of off-farm mobility are used. Furthermore, an important potential contribution of off-farm mobility studies is their ability to identify the particular processes or mechanisms by which changes occur in the farm workforce. Much of the data available on farm labour refers only to numbers employed in agriculture at certain points in time. These data do not indicate whether adjustments in farm employment are the result of occupational shifts into or out of agriculture, or whether the adjustments are due to changes in the recruitment-retirement ratio, or some combination of these processes.

3.1.1 Models of Off-Farm Mobility

The concepts most frequently used in analyses of off-farm mobility are derived from the microeconomic theory of labour supply. In simple terms, the supply of labour offered to a single market by a maximizing worker is assumed to be determined by his equating the wage rate in the market with his marginal rate of substitution between income and leisure (Gallaway, Gilbert and Smith, 1967). From this it follows that when workers consider several alternative markets or industries simultaneously, they will offer their services to that industry where the wage rate is the highest. Wage rates are usually assumed to be predetermined, presumably dependent upon the demand for and supply of labour in the market. Various movement costs or 'unique' costs associated with employment in any of the alternative industries may be incorporated into the basic conceptual framework in various ways. For instance, individuals may be assumed to discount offered wage rates by whatever amount is necessary to compensate for these costs. A common modelling procedure is to introduce the unemployment rate as an indicator of the probability of employment in alternative industries.

A typical empirical model of labour mobility takes the form:

$$M_{ij} = M_{ij} (W_i, W_j, U_j) \qquad 3.1$$

where M_{ij} = mobility of labour from industry (or area) i to industry (or area) j;

W_i = wage rate or income in i;

W_j = wage rate or income in j;

U_j = unemployment rate in j.

(after Gallaway, 1976a)

Alternative models employ wage rate and unemployment ratios (Sjaastad, 1961; Bishop, 1961), or wage rate differences (Gallaway, Gilbert and Smith, 1967), or other variables that might be considered relevant to the mobility decision (Gallaway, 1976b). Models of off-farm mobility with this general form have been estimated using least squares regression procedures on time-series and cross-section data.

Another type of model based upon the same labour mobility concepts is the cost-benefit approach (Sjaastad, 1962). In the simplest form of the cost-benefit model, a person is assumed to move if the present value of all future monetary benefits from moving is greater than the monetary cost involved. The model may be expressed as:

$$\text{if } \sum_{t=1}^{T} \frac{(I_{jt} - I_{it})}{(1+r)^t} - C > 0, \text{ then move,} \qquad 3.2$$

where I_{jt} = earnings in the tth year at destination j (industry or area);

I_{it} = earnings in the tth year at origin i;

C = costs of moving;

T = total number of years in which future returns are expected;

r = rate of interest used to discount future earnings.

The determination of the interest rate (r) and the total number of years (T) to be used in 3.2 presents a problem which is typical of most cost-benefit calculations. The problem can be circumvented if one is willing to assume that the difference in income between the two places remains constant. Then the equation reduces to:

$$\text{if} \quad h\,(I_j - I_i) - C > 0, \text{ then move} \qquad 3.3$$

where $h = \sum_{t=1}^{T} \frac{1}{(1+r)^t}$, to be determined empirically.

Alternative cost-benefit formulations in an off-farm mobility context are discussed in Diehl (1966) and Speare (1971). Speare's analysis is based on data pertaining to individuals, whereas Diehl's observations relate to economic areas. In both cases, the cost-benefit formulation is transformed into a regression framework for testing.

Models of the type (3.1, 3.2) have been used as a basis for numerous empirical analyses of off-farm mobility. Mumey (1959), Bishop (1961), and Sjaastad (1961) use simply-specified regression models and aggregate time-series data to investigate off-farm mobility in the United States. In each case, the dependent variable is the annual rate of change in the farm population. Thus, these studies attempt to account for temporal changes in net off-farm migration rates for the conterminous United States. The common conclusion is that off-farm mobility rates are related to the availability of nonfarm employment. A major weakness of these investigations is the high degree of aggregation, both structural and spatial. Structural aggregation refers to the consideration of the entire farm population as a homogeneous group. Spatial aggregation involves the assumption that the mobility processes are the same throughout the entire country, and that individuals respond to national average wages and prices rather than to local wages and prices.

Spatially disaggregated data are used in Szabo's (1965; 1966) analyses of the spatial variation in farm depopulation rates in the Canadian prairies between 1951 and 1961. Rates of net farm outmigration from 'areal divisions' are related to characteristics of the economies and populations of those areas. The approach seeks to identify the characteristics of areas that give rise to spatial differences in their off-farm mobility rates. These spatial variations in off-farm mobility rates appeared to be related to size distributions and degree of commercialization of farms on the prairies.[1] A similar approach

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[1] Changes in farm numbers and the size distribution of farms in the Canadian Prairies between 1961 and 1966 are analysed by McMillan, Tung and Tullock (1974). Regression and Markov chain models are used to project farm (and thus farm operator) numbers.

is employed in Winkelmann's (1966) study of the exodus of labour from agriculture in Minnesota. Winkelmann uses data from 87 counties in an attempt to account for the spatial variation in the rate of reduction in the farm labour force in the period 1950 to 1960. The main conclusion is that farm workers were responsive to differences in income levels, but the response was not dramatic. The study is notable not only for its cross-section approach, but also because it considers net shifts in the occupation of the farm labour force rather than residence shifts of the farm population.

The problem of testing theories of labour mobility at an appropriate level of aggregation is approached by Cowling and Metcalf (1968) in a different manner, and using yet another measure of off-farm mobility. Cowling and Metcalf are primarily concerned with the year to year variability in the net occupational outflow of the hired component of the farm labour force at the regional level in England. Be examining only hired labour, the problems of structural aggregation are greatly reduced (at the cost of neglecting other types of farm labour), and by considering mobility at the regional level the disadvantages of spatial aggregation are also diminished. However, limitations in the time-series data at the regional level forced the pooling of the time-series and cross-section data. This pooling of data creates difficulties in interpreting the results of the analyses. Specifically, although the variables in the model may change from one time point to another, and from one region to another, the relationships embodied in the model are constrained to be invariant over both time and space. In some of the tests, regional dummy variables are introduced to allow for different intercept terms among the regions, but the slopes are assumed constant over the time points and the regions. Consequently, while Cowling and Metcalf conclude that off-farm mobility rates vary with farm-nonfarm income differentials and with unemployment levels, it is difficult to distinguish effects of temporal variation from effects of spatial variation.

The use of regional data and the consideration of only hired farm workers constitute improvements in model specification and application, but by no means do they overcome the problems of aggregation. The conceptual models upon which all of these studies are based pertain to individuals, that is, they are micromodels. Yet these micromodels are applied to data pertaining to groups of individuals, or aggregates. The crucial step relating a theory about individuals to a model of aggregates is not treated explicitly. It is assumed, usually implicitly, that the aggregate behaves as the individual.

One way of overcoming this problem is to test the micromodel with data on individuals. The studies of hired farm worker mobility in the United States by Gallaway (1967; 1968), Perkins and Hathaway (1966), Hathaway and Perkins (1968), and

Gasson (1974) are of this type. Using data on individual employment and earnings histories, these studies yield some useful results. They demonstrate that large numbers of individuals move out of and into the farm workforce each year. Both the geographical and occupational mobility of hired agricultural workers appear to be related to wage and earnings differentials in the direction suggested by the theory of labour supply. However, the bulk of those who changed from farm to nonfarm work did not migrate, emphasising the importance of local labour markets.

A related approach, followed mostly by sociologists, focuses on the characteristics of farm operators who leave agriculture and their reasons for doing so. Based on data from personal interviews, the studies of Hill (1962), Guthier (1963), and Baumgartner (1965) demonstrate the wide range of factors that influence the decisions of individual operators to leave agriculture in the United States. In many instances, the need for larger farm units in order to benefit from advances in agricultural technology forced operators out of agriculture. Gasson (1970) notes the impact of these structural changes on the mobility of farm operators in other countries. Clawson (1963) argues that the bulk of the change in the number of farm operators has not resulted from a shifting of the operators out of the industry but rather from a decline in the rate of entry into farming to replace retirees. Hathaway (1967) argues in a similar vein, pointing out that changes in the structure of agriculture resulting in reduced opportunities for new entrants into agriculture are the important factor influencing changes in farm operator employment. It is clear that farm operators are not responsive to earnings and wage differentials in the same manner as hired farm labour, although nonfarm income levels and employment opportunities are relevant in determining the timing and extent off-farm shifts (Gilchrist, 1963).

Another group of studies that is pertinent to the analyses of off-farm mobility attempts to ascertain personal characteristics that are related to propensities to move. The method generally involves comparing migration rates from rural or farm areas with the characteristics of the populations in those areas. These off-farm and rural-urban mobility differentials tend to conform to the differentials found in other types of mobility and migration. For instance, the tendency for young adults to be the most mobile group generally is true also for the rural farm population (Bowles, 1956; Parnes, 1960; Bishop, 1967). Educational selectivity is another common feature of off-farm mobility (Bogue and Hagood, 1953; Luebke and Hart, 1958; Gisser, 1965). Differences in population characteristics help explain differences in off-farm migration rates from one area or region to another. However, these studies are of little relevance to the analysis of year-to-year changes in farm labour force size because the structure of populations rarely changes significantly over such a short term.

It is difficult to generalize from the results of the empirical analyses of off-farm mobility because so few studies have a common framework in terms of the measure of mobility used, the type of worker considered, the degree of aggregation at which the problem is approached, and the context in which the analysis is undertaken. Nevertheless, the empirical investigations tend to give general support for the broad economic principles of labour supply, but modifications are clearly necessary in specific applications of these principles. For instance, it would seem logical that the forces which determine farm operator mobility are different from the determinants of hired farm worker mobility. Similarly, investigations of differences in off-farm mobility rates from one area to another require quite different models from studies of changes through time in mobility rates within a particular area.

3.2 Labour Markets

Analyses of off-farm mobility concentrate on the supply side of the labour market, whereas employment in agriculture is influenced by both supply and demand forces in the market. In economic terminology, the concept 'market' relates to the existence of buyers and sellers of a factor of production. A market for labour serves as a mechanism to allocate labour according to market demand and supply in various occupations, industries, and areas. General economic theories of the supply of labour and demand for labour are well established (Reynolds, 1951). The basic principles of the theory of labour supply are outlined in Section 3.1. The demand for labour, often called a derived demand, is derived in part from the demand for the final goods the factor cooperates in producing. The basis of this part of labour market theory is the principle of marginal productivity (Fleisher, 1970). A firm that is aiming to maximize its profits will hired additional amounts of labour so long as the costs of doing so are no greater than the addition of total revenue resulting from the sale of the higher level of output achieved. Marginal productivity theory is only a theory of the demand for labour, and like the theory of the supply of labour, does not in itself afford an explanation of employment determination. Only when the theory of labour demand is brought into juxtaposition with the theory of labour supply does a theory of employment and wage determination emerge. These general principles of labour supply and demand form the conceptual basis for models of the market for agricultural labour (Johnson, 1961; Schuh, 1962).

3.2.1 Econometric Models of the Market for Labour in Agriculture

Econometric models of farm labour market represent attempts to quantify relationships and test hypotheses derived from labour market theory. Little attention has been given to the explicit theoretical derivation of models of labour supply and demand in agriculture. Econometric analyses of farm labour supply and demand focus on the estimation of economic relations which are invariably specified directly at the aggregate level, by analogy with the microeconomic theory of the labour market.

Demand and supply relations for agricultural labour typically take the form used by Johnson (1961):

$$D = D\ (W,\ P,\ M,\ T) \qquad 3.4$$

$$S = S\ (W,\ N,\ T) \qquad 3.5$$

where D = quantity of labour demanded;

S = quantity of labour supplied;

W = farm wage rate (price of labour);

P = farm price of farm products;

M = farm machinery prices;

T = time trend (to account for slowly changing forces, such as technology);

N = nonfarm income opportunities.

In order to use least squares estimation techniques, the form of the functions D and S are assumed to be linear, or linear when the logarithmic transformation is taken. Demand and supply relations such as 3.4 and 3.5 are often estimated separately, using ordinary least squares regression techniques. However, a theoretically more acceptable model would be one in which agricultural employment and agricultural wages are jointly determined; that is, where they are both considered to be endogenous variables. In such a formulation, a market clearing identity equating supply with demand is required:

D = S = employment in agriculture. 3.6

This identity, along with the behavioural equations 3.4 and 3.5, each with two endogenous variables, comprises a simultaneous equilibrium model of farm labour. Two stage least squares and limited information methods have been used to estimate such simultaneous models. Disequilibrium and dynamic versions of the basic static equilibrium model are discussed in Schuh (1962), Heady and Tweeten (1963), Cowling, Metcalf and Rayner (1970), and Tyler (1972).

Econometric studies of the agricultural labour market have generally concentrated on the hired component of the agricultural labour force. Labour market theory applies more directly to hired labour than to unpaid family or self employed labour. As a result, there are fewer specification and measurement problems in dealing with hired farm labour.

A demand relation for hired labour in agriculture in the United States is estimated by Griliches (1959) using both a distributed lag model and the more conventional static approach. The analysis of the complete market for hired labour in agriculture by Schuh (1962) established a model employed in many later studies. Schuh estimates supply and demand relations at the national level using time-series data for the period 1929 to 1957. The conceptual model, specified directly at the aggregate level, assumes that the quantity of hired labour supplied to agriculture depends upon the wages offered, alternative income opportunities, and the size of the civilian labour force. On the demand side, it is assumed that farm operators accept as given the prices they must pay for inputs other than labour, and the prices they receive for their products, and adjust their hirings in the light of these prices, the price of hired labour, and the technological alternatives open to them in production. The price of hired farm labour and the quantity employed are assumed to be endogenously determined, hence simultaneous-equations methods are used to estimate the structural relations. Schuh presents results from a static model and from a distributed lage specification, which permits the separation of short-run and long-run elasticities. The statistical results generally support the theory; most parameter estimates are significant and consistent with *a priori* expectations.

However, two important limitations are apparent in Schuh's analysis. Firstly, the model considers only hired farm labour, while the bulk of the farm workforce is family labour (self-employed farm operators and unpaid family help). Secondly, the model is applied at a high degree of spatial aggregation; data for the entire United States are used, and no investigation of regional variation in farm labour market functioning is attempted. Subsequent developments in econometric analyses of agricultural labour have addressed both of these questions.

Schuh and Leeds (1963) analyse the demand for hired farm labour on a regional basis, essentially applying Schuh's national demand model to time-series data for each of nine Census regions in the United States. The results indicate considerable variation among the regions in farmers' demand responses to changing economic conditions. Tyrchniewicz and Schuh (1966) use Schuh's national supply model to analyse the regional supply of hired labour for the nine U.S. Census regions. The coefficients of the supply relation were found to vary among the regions, although no tests for the significance of these regional differences were applied.

A more comprehensive investigation of the structure of the agricultural labour market was made by Johnson (1961), with some of the analyses published in Johnson and Heady (1962) and Heady and Tweeten (1963). This study estimates the supply and demand relations for the total farm workforce and for hired and family labour separately, at both the national and regional levels for the period 1910 to 1957. The model for family labour (operators and unpaid family) is essentially the same as that for hired labour, with the farm wage rate being used as the measure of the 'price' of both hired and family labour. Johnson's statistical results generally supported the theory for hired labour at the national level. Results from the hired labour functions varied at the regional level, the coefficients in some regions conforming to the national results, while in other regions no significant coefficients emerged. The family labour models yielded inconsistent results at both the national and regional levels.

The fact that the trend variable was often the only variable with a statistically significant coefficient would seem to indicate an incomplete or incorrect specification of the relations for family labour.

Nevertheless, Johnson's analysis marks an important stage in the development of econometric models of the market for agricultural labour. In particular, the study estimates structural supply and demand relations for two components of the farm labour force. While this recognition of the heterogeneity of the farm workforce represents an important conceptual development, several shortcomings in the model are evident. For instance, the market for family labour is assumed to operate in essentially the same manner as that for hired farm workers. This assumption could be questioned on logical grounds, and Johnson's statistical results raise doubts about such a specification. In fact, the family labour component is such a heterogeneous group, including as it does both farm operators and unpaid family workers, that inconsistent statistical results might be expected from any single specification. Furthermore, the two components, hired and family labour, are treated quite independently, when it is likely that there is considerable interdependence between them.

The analyses of farm labour employment in Canada by Yeh and Li (1966) and Yeh (1967) employ an approach similar to that of Johnson. Two categories of farm labour, hired and family, are considered; identical models, specified directly at the aggregate level are used for each of the components. The demand and supply relations are estimated using annual-average, time-series data and single-equation least squares methods at both the national and regional levels for the period 1946 to 1963. The results from this analysis give little support for the models of either component. Very few of the regression coefficients are significant in either the demand or supply relations at either the national or regional levels.

Further developments in the specification of models of the market for agricultural labour are incorporated in the analyses undertaken by Tyrchniewicz (1967) and Tyrchniewicz and Schuh (1969). The two noteworthy refinements made by Tyrchniewicz are the disaggregation of family labour into an operator component and an unpaid family worker component, and the specification of a system in which the three components of the farm labour force are assumed to be interdependent. The system is based on aggregate supply and demand functions for each component. These are basically the same form as Schuh's (1962) relations, but an attempt is made to derive appropriate measures of the 'price' for each type of labour. Included in the original structural relations for each component are the levels of employment in each of the other two components. In this way, the markets for hired labour, unpaid family labour, and farm operator labour are integrated into a six-equation model, which explains simultaneously the price and level of employment for each component of the farm labour force, subject to the set of exogenous variables. In Tyrchniewicz's model, the levels of employment for each component were treated as endogenous variables.

In order to identify the interdependencies among the components, an inductive procedure was adopted to modify the model. Variables for levels of employment in each of the components were introduced separately into the relations for the other components; those that did not yield statistically significant coefficients were omitted. As a result of this procedure, the substitution variables retained were as follows: for hired labour demand, the quantity of operator labour; for hired labour supply, the quantity of unpaid family labour; for all others, the quantity of hired labour. Tests were also made with alternative 'prices' for the family labour components, including farm wage rates, net farm income to family labour per family worker, and net farm income to family labour per farm operator. Using annual-average time-series data for the United States over the period 1929 to 1961, both dynamic (distributed lag) and static formulations of the basic simultaneous model were tested. In general, the statistical results for the model are good; the signs of the coefficients are generally consistent with the hypothesized relationships. However, statistically significant coefficients associated with the substitution variables necessarily follow from the method used to introduce these interdependent effects into the model; that is, the substitution variables are retained only if the coefficients are significant.

Nevertheless, Tyrchniewicz's specification represents the most comprehensive econometric model of the market for agricultural labour. More recent studies of the farm labour market have investigated particular aspects of the market in order to estimate the effects of certain economic changes or policies on farm employment levels, farm wages, or agricultural incomes. For instance, Wallace and Hoover (1966) and Bauer (1969) examine the effects of technological change on levels of employment and incomes in agriculture using aggregative two-equation models for the total farm labour force. Supply and demand models of the hired farm labour market form the basis of investigations by Gardner (1972) and Lianos (1972) into the effects of minimum wage legislation on farm wages and employment, and Ryan and Duncan (1974) estimate supply and demand models for self-employed and hired farm labour (separately) in their analysis of the effects of a relative increase in wages on farm incomes and rural labour.

The current state of econometric analyses of farm labour can be summarized by considering, firstly, the nature of the models used and the methods of model specification, and secondly, the contexts in which these models have been applied.

The theoretical derivation of specific models of the market for labour in agriculture has been given little attention in the literature. The conceptual base of the econometric analyses is found in the microeconomic principles of factor demand and in the microeconomic theory of labour supply. However, the models employed in the empirical analyses are invariably specified directly at the aggregate level, and are not derived explicitly from these theories. The implications of this characteristic of econometric models are discussed in Section 3.3. While improvements in the conceptual basis of the models have been achieved by disaggregating the labour force, little attention has been given to developing separate models for the components, and the nature of the interdependentcies among the components is not well understood. Determination of levels of employment in the three labour force components are obviously interrelated, and thus the markets for the types of labour should be considered simultaneously. However, in the one study that addresses this problem (Tyrchniewicz), no logical argument is given for selecting one interdependent specification over another.

Most econometric models of the market for agricultural labour have been estimated using time-series data, and thus represent models of change in employment through time. However, these models have been applied to data for different time periods and for different spatial units. Models for hired farm labour, for instance, have been applied to national level data in the United States for various time periods between 1912 and

1969. While the models have yielded results generally consistent with the hypothesised relationships, the parameter estimates appear sensitive to the time period chosen. Hammonds, Yadar and Vathana (1973) have demonstrated that estimates of the elasticity of demand for hired labour in the United States have changed from one time period to another. Cowling, Metcalf and Rayner (1970) have found that in Britain the hired labour market relationships for the interwar period (1923 to 1938) differ from those in the postwar period (1946 to 1964). Clearly, relationships estimated using time-series data require tests for temporal stability, especially when the data cover a long period of time. At the same time, similar models have been shown to yield different results when applied to different spatial units. Whereas models applied at the national level in the United States appear to fit the data reasonably well, similar models applied to regional data do not produce such consistent results, and empirical tests on Canadian data have yielded few significant estimates at either the national or regional levels. While such variations in statistical results may to some extent reflect the inadequacy of the underlying models (Tyrchniewicz's interdependent disaggregated model has been tested only at the national level in the United States), the necessity of testing for spatial stability in empirical results is clearly apparent.

3.3 The Aggregation Problem

In the preceding Sections, 3.1 and 3.2, various approaches to the modelling of farm labour change have been described. This section examines in a general way the relations between models of the type used in the empirical studies of farm labour and the theories upon which such models are based. Empirical analyses of the farm labour market, like empirical analyses of other labour market phenomena, most commonly are based on macromodels; that is, models that pertain to aggregate variables. However, it is usually implied that the behaviour of these aggregates corresponds to the behaviour of the individuals that make up the aggregates. In other words, empirical descriptions of workers' employment behaviour are nearly always confined to the behaviour of groups of individuals, but the theories that underly these studies refer mostly to individuals.[1]

Hence, it is useful to distinguish relations postulated by a theory of individual workers, households, or firms (the *microtheory*) as *microrelations* or *microequations*. The variables in these equations are the *microvariables*, and the parameters specifying these relations are the *microparameters*. A *macrotheory* postulates that *macrovariables* (aggregates, or certain

[1]This section considers aggregation over individuals; the related questions of aggregation over time or aggregation over space are addressed in Section 3.4.

functions of the microvariables) are connected by *macrorelations* or *macroequations*, which in turn are specified by a number of *macroparameters*.

The development of macromodels may proceed via several alternative routes. One method involves the specification of macromodels by analogy with an underlying micromodel. An alternative approach explicitly considers the relations between the microtheory and the macromodel, and establishes the conditions necessary for consistency between the two levels. A third method is to construct macromodels directly, without reference to underlying theories. These approaches, and the implications associated with each approach, are now considered in more detail.

The most common approach to the construction of macromodels is to proceed from the microtheory to the macrotheory by analogy. For example, if a microtheory tells us that a firm's demand for labour depends upon the quantity of output produced by that firm, then the macrotheory is usually given the form: total demand for labour depends upon an index of total production. Gallaway, Gilbert and Smith (1967), consider quite explicitly the theory of labour supply at the microlevel and derive microsupply relations from the theory of consumer demand. However, the model that is tested empirically is an analogous macromodel, pertaining to aggregate variables of employment, wages, unemployment, and welfare benefits. The macromodels of Diehl (1966) and Cowling and Metcalf (1968) are similarly based upon underlying micromodels by analogy. Econometric models of the farm labour market are also macrorelations, based implicitly upon microeconomic theories of labour supply and demand.

The principal merits of constructing macromodels by analogy with an underlying microtheory lie in the simplicity of the method. However, the inference that the empirically estimated macroparameters reflect corresponding microparameters may be invalidated by aggregation bias. Aggregation bias refers to the relationship between the microparameters, pertaining to individuals, and the corresponding macroparameters, relating to aggregates of individuals. It can be shown (Appendix 2) that only under certain rather restrictive conditions can the macroparameter estimates by interpreted as reflecting the analogous microparameters which describe the behaviour of individuals.

An alternative treatment of macromodels and their underlying theory explicitly considers the relations between the microtheory and the macrotheory. Whereas the construction of macromodels by analogy with microtheories conveniently evades the problems of aggregation, the essence of this alternative approach is that the connections between the macrotheory and the microtheory are considered explicitly in order that a macromodel is specified that can be tested with aggregates (or averages, or indices), and which is consistent with the underlying microtheory. While various approaches to establishing consistency are recognised (Thiel, 1954), the end results are similar:

(i) explicit assumptions about a micromodel (behaviour of individuals);

(ii) definition of macrovariables;

(iii) specification of a macromodel (behaviour of aggregates), such that (i), (ii), and (iii) are consistent.

Another approach to the specification of macromodels is to postulate macrotheories directly, without reference to underlying microtheories. It might be argued, however, that few 'real' macrotheories exist, particularly in the field of labour markets. For instance, a common approach to farm labour supply analysis is to consider average farm wages and some average alternative wage as possible determinants of aggregate farm labour supply. However, the theorist does not adopt this approach because it is supposed that some mythical collective reacts to these variables, but because men and women are known to, or supposed to respond to certain relevant microvariables corresponding to these aggregates. In such cases, the macrotheory may be described as a construction based on the underlying microtheory.

Nevertheless, it is quite possible to base a macromodel on a theory about relations between macrovariables. Whereas microeconomic theories of labour demand are most commonly based on assumptions about production functions and the maximizing behaviour of firms, aggregate farm labour demand relations might be (and are) based on the assumption that production functions are relevant for the entire agricultural industry, which is assumed to employ resources in order to maximize output or profit.

Such models resemble those specified by analogy, except that the directly-specified models do not refer to any underlying microtheory. Hence, the question of consistency between the micro- and the macromodels, and the problem of aggregation bias in the macroparameter estimates do not arise in purely aggregate studies. These questions arise only when an attempt is made to derive information about the behaviour of individuals from models tested with aggregate data. As a consequence, however, 'pure' macromodels are able to provide very little information regarding the processes which result in aggregate changes. In particular, no inferences about individual behaviour can validly be made from models specified directly at the aggregate level. The models may be highly successful from a predictive point of view, yet at the same time fail to explain the way in which these macro-relations arise.

On the other hand, the testing of theories with aggregate data has definite practical advantages. To aggregate reflects a desire to make a problem more manageable. In deciding upon the level of aggregation at which to work, the researcher weighs the benefits of aggregation, namely a simplified model structure and reduced data and computational requirements, against the costs, particularly the loss of detailed information. Frequently, however, the researcher cannot choose the level of aggregation used in an empirical investigation, since data pertaining to individuals are not readily available. Hence, empirical analyses are often forced to use aggregate data.

However, the 'costs' of using aggregate data are minimized when the macromodels tested are consistent with an underlying micromodel. Such consistency permits macrorelations to be interpreted with reference to individual behaviour. At the same time, the assumptions necessary to achieve this consistency are more reasonable when the aggregates to which they refer are relatively homogeneous. The structural disaggregation of the farm labour force into separate components reduces the heterogeneity of the aggregates in the macromodel. Yet, as Grunfeld and Griliches (1960) point out, "it may be futile ... to expect that disaggregation will result in a better explanation of the aggregates without an appropriate change in the model". In other words, attempts to explain phenomena at different levels of aggregation require models based on theories that are appropriate to those levels.

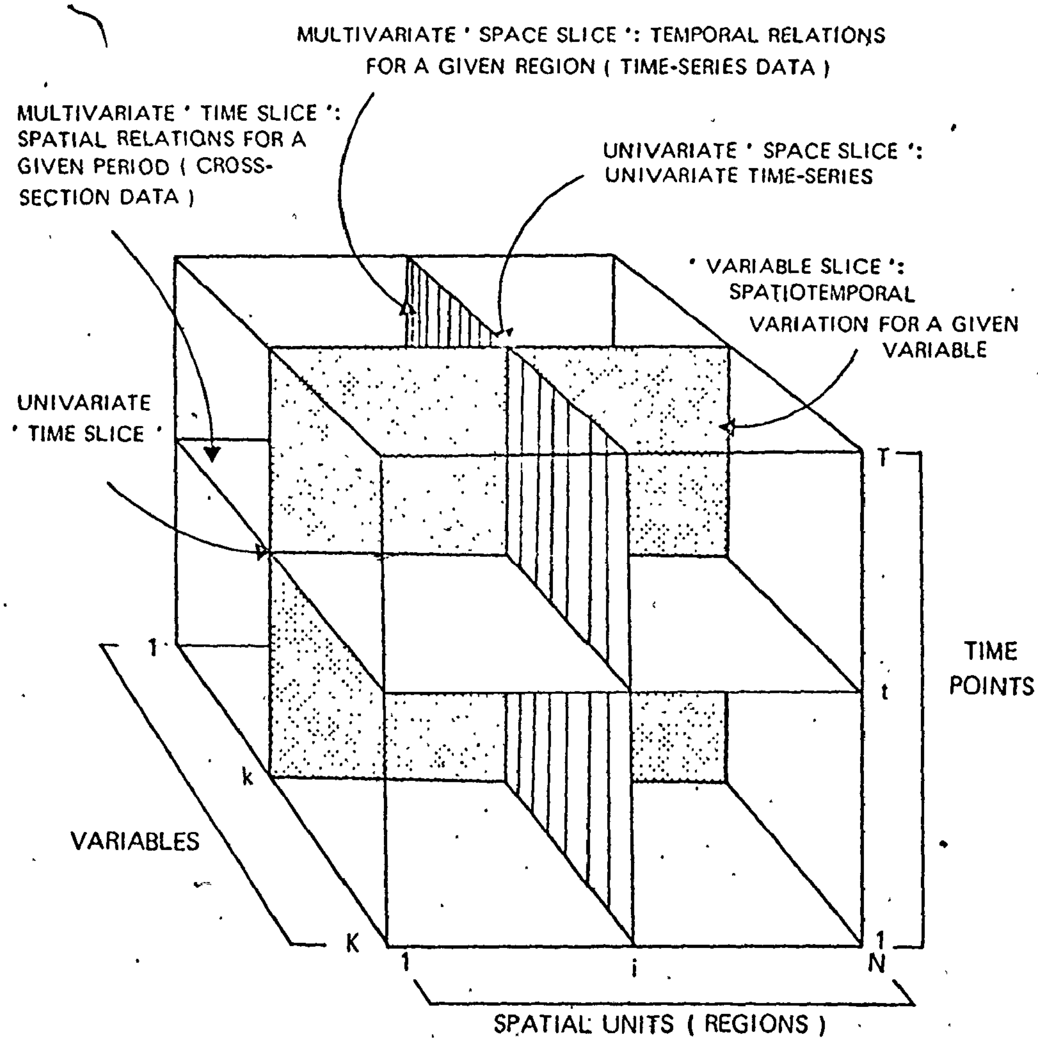
3.4 Models of Temporal and Spatial Variation

It was noted in Sections 3.1 and 3.2 that analyses of farm labour have been concerned with variations in off-farm mobility and agricultural employment both through time and over space. This section notes the essential differences between these problems, and describes a research strategy, applicable to the analysis of farm labour, in which both temporal and spatial variations are considered. Various types of spatio-temporal problems and methods of analysis can be identified by referring to the general multivariable spatio-temporal scheme presented in Figure 3.1.

The conventional approach in human geography has been the 'time slice' or comparative static analysis over space. For a given point in time, the spatial variation of a variable is considered either by itself in a descriptive manner (univariate time slice), or with respect to other variables (multivariate time slice). A common example of this approach is the use of regression techniques to relate the spatial variation of one 'dependent' variable to the spatial arrangement of one or more 'independent' or 'exogenous' variables. In the off-farm mobility literature, this approach is represented by the studies of Szabo (1965; 1966) and Winkelmann (1966); they are concerned to account for differences in off-farm mobility rates from one area to another. Examples of econometric models of farm labour tested with cross-section data are Gisser (1965), and Bauer (1969). In effect, these studies examine spatial differences in levels of agricultural employment and wages at a single point in time.

FIGURE 3.1

TYPES OF SPATIO-TEMPORAL PROBLEMS



SOURCE: Adapted from Cliff et. al. 1975.

An alternative approach is to concentrate on variations through time for a single spatial unit. This time-series approach is labelled the 'space slice' in Figure 3.1, and itself incorporates several subproblems or subjects of analysis. Univariate time-series analyses (univariate space slice) are essentially descriptive, and seek to identify patterns or components of variation through time for a particular spatial unit. Spectral analysis, for example, can be used to decompose univariate time series into a number of underlying components of variation. Given monthly or quarterly data on employment in agriculture, such techniques might be used to separate seasonal fluctuations from longer term variations. The 'multivariate space slice' is represented by models which use time-series data to estimate relations among variables over time for a particular spatial unit. Most of the econometric models of the farm labour market, discussed in Section 3.2, are of this type. The approach focuses on changes through time, whether the models are comparative static in nature, or include temporal lag structures.

The essential distinction between these two approaches is that the 'time slice' or cross-section approach is concerned with *differences* from one place to another at a single point in time, whereas the 'space slice' or time-series approach deals with *changes* through time for a single place. Obviously, an understanding of changes in phenomena is essential for forecasting and planning, and since the nature and degree of change differs from one area to another, a need also exists for spatial analysis.

One method of considering both spatial and temporal aspects of employment problems is to introduce spatial lags into models of temporal variation. For instance, cross-spectral analysis can be used to compare univariate time-series of employment phenomena among different spatial units (Bassett and Tinline, 1970; Bassett and Haggett, 1971). The approach seeks to identify the relative importance of different components of a time-series among the spatial units being considered, and thus distinguish 'leading' and 'lagging' areas. A similar line of research is undertaken by Brechling (1967) and by King, Casetti and Jeffrey (1969) using regression analysis. These procedures, essentially spatial comparisons of univariate time-series, are represented in Figure 3.1 by the 'variable slice' plane. These studies are descriptive in their emphasis, concentrating on the nature of lags in the transmission of impulses from one spatial unit to another. The 'exogenous' factors which might determine the patterns of change are not sought.[1]

An alternative approach to the general spatio-temporal problem that does consider exogenous forces follows from the observation that patterns of change through time in a particular variable differ from region to region. An econometric-type

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[1]A generalization of the King, Casetti, Jeffrey (1969) approach to incorporate spatial and temporal lags and exogenous variables is given by Bennett (1976). However, it is not altogether clear how such models of the spatio-temporal problem might be estimated.

model can be developed to account for the temporal variation at the regional level. The interesting question that then arises is whether the relationships embodied in this model vary from one region to another. In other words, do the processes determining the observed changes through time vary among the regions? This approach may be seen as a series of 'space slices' (Figure 3.1), each describing the relations among a set of variables through time for a particular region. The regional analyses of farm labour by Johnson (1961), Schuh and Leeds (1963), Tyrchniewicz and Schuh (1966), and Yeh and Li (1966) are of this type, although no tests for regional variability in the relationships are made in these studies. Once the relations are estimated for each region, it is useful to determine whether they vary significantly among the regions, or whether the relationships are spatially stable.[1] For models estimated with least squares methods such tests can be made using quite standard statistical procedures. The approach assumes that the parameters are invariant over time, but vary among the regions, and it is this assumption that is tested. Appropriate test procedures are described later in this thesis.

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[1]A related approach is a series of 'time slices', in which relations are assumed constant over the spatial units involved, but are assumed to vary from one time point to another (Ichimura, 1966; Cliff and Ord, 1971).

3.5 Summary

It is clear from the preceding sections that econometric-type models, using time-series data are appropriate for comprehensive empirical analyses of changes through time in agricultural employment. However, despite developments in the specification and testing of econometric models of the market for labour in agriculture, several important shortcomings remain in the conceptual bases of these models and in their applications. The lack of explicit derivations of econometric models from the underlying microeconomic principles means that interpretations given the statistical results are tenuous. The problems of aggregation have been reduced to some extent by the structural disaggregation of the farm labour force. However, little attention has been given the development of models of employment in the family labour components; clearly, the assumption that the processes determining farm operator and unpaid family employment are essentially the same as those determining hired farm labour employment is inadequate. Furthermore, the nature of the interdependencies among the components of the farm workforce has been given little theoretical consideration and is not well understood. While models of farm labour change have been applied to spatially disaggregated data, no arguments for expecting particular regional differences have been proposed, and no tests of significance of regional differences in employment relations have been applied.

CHAPTER 4

THE CONCEPTUAL FRAMEWORK

This chapter describes the conceptual framework used in the empirical analysis of farm labour changes in Canada. The general research strategy, essentially a regional comparison of the determinants of farm employment changes, is outlined, and a theoretical model of agricultural labour, which addresses some of the shortcomings of existing models, is developed. The question of regional differences in the patterns of farm employment change and possible explanations for such differences are discussed in Section 4.3. The chapter concludes with a description of the data and the degree to which the derived empirical measures coincide with the theoretical concepts.

4.1 Regional Analysis of Farm Employment Changes

The prime concern of this investigation is with changes through time in the size and composition of the farm workforce in the regions of Canada, and with the differences among the regions in the determinants of these patterns of change. The general problem, therefore, may be described as a number of 'space slices' (see Section 3.4). The research strategy involves developing and estimating employment relations, using time-series data, for each 'space slice' or region. The statistical estimates are then analysed to determine the nature and degree of regional variation in farm employment relations, and an attempt is made to account for observed regional differences in the determinants of farm employment.

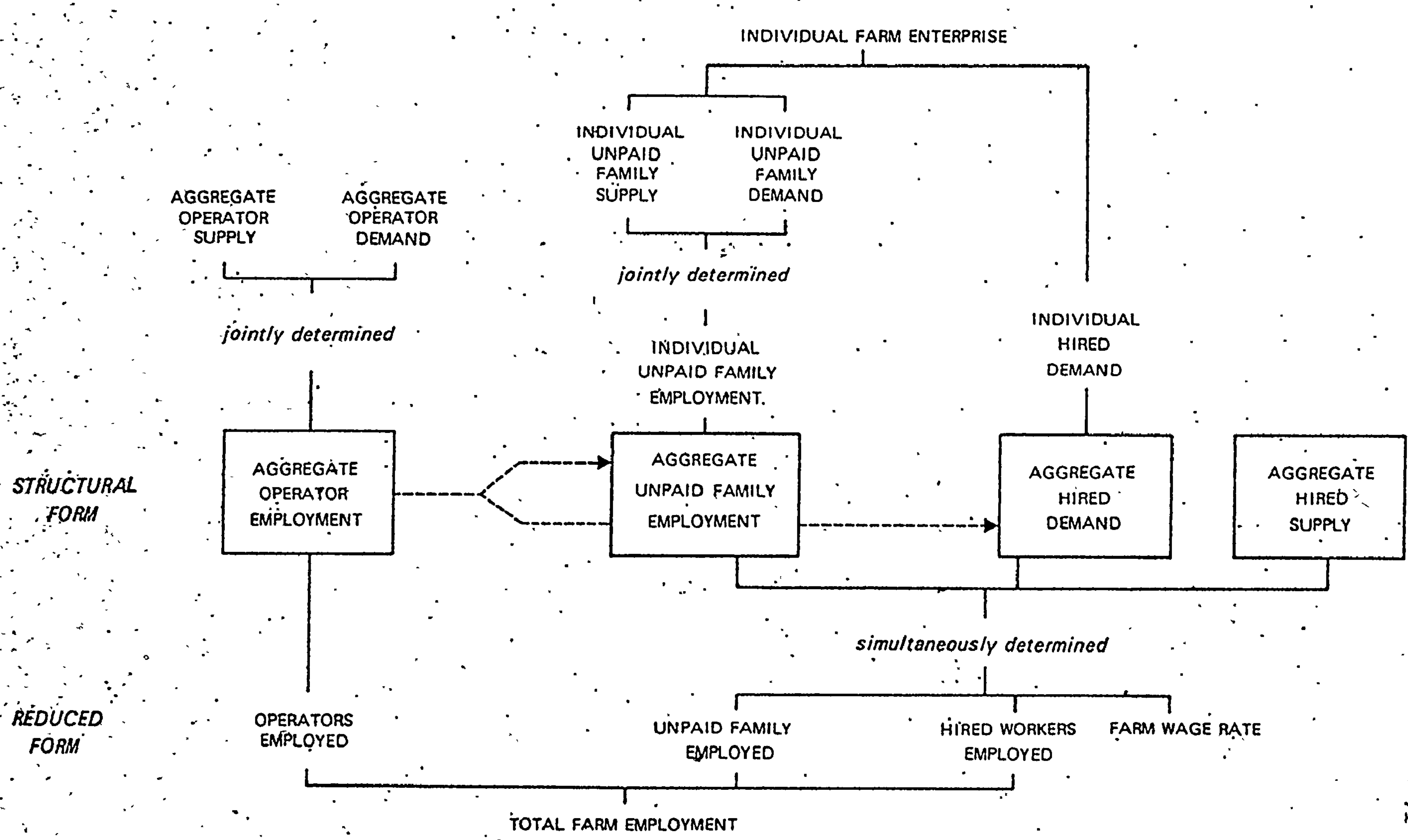
The first step in this strategy is to model year to year variations in the employment of labour in agriculture. An attempt is made to overcome some of the shortcomings of existing models of farm labour, noted in Chapter 3. The farm labour force is disaggregated into three components, namely, farm operators, unpaid family workers, and hired farm labour. The submodels, required to account for changes in the numbers employed in each of the components, are based upon theoretical foundations considered appropriate to those components. The aggregation problem is acknowledged to the extent that the assumptions necessary for consistency between the submodels, empirically testable with aggregate data, and the underlying microrelations are made explicit. The model also addresses the question of the interdependencies among the components of the farm labour force.

4.2 A Model of Labour Employment in Agriculture

The theoretical framework upon which the model of farm employment is based is illustrated in Figure 4.1. Total farm

FIGURE 4.1

THEORETICAL FRAMEWORK FOR FARM EMPLOYMENT MODEL



employment is disaggregated into three distinct components: self-employed farm operators, unpaid family workers, and hired farm labour. The forces which determine the numbers employed in each of these components are assumed to differ among the components; hence each component is considered in turn. The conceptual basis of each of the submodels partly reflects the treatment given these problems in the literature. Whether the employment functions are specified directly at the aggregate level or derived from microeconomic principles depends upon the degree to which the microeconomic theory is established and pertinent to the labour component being considered. The bulk of the theoretical analysis of labour supply and demand has been concerned with labour that is hired. As a consequence, the theory of hired labour supply and demand is well-founded, and a conventional approach is followed in the derivation of supply and demand functions for hired farm labour.

On the other hand, little theoretical (or empirical) consideration has been given to the family labour components. Models of family labour in agriculture, such as those of Yeh and Li (1966) and Tyrchniewicz and Schuh (1969), have assumed that the same principles of supply and demand for hired labour apply to the family labour components. However, the supply of and demand for family labour in agriculture are determined by the same individuals. Consequently, the structural differentiation between the supply of and demand for labour is difficult in the case of farm operators and unpaid family workers. Heady and Tweeten (1963) note the problems associated with treating family labour in agriculture in the same manner as hired farm labour. They argue that the conventional theories of labour supply and demand are relevant for hired farm labour, but are likely to be inappropriate when applied to family labour in agriculture. An alternative approach to the formulation of models of the family labour components in agriculture is considered here, with particular attention being given to the derivation of an employment function for unpaid family labour.

4.2.1 Unpaid Family Labour

The unpaid family labour component has largely been ignored in both the theoretical and the empirical analyses of farm labour. The notable exception is Tyrchniewicz and Schuh (1969), who base aggregate supply and demand functions for unpaid family labour on the conventional theories of labour supply and demand. However, as with family labour generally, it is difficult to differentiate between supply and demand forces in the case of unpaid family labour. Both the demand for and supply of non-operator family labour are determined jointly by the farm family. In this section, an employment function for unpaid family labour is derived from a model of the individual farm.

A production function is postulated for the fth farm, whose area is taken as fixed. The amount of output produced in time t is a function of the quantities of the variable inputs employed in time t, namely capital, unpaid family labour, and hired labour

$$Q_{ft} = Q_{ft} (K_{ft}, F_{ft}, H_{ft}) \qquad 4.1$$

where: Q_{ft} = output of the fth farm in time t;

K = capital inputs;

F = unpaid family labour employed;

H = hired labour employed.

The novel feature of this production function is the disaggregation of the variable labour resource into hired and unpaid family components. Unpaid family labour (F) and hired farm labour (H) appear as separate arguments since each component represents a distinct type of input, in terms of the manner in which it is employed and the nature of the services it supplies.

'Real' net income to the fth farm enterprise is the difference between total revenue and total cost

$$I_{ft} = p_{ft} Q_{ft} - C_{ft} \qquad 4.2$$

where: I = 'real' net farm income;

p = 'real' farm price of farm products;

C = total cost of production.

The term 'real' is used to denote values corrected or discounted in order that values are comparable between different time periods and different areas.

Total cost of production on the fth farm is given by

$$C_{ft} = c_{ft} K_{ft} + w_{ft} H_{ft} \qquad 4.3$$

where: c = 'real' cost per unit of capital input;

w = 'real' cost per unit of hired labour input (farm wage rate).

Substituting for Q_{ft} and C_{ft} in 4.2 gives the fth farm's function for net income from farming operations in time t

$$I_{ft} = p_{ft} Q_{ft} (K_{ft}, F_{ft}, H_{ft}) - c_{ft} K_{ft} - w_{ft} H_{ft} \qquad 4.4$$

This income to the farm family may be supplemented by income earned by family members from nonfarm sources. Total income to the farm family is thus comprised of net income from farming operations plus income from nonfarm sources

$$I^*_{ft} = I_{ft} + F_{n_{ft}} F'_{ft} \qquad 4.5$$

where: I^* = 'real' total farm family income;

F_n = 'real' nonfarm wage rate (of farm family labour);

F' = number of family members employed off the farm.

This specification takes account of the interdependence between the farm firm and the farm household (Heady, Back, et. al., 1953). Substituting for I_{ft} in 4.5 yields the farm family income function

$$I^*_{ft} = p_{ft}\, Q_{ft}\, (K_{ft}, F_{ft}, H_{ft}) - c_{ft}\, K_{ft} - w_{ft}\, H_{ft} + {}^{F}n_{ft}\, F'_{ft} \quad 4.6$$

Now assume that farm families employ their resources in order to maximize their total family income, subject to the constraint that more family members cannot be employed, neither on nor off the farm, than the family has members eligible for this type of employment. Thus, the problem is to maximize 4.6 subject to

$$F''_{f} - F'_{ft} - F_{ft} = 0 \quad 4.7$$

where: F'' = potential unpaid family employment.

In this derivation, F'' is assumed to be invariant over time, but the proportions of the non-operator family labour force working on and off the farm may vary.[1] To maximize 4.6 subject to 4.7, form the function

$$L_{ft} = p_{ft}\, Q_{ft}\, (K_{ft}, F_{ft}, H_{ft}) - c_{ft}\, K_{ft} - w_{ft}\, H_{ft} + {}^{F}n_{ft}\, F'_{ft} + \gamma\, (F''_{f} - F'_{ft} - F_{ft}) \quad 4.8$$

where γ is an undetermined Lagrange multiplier.

Maximizing L_{ft} is equivalent to maximizing 4.6 subject to the constraint 4.7 (Henderson and Quandt, 1971). In addition,

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[1]F'', potential unpaid family employment, is not retained as a variable in this analysis largely because of data limitations. However, available data on farm family size indicate minor and very slow changes over the time period of this study. Nevertheless, equation 4.7 implies that the potential family workforce is employed either on the farm or elsewhere, and thus avoids the question of work-leisure choice.

I^*_{ft} is equal to L_{ft} only for those values that satisfy the constraint. Setting the partial derivatives of 4.8 equal to zero

$$\frac{\partial L}{\partial K} = p_{ft}\, Q^K_{ft}\,(K_{ft}, F_{ft}, H_{ft}) - c_{ft} = 0$$

$$\frac{\partial L}{\partial H} = p_{ft}\, Q^H_{ft}\,(K_{ft}, F_{ft}, H_{ft}) - w_{ft} = 0$$

$$\frac{\partial L}{\partial F} = p_{ft}\, Q^F_{ft}\,(K_{ft}, F_{ft}, H_{ft}) - \gamma_{ft} = 0 \qquad 4.9$$

$$\frac{\partial L}{\partial F^1} = {}^F n_{ft} - \gamma_{ft} = 0$$

$$\frac{\partial L}{\partial \gamma} = F''_f - F'_{ft} - F_{ft} = 0 .$$

Assuming the second-order conditions for a maximum are fulfilled, the system 4.9 may be solved for F_{ft} to yield the employment function for unpaid family labour on the fth farm

$$F_{ft} = F_{ft}\,(p_{ft}, c_{ft}, w_{ft}, {}^F n_{ft}) . \qquad 4.10$$

This employment function is based upon the notion that the occupations of the farm operator's employable dependents are determined within the farm family. It is assumed that the income maximization procedure jointly determines both the supply of and demand for (and, hence, employment of) unpaid family workers on the fth farm.

The exact form of this unpaid family labour employment relation (4.10) depends upon the properties of the production function (4.1). A loglinear functional form is assumed for 4.10, which serves as an approximation for equations derived from a variety of production functions

$$F_{ft} = \beta_{1f} \cdot p_{ft}^{\beta_{2f}} \cdot c_{ft}^{\beta_{3f}} \cdot w_{ft}^{\beta_{4f}} \cdot {F_n}_{ft}^{\beta_{5f}} \quad 4.11$$

With this derivation, the signs of the exponents of the variables p_{ft} and ${F_n}_{ft}$ are assumed *a priori* to be positive and negative respectively, but the signs of the other parameters are ambiguous.[1]

The aggregate employment function for unpaid family labour is found by summing the individual employment functions over the number of farm operators or farm operations

$$F_t = \sum_{f=1}^{S_t} F_{ft} \quad 4.12$$

where F_t = aggregate employment of unpaid family labour in agriculture;

S_t = number of self-employed farm operators.

In order that the parameters of the macromodel correspond with the micro employment function (4.11), it is necessary to assume that all farm enterprises have the same unpaid family labour employment functions and face identical prices and wages. Under these assumptions, the macroparameters are identical to the microparameters, and the aggregate employment function for unpaid

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1 The signs of the exponents of the variables c_{ft} and w_{ft} remain *a priori* unknown, unless additional assumptions are made on the production function.

family labour in agriculture becomes

$$F_t = \beta_1 \cdot S_t^{\beta_6} \cdot p_t^{\beta_2} \cdot c_t^{\beta_3} \cdot w_t^{\beta_4} \cdot F_{n_t}^{\beta_5} \qquad 4.13$$

where $\beta_6 = 1$.

These assumptions may be relaxed if the macroparameters are not to correspond directly to the parameters of the micro-relation. For instance, rather than assuming that all farmers have identical unpaid family employment functions, it might be assumed that the distribution of individual employment functions does not change over the time period of concern. However, only if that distribution is known is it possible to determine the composition of the macroparameters in terms of the underlying microparameters.

It is assumed in this model that aggregate employment is a function of the form (4.13), and that the signs of the parameters reflect the underlying microtheoretical hypotheses. Thus, the number of unpaid family workers employed in agriculture is hypothesized to be positively dependent upon the number of farm operators and the farm price of farm products, and negatively related to wages available to farm family members in the nonfarm sector. The direction of the relationships between unpaid family employment and the prices of farm capital inputs and hired labour (the farm wage rate) are *a priori* unknown, but may be estimated empirically.

4.2.2 Hired Farm Labour

Levels of employment of hired farm labour are established differently from unpaid family labour employment. The supply of and demand for hired farm workers are determined simultaneously, but by separate groups. Potential farm workers establish the supply of hired farm labour, whereas the demand for hired workers is determined by farm enterprises, simultaneously with the determination of unpaid family labour employment. In this section, firstly demand, and then supply functions for paid workers in agriculture are developed.

4.2.2.1 Hired Labour Demand

The demand for hired farm labour is assumed to be determined simultaneously with the employment of unpaid family labour. Thus, the derivation procedure follows that outlined in section 4.2.1. Maximizing the farm family income function

$$I^*_{ft} = p_{ft}\, Q_{ft}\,(K_{ft},\, F_{ft},\, H_{ft}) - c_{ft}\, K_{ft} - w_{ft}\, H_{ft} + F_{n_{ft}}\, F'_{ft} \qquad 4.6$$

subject to the constraint that

$$F''_{t} - F'_{ft} - F_{ft} = 0 \qquad 4.7$$

will yield a demand function for hired labour for the fth farm. Using a loglinear approximation, this hired labour demand relation may be presented

$$H_{ft}^{d} = \gamma_{ft} \cdot p_{ft}^{\gamma_{2f}} \cdot c_{ft}^{\gamma_{3f}} \cdot w_{ft}^{\gamma_{4f}} \cdot F_{n_{ft}}^{\gamma_{5f}} \qquad 4.14$$

where H_{ft}^{d} = quantity of hired labour demanded by the fth farm. The aggregate demand for hired labour is found by summing the individual demand functions over the number of farm operators. Assuming, as before, identical demand functions and prices; the aggregate demand relation has parameters consistent with the individual hired labour demand function

$$H_{t}^{d} = \gamma_{1} \cdot S_{t}^{\gamma_{6}} \cdot p_{t}^{\gamma_{2}} \cdot c_{t}^{\gamma_{3}} \cdot w_{t}^{\gamma_{4}} \cdot F_{n_{t}}^{\gamma_{5}} \qquad 4.15$$

where H_{t}^{d} = aggregate demand for hired labour in agriculture, and $\gamma_6 = 1$. The quantity of hired labour demanded in agriculture is thus hypothesized *a priori* to be positively dependent upon the number of farm operators and the price of farm products, negatively related to the farm wage rate, and associated in an unknown direction with the price of capital inputs in agriculture and the nonfarm wage rate.

4.2.2.2 Supply and Hired Labour

Individual supply functions for labour can be derived from the maximization of individual worker utility functions in essentially the same way that labour demand functions can be based on the assumption of enterprise income maximization. The derivation of supply functions for hired agricultural labour has been considered by Gallaway (1967; 1968). Following Gallaway, the quantity of labour which a worker supplies to a single market is assumed to be determined by his equating the wage rate in the market with his marginal rate of substitution between income and leisure. It follows that when a worker considers several alternative markets simultaneously, he will offer his labour services in that market where the wage rate is the highest, provided there are no unique costs associated with employment in any of the markets.

However, if there are such costs associated with employment in any or all of the markets, the decision-making process is somewhat more complex. Although not easily quantified, such costs can conceptually be incorporated into the analysis with only slight modifications. Their presence makes a market less attractive as an employment possibility, for when individuals evaluate various possible employment opportunities they discount or correct offered wage rates by whatever amount is necessary to compensate for these costs. This concept of 'corrected' wage rates is analogous to that of 'real' wages and prices noted in Section 4.2.1.

Since this analysis is concerned with the supply of hired workers to agriculture, two markets are considered, namely, the farm and nonfarm sectors of the economy. Thus, the supply of labour to agriculture is a function of the 'corrected' wage rates in these two sectors. The particular form of such a function depends upon the properties of individuals' utility functions with respect to work in agriculture.

Aggregate labour supply functions may be developed via several routes. A common procedure is to derive from a utility function a general functional form for an individual's supply of labour to agriculture, then aggregate over the number of potential suppliers of hired farm labour. Aggregate hired farm labour supply functions are constructed in this manner by Tyrchniewicz (1967) and Gallaway (1968). An alternative approach is to postulate a form of utility function which incorporates a distribution of preferences for work in agriculture related to wages in the farm and nonfarm sectors. By integrating over such a distribution (to get the proportion of the potential hired workforce choosing agriculture), and by multiplying the integral by the number of potential suppliers of hired labour, an aggregate supply function may be specified without considering the nature of individual supply functions. Labour supply functions, in other contexts, are constructed in this spirit by Altman and Barro (1970), Grant (1973), Heckman (1974) and Robb (1975).

Either approach could yield an aggregate hired farm labour supply function of the following general form

$$H_t^s = H_t^s \ (w_t, \ {}^{H}n_t, \ L_t) \qquad 4.16$$

where: H^s = quantity of hired labour supplied to agriculture;

w = 'real' farm wage rage'

H_n = 'real' nonfarm wage rate (of potential hired farm workers);

L = potential hired farm labour force.

A loglinear relation is specified as an approximation to the range of supply functions possible

$$H_t^s = \delta_1 \cdot w_t^{\delta_2} \cdot H_{n_t}^{\delta_3} \cdot L_t^{\delta_4} . \qquad 4.17$$

The quantity of hired labour supplied to agriculture is hypothesized *a priori* to be positively related to the number of potential hired farm workers and the farm wage rate, and negatively associated with the real wage rate in the nonfarm sector.

4.2.2.3 Hired Labour Supply and Demand

The convential market clearing equation is

$$H_t^d = H_t^s = H_t$$

and so the structural relations for hired farm labour are

hired labour demand:

$$H_t = \gamma_1 \cdot S_t^{\gamma_6} \cdot p_t^{\gamma_2} \cdot c_t^{\gamma_3} \cdot w_t^{\gamma_4} \cdot F_{n_t}^{\gamma_5} \qquad 4.15$$

hired labour supply:

$$H_t = \delta_1 \cdot L_t^{\delta_4} \cdot w_t^{\delta_2} \cdot H_{n_t}^{\delta_3} \qquad 4.17$$

These two equations, along with the employment function for unpaid family labour (4.13), represent a system in which unpaid family employment (F_t) and hired labour employment (H_t) are determined simultaneously, along with the farm wage rate (w_t).

4.2.3 Farm Operators

In the preceding Sections, 4.2.1 and 4.2.2, the number of farm operators has been taken as predetermined. In this section a model of farm operator employment is presented.

In contrast to the other components, the employment of farm operators is essentially an aggregate concept. Changes in the demand for farm operators are derived from structural changes in the agricultural industry which effect changes in the number and size of farm operations; and the supply of operators, also related to these organizational adjustments, is a supply to the industry rather than a supply to individual enterprises. Furthermore, the differentiation of supply and demand processes is difficult in the case of farm operators, since in effect both supply and demand are determined in the same decision by the same individuals, the farm operators.

No detailed theoretical consideration of the farm operator component is undertaken in this study. Given the nature of operator employment, a single farm operator employment equation specified directly at the macrolevel is considered appropriate. This operator employment function is based largely upon the theoretical propositions that underly existing models of farm labour relevant to operators, and upon the degree to which empirical analyses have supported these propositions.

An important determinant of changes in the number and size of farm operations, and hence of changes in the number of farm operators, is the development of technology in agriculture. The influence of technological change on agricultural labour is well recognized in the literature (see Tolley and Farmer, 1963; Fuller and VanVuuren, 1972; Gupta, 1972), but this factor has proven difficult to incorporate into models of agricultural employment. A common practice has been to assume that such technology-induced changes have been taking place at a constant rate, and to introduce a time variable in the model as a surrogate (for example, Heady and Tweeten, 1963; Yeh and Li, 1966). However, indices of technological change in agriculture have been developed, and employed in econometric models of farm labour with considerable success (Tyrchniewicz and Schuh, 1969). Such an index of technological change has been developed for Canadian agriculture (Yeh and Li, 1968), and is included in the operator employment function on the assumption that technological developments in agriculture have tended to encourage larger and fewer farms, and thus reduce the number of farm operators.

Given the level of technology in agriculture, other factors assumed to influence operator employment are the profitability of producing agricultural products, and the income levels in alternative occupations. Those models that have considered farm operator (or family) labour separately have attempted to derive a measure of the return to operator (or family) labour in agriculture. However, it can be argued (see Jones, 1966; Tyrchniewicz and Schuh, 1969) that farm operators consider not only their return to labour, but the return to their total bundle of inputs, many of which are essentially locked into agriculture. Thus, a measure of the profitability of farming is more appropriate in the operator employment relation than an estimate of the return to operator labour in agriculture. The farm price of farm products, which derives from the demand for agricultural output, is deflated by the price of inputs used in agriculture to yield an indicator of the relative profitability of farming. Assuming that farmers tend to remain in agriculture (or new recruits enter the industry) when farming is relatively profitable, and/or that operators tend to leave the industry (change employment or retire) in periods when agricultural prices are low relative to costs, a positive relation is hypothesized between operator employment and the farm profitability index.

Operator employment is assumed to be influenced also by 'real' wage rate or income levels in alternative occupations (Gallaway, 1967b). Farm operator employment is hypothesized to be negatively related to the 'corrected' wage rate in the occupations considered as alternatives by farm operators.

The number of self-employed farm operators is thus specified as a function of the level of technology in agriculture, the profitability of farming, and real wage levels in alternative occupations. The farm operator employment relation is approximated in a loglinear form

$$S_t = \alpha_1 \cdot r_t^{\alpha_2} \cdot S_{n_t}^{\alpha_3} \cdot T_t^{\alpha_4} \qquad 4.18$$

where: S = number of self-employed farm operators;

r = index of relative farm profitability;

S_n = real nonfarm wage rate (of farm operators);

T = level of technology in agriculture.

4.2.4 The Submodels Combined

In the preceding sections, conceptual submodels for each of the labour components in agriculture have been presented. Together, these submodels comprise a system which determines levels of employment in the three farm labour components

operator employment:

$$S_t = \alpha_1 \cdot r_t^{\alpha_2} \cdot S_{n_t}^{\alpha_3} \cdot T_t^{\alpha_4} \qquad 4.18$$

unpaid family employment:

$$F_t = \beta_1 \cdot S_t^{\beta_6} \cdot p_t^{\beta_2} \cdot c_t^{\beta_3} \cdot w_t^{\beta_4} \cdot F_{n_t}^{\beta_5} \qquad 4.13$$

hired labour demand:

$$H_t = \gamma_1 \cdot S_t^{\gamma_6} \cdot p_t^{\gamma_2} \cdot c_t^{\gamma_3} \cdot w_t^{\gamma_4} \cdot F_{n_t}^{\gamma_5} \qquad 4.15$$

hired labour supply:

$$H_t = \delta_1 \cdot L_t^{\delta_4} \cdot w_t^{\delta_2} \cdot H_{n_t}^{\delta_3} \quad . \qquad 4.17$$

The system of equations above represents a macromodel of farm employment which is disaggregated into three submodels, each pertaining to a distinct component of the farm labour force, and each based on a theoretical foundation considered appropriate to that submodel. As a consequence, the processes that determine levels of employment in agriculture are not assumed to be the same for all types of labour. The submodels for hired and unpaid family labour are derived explicity from behavioural models of individual farms and workers. Some rather strong assumptions are necessary to ensure consistency between the parameters of the microrelations and those of macro submodels. However, these assumptions are not considered unreasonable given that they refer to individuals within particular classes of farm labour, and not to the entire farm workforce. In these respects, an important portion of the heterogeneity of the farm labour force is embodied in the model.

In addition, the model recognizes that the farm labour components are unlikely to vary independently of each other. Whereas other disaggregated models have either made the simplifying assumption that there is no interaction among the components or have specified interdependencies among the components on an *ad hoc* basis, the interrelations among the components in this model follow directly from the construction of the submodels. The number of farm operators is assumed to be determined independently of the other components.[1] The unpaid family employment function and the demand equation for hired workers are derived from a model of the individual farm enterprise. The aggregation procedure gives the intuitively appealling result that aggregate employment of unpaid family workers and aggregate demand for hired farm workers are related to the number of farm operators (and to other variables). At the same time, unpaid employment, hired labour demand, and hired labour supply are jointly dependent upon the farm wage rate, and are assumed to be determined simultaneously.

A further important characteristic of the model is that it is specified in a form conducive to empirical testing. While further disaggregation of the labour force, for example by sex or length of employment, might result in an improved conceptual model, such a model could not be tested at present (in Canada at least) since the necessary data are not available. Similarly, more sophisticated theoretical models, which might result from the relaxation of some of the assumptions (about functional forms or

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[1] Except in as much as factor costs influence profitability, although this simultaneity is not taken into account.

aggregation), are also likely to face estimation problems. The model developed in this section represents a compromise between theoretical elegance and empirical tractability.

4.3 Rationale for Regional Differences

The model developed in Section 4.2 is to be fitted to time-series data for each of the five regions of Canada. The use of regional data seems desirable given the assumptions embodied in the model. In particular, assumptions relating to the homogeneity of farm enterprises and prices are more reasonable when the model is applied to regional rather than to national aggregate data. Just as the structural disaggregation of the farm workforce refines the specification of the model, so this spatial disaggregation results in an improvement in the conceptual basis of the model.[1] The remainder of this section briefly outlines some of the reasons why regional differences in the determinants of labour force change are anticipated, and considers the nature of regional differences that might be expected.

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[1] However, as noted in Section 3.3, such disaggregation does not necessarily 'improve' statistical results; in fact, most empirical studies (eg. Grunfeld and Griliches, 1960; Schuh and Leeds, 1963; Yeh and Li, 1966) have found that the models fit spatially disaggregated data no better than national aggregate data.

4.3.1 Existence of Regional Differences

Regional differences in changes in the size and composition of the farm workforce arise from two possible sources. Firstly, the variables which induce changes in the levels of employment in agriculture may vary in magnitude from one region to another. As a result of differing systems of agriculture and general economic conditions among the regions, levels of technology in agriculture and price levels of agricultural inputs and outputs are also likely to differ among the regions. Similarly, the regions are likely to experience differences in nonfarm wage levels and employment opportunities. In other words, the values of the variables contained in the model developed in section 4.2 are likely to vary both through time and among the regions. The empirical literature (eg. Guither, 1963; Taeuber, 1967; Hathaway, 1967) has demonstrated that individual farmers and farm workers are influenced by local conditions (prices, costs, wages levels, and employment opportunities), rather than by changes at the national level in these variables. Thus, regional differences in the variables are expected to induce regional differences in patterns of change in the farm workforce.

However, the situation is complicated by the fact that regional differences in employment trends may also arise from regional differences in the model parameters; that is, regional differences in the responses of farmers, farm families and potential farm workers to changes in the variables which influence their employment decisions. Differences in the structure and organization of agriculture (production functions) among the regions are likely to result in different responses by farm operators to changes in technology and shifts in prices and wages. Similarly, preferences of farm family members and potential farm workers in the Prairies, for example, might be quite different from those in Ontario or Québec. As a consequence, regional differences in farm employment levels and composition may arise from parameter differences even though the values of the variables do not differ among the regions. In practice, it is likely that both the values of the variables and the parameter values differ among the regions.

4.3.2 Nature of Regional Differences

While regional differences in the determinants of farm employment are expected, there is little theoretical or empirical foundation on which to base hypotheses about the nature or direction of these differences. Regional differences in the values of the variables are likely to be related to scale effects and differences in regional economic structure. However, the prime concern here is not with regional differences in the variables, but with regional differences in the parameters or relationships embodied in the model. In this study, the question of interpreting particular parameter differences among the regions is treated in an inductive manner. However, some *a priori* expectations regarding regional differences in the general performance of the model may be based on Schultz's (1953) 'urban-industrial' hypothesis. Schultz put forward the argument that factor markets 'work better' in areas adjacent to centres of urban industrial development, specifically that:

> The existing economic organization works best at or near the centre of a particular matrix of economic development and it also works best in those parts of agriculture which are situated favourably in relation to such a centre; and it works less satisfactorily in those parts of agriculture which are situated at the periphery of such a matrix. (Schultz, 1953, p. 147).

Empirical tests of the Schultz hypothesis (for example, Tang, 1958; Sisler, 1959; Nicholls, 1961) have yielded some evidence that the operation of factor markets in agriculture, including agricultural labour markets, is related to levels of economic development. The relevance of the proposition to this study is that the farm labour model might be expected to perform 'better' in those regions where Canada's urban-industrial development is centred.

However, the urban-industrial hypothesis relates to the general performance of the model, and provides no indication as to how particular relationships might differ among the regions. The difficulty in postulating systematic regional differences in the model parameters reflects the lack of attention paid to this question. There is little or no theoretical analysis of this issue, and few empirical investigations have considered the conceptual basis of regional differences in coefficients or elasticities.[1] In this study, the position is further complicated by the fact that so little is known about the processes which influence changes in employment in the various components of the Canadian farm labour force at any spatial level. Since the processes themselves are hardly identified, it is obviously difficult to postulate plausible explanations for regional differences in the processes.

4.4 Empirical Measures for Theoretical Concepts

In order to empirically test the farm labour model, time-series data are required for Canada and the five regions. Ideally, data used in empirical investigations should coincide with the concepts contained within the theoretical model. However, single measures which correspond exactly to a theoretical concept are rarely available, and compromises need to be made between theoretical concepts and the available data series. This section describes and evaluates the measures used in the empirical analysis. More detailed descriptions of data sources definitions are given in Appendix 1.

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1 The question is considered in Weatherford (1957), Wolfson (1958), Schuh and Leeds (1963) and Tyrchniewicz and Schuh (1966), but no substantive conclusions pertaining to the nature of regional differences in farm labour market processes are reached in these studies.

Farm Employment. The data on employment in agriculture by class of worker (self-employed farm operators, unpaid family workers, paid workers) are derived from published and unpublished estimates supplied by the Labour Force Survey Division of Statistics Canada. The yearly estimates of numbers employed represent annual averages from quarterly (1946 to 1952) and monthly (1953 onwards) statistics obtained from sample surveys.

A person employed in agriculture represents anyone, 14 years of age and over, who, during the reference week, did any work at all in agriculture, or had a farm job but was not at work because of illness, vacation, and so on. The term 'work' includes any work for pay or profit. That is, paid work in the context of an employer-employee relationship, or self employment. Unpaid family work is defined as work which contributed directly to the operation of a farm, which is owned or operated by a related member of the household. Housewives are enumerated as unpaid family workers only if they report more than 20 hours of farm work in the reference week.

The data on numbers employed in agriculture by region and class of worker are, to the author's knowledge, a more complete breakdown of annual agricultural employment than has been used previously in investigations of this type. Yeh and Li (1967) distinguish only between paid workers and family workers employed in agriculture. Tyrchniewicz and Schuh (1966) consider three employment categories, but their estimate of the number of self-employed in agriculture is the U.S.D.A. estimate of the number of farms, with unpaid family workers comprising the residual after paid workers and the farm operator estimate are subtracted from the total employment in agriculture. The data used in this study, derived from the Labour Force Survey, represent direct estimates of employment in each of the three classes of agricultural worker in Canada and the regions.

While these data are the best available, they have some limitations. The employment series represent the number of people gaining employment in agriculture in each of the farm labour categories, rather than a measure of the amount of work input into agriculture. These two measures would vary together only if the full-time/seasonal/part-time distribution and the distributions of age and sex within each component remain relatively constant over the period being considered. Although a measure of the quantity of work input has some theoretical advantages with respect to labour demand, the number-employed measure permits the discussion of changes in actual numbers of people engaged in agricultural employment, rather than changes in some concept such as man-year equivalents of labour input.

It is also recognized that the survey-based data are likely to contain both sampling and non-sampling errors. The rounding procedure used (to the nearest thousand) has meant that in some regions, notably the Atlantic region and British Columbia, the employment estimates for some components are rather crude because they involve small numbers.

Farm Wages. The measure used for real farm wages is 'average wages of male farm help, per month, without board', deflated by the 'Consumer Price Index'. The farm wage data purport to reflect the average of wages paid to all male farm help in a region regardless of age or skill. Because the wage rates used to calculate this composite measure may cover a wide range of skills, types of work, and ages of hired farm workers, it is felt that the chief value of the data is to indicate relative change over time rather than to measure accurately absolute wage levels. This measure, available at the regional level, is considered well suited to the needs of the analysis.

Nonfarm Wages and Employment Opportunities. The conceptual model requires data on nonfarm incomes, corrected for costs associated with nonfarm employment, for each of the labour force components (that is, ${}^{S}n$, ${}^{F}n$, ${}^{H}n$). It might be argued that operator labour, with its entrepreneurial skills, considers different nonfarm employment alternatives than unpaid family or hired farm labour. However, the limited evidence available (Sjaastad, 1961; Gallaway, 1967; Hathaway and Perkins, 1968) suggests that off-farm migrants as a group tend to work as operatives, labourers, craftsmen and foremen in a variety of industries. In the absence of evidence that particular classes of farm worker are attracted to (or from) particular nonfarm occupations or industries, one broad-based measure of nonfarm income alternatives is used for the three components. The 'industrial composite average weekly earnings' is deflated by the consumer price index to give a measure of the real nonfarm income alternative in each region, n_{it}.

However, this nonfarm income measure needs to be corrected also for costs or barriers associated with employment in the nonfarm sector. The commonly used variable in this regard is the level of unemployment in the economy (Tyrchniewicz and Schuh, 1969). High unemployment rates are assumed to indicate job scarcity and job uncertainty in the nonfarm sector, and thus discount nonfarm income levels. Hathaway (1964) argues that 'intersector labour transfers occur largely in response to employment availability rather than through income differentials. After all, expected income is a function of observed income differentials and the probability of achieving them'. In order to derive a measure of 'expected' or 'discounted' nonfarm income, the real nonfarm wage rate n is 'corrected' for the level of unemployment in the economy

$$n'_{it} = n_{it} \ (100 - U_{it}) \ /100$$

where U_{it} is the annual average regional unemployment rate.

Farm Prices Received. The measure used for the price of farm products variable is the index of 'farm prices of agricultural products'. This index is a measure of changes taking place, between the base period and the current period, in the average prices farmers receive at the farm level from the sale of farm products. This index is deflated by the 'consumer price index', to yield a measure of 'real' farm prices in each region.

Relative Profitability of Farming. The parity ratio, or the ratio of prices farmers receive for their goods to prices farmers pay for inputs used in production, is used to indicate farm profitability. In this study, the index of farm prices of agricultural products is deflated by the 'farm input price index', which is designed to measure the movements of prices paid by farmers for inputs into farm production, to yield a measure of the relative profitability of farming.

Cost of Machinery Inputs. The price index of the input component 'farm machinery and motor vehicles' is used in this study as a surrogate for the price of capital inputs which might substitute for, or complement labour inputs in agricultural production. The Western Canada index is used for the Prairie region and British Columbia, and the Eastern Canada index is used for Ontario, Quebec, and the Atlantic region. The price index is deflated by the consumer price index to yield a measure of the real cost of machinery inputs.

Consumer Price Index. The consumer price index is used in this study as a deflator of wages and prices in order than these data series are in 'real' terms. From the statistical point of view, deflation helps reduce some of the collinearity among the variables, thus improving the reliability of the parameter estimates. The consumer price index is a measure of change in the cost of living in urban areas; no comparable rural or farm consumer price index is currently available in Canada. The regional indices used in this study are calculated using the weighted averages of cities for which the index is supplied.

Technology. Various attempts have been made to measure technological changes in agriculture. A summary of the various approaches is given by Lave (1966). All the measures have technical and empirical shortcomings, and a less than perfect measure is used in this study. The model employed to measure technological change in agriculture is that used by Yeh and Li (1968), based on the concept of net (value-added) output, after Solow (1957)[1]. The model may be presented

$$\frac{\Delta T_t}{T_t} = \frac{\Delta Y_t}{Y_t} - \left[I_t^k \frac{\Delta K_t}{K_t} + I_t^m \frac{\Delta M_t}{M_t} \right]$$

where: $\frac{\Delta T_t}{T_t}$ = annual measure of technological change;

Y = value added or net output;

K = farm capital inputs;

M = farm labour inputs;

I^k = relative share in income of capital;

I^m = relative share in income of labour.

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[1] For a detailed discussion of the theoretical basis of this measure see Yeh and Li (1968).

The model yields a series of annual measures of technological change that can be estimated from time series data of Y, K, M, I^k and I^m. In essence, this index of technological change in any year is measured as the difference between two ratios. The first ratio is the observed relative change in labour productivity, and the second is the relative change in labour productivity that is caused by the relative change in the capital-labour ratio. Successive multiplication of year-to-year measures of technical change and setting $T_t = 100$ in the base year gives an annual series of indexes of cumulative technical change.

The variables used in the calculations were derived from Statistics Canada time-series data using 1961 as the base year:

Y = value of gross farm output (deflated by output price index) minus material inputs (deflated by input price index);

K = value of capital stock (deflated by price index);

M = total employment in agriculture.

Following Yeh and Li (1968), I^k and I^m were measured as

$$I^k_t = \frac{.06K_t}{Y_t} \; ;$$

$$I^m_t = (1 - .06) \frac{K_t}{Y_t} \; .$$

Indexes were calculated for the period 1946 to 1973 (1961 = 100) for Canada and each of the five regions. The cumulative technological change series derived in this manner closely approximate the series calculated by Yeh and Li for the years 1946 to 1965 using more disaggregated data.

Potential Hired Farming Workers. The most commonly used variable to 'aggregate' labour supply functions is the civilian labour force. However, changes in the potential hired farm work forces are unlikely to be reflected in changes in the total civilian labour force, which is predominantly urban. In order to exclude the workers in the large urban areas, and thus more closely approximate the number of people who consider employment in the farm sector, the following measure is used:

for each region,

$$L_t = C_t - \sum_{j=1}^{J_t} A_{jt}$$

where: L_t = estimate of potential hired farm work force in year t;

C_t = total civiliam labour force in year t;

A_{jt} = labour force in urban area j (>20,000 labour force) in year t;

J_t = number of urban areas with more than 20,000 labour force in year t.

Thus, the potential hired farm labour force is assumed to exclude workers in urban areas with more than 20,000 labour force.

4.5 Summary

Several of the important shortcomings in the conceptual bases and applications of farm employment models noted in Chapter 3 have been addressed in the development of the conceptual model and the testing strategy outlined in this chapter. The model is disaggregated into three submodels, each pertaining to a distinct component of the farm labour force and each derived from a theoretical foundation considered appropriate for that component. Particular attention is given the unpaid family segment of the agricultural workforce, since this component has been largely ignored in the literature. The derivation procedures produce a model in which specific interdependencies among the components of the farm workforce are specified. The model is thus represented as a simultaneous system of four equations.

The farm employment model is to be fitted to national aggregate data and to data pertaining to each of the five regions of Canada. This spatial disaggregation permits analysis of regional differences in the determinants of changes in farm employment. Some of the reasons for expecting regional differences are discussed, and the time-series data used in the statistical analysis which follows are described and evaluated.

CHAPTER 5

THE STATISTICAL MODEL AND ESTIMATION

This chapter discusses the statistical model, its characteristics and the techniques used in estimating the structural equations. It begins with the transformation of the conceptual model into a form which facilitates statistical estimation. The identification properties of the model are then considered, and the appropriate estimation procedures are described. A distribution lag formulation of the basic model is presented, and the chapter closes with an outline of methods for testing the regional and temporal stability of the statistical results.

5.1 The Statistical Model

The theoretical model derived in Chapter 4 is readily transformed into a system of equations that permits the estimation of the model parameters. In order to comply with both the nonlinear relationships of the theoretical model and linearity assumptions of the estimation techniques, the data used in the estimation procedures are transformed to logarithms. This logarithmic transformation serves other purposes.

In particular, if a relationship is formulated in terms of logarithms, the derivatives turn into elasticities, since:

$$\frac{d \log X}{d \log Y} = \frac{Y}{X}\frac{dX}{dY} = \frac{dX}{X} / \frac{dY}{Y} \quad .$$

Thus, the estimated coefficients of the structural models will represent direct estimates of the elasticities. The elasticity concept indicates the degree of responsiveness of the dependent variable to changes in particular exogenous or predetermined variables. It depends upon *relative* changes and is independent of the units used to measure the variables concerned. Arguments for introducing elasticities as a means of relating relative changes in cause and effect are given in Cramer (1971).

The great practical advantage in this study is that, as a measure of relationships among variables, elasticities have the dimension of a pure number so that it is not necessary to standarize units of measurement in order to compare coefficients from different countries, regions, or time periods. Moreover, the logarithmic transformation may offer distinct technical advantages in regression analysis, namely in the cases of heteroskedasticity and autocorrelation (Johnston, 1972).

By taking the logarithms of the variables, and by introducing random disturbances which recognise that the relations do not hold exactly, the structural form of the model may be presented

Operator employment:

$$S^*_{it} = a_{1i} + b_{1i}\ r^*_{it} + b_{2i}\ n^*_{it} + b_{3i}\ T^*_{it} + u_{1i} \quad 5.1$$

Unpaid family employment:

$$F^*_{it} = a_{2i} + b_{4i}\ S^*_{it} + b_{5i}\ w^*_{it} + b_{6i}\ p^*_{it} + b_{7i}\ n^*_{it} + b_{8i}\ c^*_{it} + u_{2i} \quad 5.2$$

Hired labour demand:

$$H^*_{it} = a_{3i} + b_{9i}\ S^*_{it} + b_{10i}\ w^*_{it} + b_{11i}\ p^*_{it} + b_{12i}\ n^*_{it} + b_{13i}\ c^*_{it} + u_{3i} \quad 5.3$$

Hired labour supply:

$$H^*_{it} = a_{4i} + b_{14i}\ w^*_{it} + b_{15i}\ n^*_{it} + b_{16i}\ L^*_{it} + u_{4i} \quad 5.4$$

where the variables:

S^* = log S, the number of self-employed operators;

F^* = log F, the number of unpaid family workers;

H^* = log H, the number of hired farm workers;

W^* = log w, the real farm wage rate;

p^* = log p, real farm prices of agricultural products;

n^* = log n', discounted nonfarm wage rate;

T^* = log T, level of technology in agriculture;

r^* = log r, farm profitability index;

c^* = log c, real price of machinery inputs;

L^* = log L, the potential hired farm workforce;

the coefficients

$a_{(1,\ldots 4)}$ and $b_{(1,\ldots 16)}$ are the parameters to be estimated;

the terms

$u_{(1,\ldots 4)}$ are disturbance terms;

the subscript

i refers to the region ($i = 1,\ldots 5$).

The levels of employment in each of the labour force components (S^*, F^*, H^*) and the farm wage rate (w^*) are determined endogenously with the system.

This statistical model (5.1 - 5.4) represents a 'bloc recursive' system. The farm operator equation (5.1) specifies the endogenous variable S^* as a function of exogenous variables only, indicating that S^* is determined independently of the other endogenous variables. Thus the single equation for S^* comprises the first bloc. The value for S^* then becomes a predetermined (and thus exogenous) variable in the second bloc of three equations in which the values of F^*, H^* and w^* are determined simultaneously. The second bloc, recursively related to the first, is thus comprised of the three-equation simultaneous system (5.2 - 5.4).[1]

The estimation of bloc recursive systems requires a bloc by bloc approach. In this case, Ordinary Least Squares (OLS) provides an optimal technique for estimating the parameters of the

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[1] The properties of the statistical model are discussed in more detail in Appendix 3.

single equation bloc (5.1). However, the estimation of a simultaneous system of equations such as the second bloc (5.2 - 5.4) involves three issues, each of which must be settled satisfactorily before going on to the next.

First, the system must be mathematically complete; that is, if the errors, exogenous variables, and structural parameters are known, the endogenous variables are uniquely determined. If this requirement is not met then the model provides no solution to the endogenous variables and cannot indicate how changes in exogenous variables influence endogenous variables. The system is evidently mathematically complete.

The second issue is identification, a condition that should be established prior to any examination of statistical evidence. Once it is shown that the equations are identified, the third issue, that of statistical estimation can be confronted.

5.2 Identification

Identification means that if the endogenous variables, the exogenous variables, and the errors are known, the structural parameters are uniquely determined (Wonnacott and Wonnacott, 1970, p. 189). If an equation is under-identified, then it is not possible to estimate that equation, since there will be no way of knowing whether this specific equation is being estimated or whether some bogus combination of equations in the model is being estimated. In other words, without identification, the true structure cannot be identified from a whole set of bogus structures.

Operationally, there are necessary, and necessary and sufficient conditions which must be met in order that a structural relation be identified (Koopmans and Hood, 1953). The necessary (order) condition for identification is that the total number of predetermined variables excluded from the equation must be at least as great as the total number of endogenous variables in the equation less one. This order condition is met in each of the three structural relations of the second bloc. The necessary and sufficient (rank) condition is that the coefficient matrices for the variables omitted from the equation together form a matrix that is of full rank. Given our *a priori* knowledge of the coefficients, this condition is also satisfied in the three-equation system.[1]

The unpaid family employment equation (5.2) and the hired labour demand equation (5.3) are exactly-identified, and the hired labour supply equation (5.4) is over-identified. In over-identified models, where there are more exogenous variables than necessary to identify the relation, the estimation problem is how to use all this information effectively.

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[1] Identification of the equations in the model is discussed in more detail in Appendix 3.

5.3 Estimation Procedures

Given the identification properties of the bloc (5.2 - 5.4), Two Stage Least Squares (2SLS) provides an efficient technique for estimating the structural parameters of the simultaneous equations (Thiel, 1971). Application of OLS to the equations of the system would yield inconsistent estimates of the structural parameters, since one of the regressors (w^*) is endogenous to the system, hence is dependent on the error terms $u_{(2, 3, 4)}$.

The 2SLS procedure is designed to eliminate this problem by purging w^* of its dependence on u. The first stage involves finding a modified regressor $\hat{w}^*$ that resembles w^*, yet is independent of the u terms. This is done by regressing w^* on all the exogenous variables in the bloc (S^*, p^*, n^*, c^*, L^*) - that is, the reduced form for w^* - obtaining $\hat{w}^*$. Since S^*, p^*, n^*, c^*, L^* are exogenous to the bloc, each is independent of the errors u; hence any function of them (in particular, the linear combination $\hat{w}^*$) will also be independent of the u terms.

In the second stage $\hat{w}^*$ is substituted for w^* in the structural equations, and OLS is used to estimate the structural parameters. This procedure is now legitimate, since $\hat{w}^*$ is uncorrelated with the error terms. Thus, the relations of the simultaneous equations bloc are estimated using 2SLS.

Operationally, the statistical estimation of the complete model involves the following steps:

(i) OLS estimation of the parameters of the first bloc (5.1);

(ii) OLS estimation of the reduced form for w^*, yielding $\hat{w}^*$;

(iii) Substitution of $\hat{w}^*$ for w^*, then OLS estimation of the structural equations of the second bloc (5.2, 5.3, 5.4).

5.4 A Distributed Lag Specification

It is commonly argued that observations on economic behaviour generally involve a mixture of short-run and long-run adjustments, and that statistical estimation should attempt to separate the two. The difference between short-run and long-run elasticity is the difference in response time that individuals or groups of individuals make to economic stimuli. A short-run response consists of the reaction to changed economic conditions within a specified period of time. The long-run response consists of the complete adjustment to changed economic conditions, however much time it should require. The general presupposition is that the long-run response is larger than the short-run response, or that economic entities do not make a complete adjustment to changed economic conditions within a given time period. Rather, it is assumed that there is an incomplete adjustment or lag in their responses to changing economic conditions.

There are numerous reasons for expecting lags in the em-employment decisions of farm operators and farm workers. Apart from a general inertia or reluctance to change, operators and workers may be uncertain as to whether changes are permanent or merely temporary fluctuations, or they may be unaware of certain economic changes or alternative employment opportunities. Adjustments in labour employment may be delayed because of complementarities with other durable resources, or because the costs involved in adjustment and readjustment may more than offset the gains from maintaining a previously established equilibrium position.

One commonly used method for introducing such temporal lags into models of the type developed in this study is the procedure of Nerlove (1958). Nerlove assumes a long-run equation and an adjustment equation. For instance, a simple long-run equation may take the form:

$$y_t^o = a_o + a_1 x_t \qquad 5.5$$

where: y_t^o is the long-run or equilibrium level of the quantity employed and x_t is the price of y_t.

Assuming that the current quantity employed, y_t, will change in proportion to the difference between the long-term equilibrium quantity and the current quantity, a difference equation, called the adjustment equation, can be specified:

$$y_t - y_{t-1} = \gamma\ (y_t^o - y_{t-1}) \qquad 5.6$$

where: γ, a constant of proportionality called the coefficient of adjustment, indicates the relative speed of adjustment. This specification assumes that a given disequilibrium is not removed in a given time period, but rather that only a constant fraction is eliminated. In the absence of further changes in the predetermined variables, however, the actual level of quantity employed would, over time, approach asymptotically the equilibrium level of employment.

Substituting the adjustment equation (5.6) into the long-run equation (5.5), the following estimating equation is derived:

$$y_t = \gamma a_o + (1 - \gamma)\, y_{t-1} + \gamma a_1\, x_t \quad . \qquad 5.7$$

Clearly, the method is valid for any number of x_t's. Operationally the procedure involves including the lagged dependent variable as a predetermined variable on the right hand side of the estimating equation.[1] The coefficient of adjustment, γ, can be obtained by subtracting the coefficient of the lagged dependent variable from one. If the variables are measured in logarithms,

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[1] Although the estimating techniques described above are appropriate also for this model, the use of a distributed lag formulation of this type has some problems in empirical applications, especially with time-series data (Griliches, 1961). The lagged dependent variable tends to pick up the effects of omitted variables, thus leading to serious problems of specification bias in inadequately specified models. This same tendency causes available tests for serial correlation in the calculated residuals to be comparatively weak in distributed lag models.

the coefficients of the estimating equation are direct estimates of the short-run elasticities. The coefficient γ, then, is an elasticity of adjustment, and the long-run elasticities are obtained directly when the coefficients of the estimating equation are divided by γ.

The distributed lag hypothesis is that γ, the coefficient of adjustment, is constrained between the interval zero and one. The coefficient of the lagged dependent variable, say b_1, is equal to $1-\gamma$. If $b_1 = 0$, then $1-\gamma = 0$. This would imply that all of the adjustment to a new equilibrium is within the period of observation ~~for~~ the data, and there is no lag in response. On the other hand, if $b_1 = 1$, then $1-\gamma = 1$, and $\gamma = 0$, suggesting that there is no adjustment at all. To provide support for the distributed lag hypothesis the coefficient of the lagged dependent variable must be significantly different from both zero and one.

5.5 Tests for Spatial Stability

The strategy adopted in this investigation assumes that the model parameters are constant over time in each region, but vary among the regions. Once the parameters are estimated for each region, it is of interest to determine whether they are relatively stable over space. This type of question can be answered using techniques of covariance analysis (Johnston, 1972).

The tests for regional differences will be made on an equation by equation basis in order that differences in particular processes can be ascertained.[1] To demonstrate the testing techniques, consider the general form of the equations in the farm employment model

$$Y_{it} = \sum_{k=1}^{K} X_{kit} \beta_{ki} + e_{it} \qquad 5.8$$

where: Y_{it} = value of dependent variable in region i (i = 1,...N) at time t (t = 1,...T);

X_{kit} = value of predetermined variable k (k = 1,...K) in region i at time t;[2]

β_{ki} = coefficient of variable k in region i;

e_{it} = disturbance term in region i at time t.

Regional differences in the relationships embodied in (5.8) might arise from three sources. Firstly, the intercepts (β_{1i}) may differ among the regions, but the 'slopes' or coefficients other than the intercept term are constant for all regions; that is

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[1] The tests described in this section are designed for single equation models. This author is unaware of comparable methods for testing for differences in parameters from multiple equation models. However, by testing for regional differences in each of the submodels in turn, the single equation procedures are applicable.

[2] X_{1it} takes the value 1 to allow for a single intercept.

$$\beta_{ki} = \beta_k \quad \text{for all } k \neq 1,$$

$$\beta_{11} \neq \beta_{12} \neq \ldots \neq \beta_{1i} .$$

Secondly, the coefficients other than the intercept term may differ among the regions, but the intercepts are invariant among the regions; that is

$$\beta_{1i} = \beta_1 \quad \text{for all } i,$$

$$\beta_{k1} \neq \beta_{k2} \neq \ldots \neq \beta_{ki} \quad \text{for all } k \neq 1.$$

Thirdly, the complete relationship, that is, ignoring the distinction between intercepts and slope coefficients and considering the relation as a whole, differs among the regions; that is

$$\beta_{k1} \neq \beta_{k2} \neq \ldots = \beta_{ki} \quad \text{for all } k \text{ and all } i.$$

Covariance analysis can be used to test for each of these kinds of differences among the regions. The appropriate tests are based on comparisons between pairs of three basic regressions. Firstly, pooling the time-series and regional data, regress the vector of Y's on the (K x NT) data matrix of X's consisting of a column of ones and the observations on the explanatory variables $X_2, \ldots X_k$

$$Y_{it} = \sum_{k=1}^{K} X_{kit} \hat{\beta}_k + e'_{it} . \qquad 5.9$$

This yields the estimated vector of coefficients $\hat{\beta}_k$ and the residual (unexplained) sum of squares

$$Q_1 = \sum_{it=1}^{NT} e'^{2}_{it} \quad . \tag{5.10}$$

The equation 5.9 says, in effect, that there are no significant regional differences in the relationship, and to consider each region separately has no relevance.

Secondly, using pooled data, regress the Y's on the partitioned ((N-1) x NT : K x NT) matrix of D_j's and X's, where the D_j's are regional dummies; that is, D_{jit} = 1 for region j, zero for all other regions i ≠ j

$$Y_{it} = \sum_{j=1}^{N-1} D_{jit} \hat{\alpha}_j + \sum_{k=1}^{K} X_{kit} \hat{\beta}_k + e''_{it} \quad . \tag{5.11}$$

This regression allows each region to have a different intercept ($\hat{\alpha}_j$), but imposes a common vector of slope coefficients ($\hat{\beta}_k$) on all regions. The residual sum of squares from this regression is denoted

$$Q_2 = \sum_{it=1}^{NT} e''^{2}_{it} \quad . \tag{5.12}$$

Thirdly, fit a regression to the data for each region (that is, 5.8) and sum the residual sum of squares over all regions to obtain Q_3

$$Y_{1t} = \sum_{k=1}^{K} X_{k1t} \hat{\beta}_{k1} + u_{1t}$$

$$Y_{2t} = \sum_{k=1}^{K} X_{k2t} \hat{\beta}_{k2} + u_{2t}$$

.
.
.

$$Y_{it} = \sum_{k=1}^{K} X_{kit} \hat{\beta}_{ki} + u_{it} \qquad 5.8$$

$$\vdots$$

$$Y_{Nt} = \sum_{k=1}^{K} X_{kNt} \hat{\beta}_{kN} + u_{Nt} \quad ,$$

$$Q_3 = \sum_{i=1}^{N} \sum_{t=1}^{T} u_{it}^2 \ . \qquad 5.13$$

The model (5.8) allows both the slope coefficients and the intercepts to vary from region to region.

The test for the homogeneity of the regressions (slopes and intercepts) between regions is then achieved by contrasting the reduction in the residual sum of squares from (5.9) to (5.8) with the residual from (5.8). This ratio, when corrected for degrees of freedom is known to be distributed as F (Johnston, 1972)

$$\frac{(Q_1 - Q_3) \ / \ K \ (N - 1)}{Q_3 \ / \ N \ (T - K)} = F_1 \ . \qquad 5.14$$

The degrees of freedom follow directly from the number of observations and the number of parameters used. This test amounts to asking if the least restricted model (5.8) gives a significant increase in the explained sum of squares over the highly restricted model (5.9). In other words, the test is to see if the reduction in the errors achieved by allowing the intercepts and slope coefficients to vary regionally is statistically significant.

The test for the homogeneity of the regional vectors of slope coefficients is based on the reduction in the residual sum of squares from (5.11) to (5.8), again contrasted with the residual from (5.8) and corrected for degrees of freedom

$$\frac{(Q_2 - Q_3) \;/\; (NK - N - K + 1)}{Q_3 \;/\; N\,(T - K)} = F_2 \;. \qquad 5.15$$

The test for differential intercepts is made by comparing the reduction in the residual sum of squares from (5.9) to (5.11) with the residual from (5.11), corrected for degrees of freedom

$$\frac{(Q_1 - Q_2) \;/\; (N - 1)}{Q_2 \;/\; (NT - N - K + 1)} = F_3 \;. \qquad 5.16$$

The principle of these tests may also be applied to test for the equality of any subset of coefficients over the N regions. The practical procedure is to fit the restricted model with the hypothetical equality imposed, all other coefficients being allowed to vary from region to region, and calculate the corresponding residual sum of squares. Then the unrestricted model is fitted in which this subset of coefficients is also allowed to vary from region to region, and the resultant residual sum of squares is calculated. The equality of the subsets is tested by contrasting the reduction in the residual sum of squares in going from the restricted to the unrestricted model against the unrestricted sum of squares.[1] These techniques apply directly for any number of regions so long as the number of observations in each region exceeds the number of parameters to be estimated. These tests are used in the statistical analysis to provide an indication of the presence and nature of regional differences in the relationships embodied in the farm labour employment model.

5.6 Test for Temporal Stability

The approach adopted in this analysis allows the parameters to vary among the regions, but assumes the relationships to be invariant over time within each region. It is of value to test for this assumption of temporal stability. Conceptually, an appropriate test might be based on a similar procedure to that described for testing for spatial stability; that is, the time point observations may be divided into several time intervals among which the parameters are allowed to vary for the unrestricted case. However, as with most tests requiring time-series data, the degrees of freedom are insufficient to yield reliable parameter estimates when the observations are grouped in this way.

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[1] The F tests described above are tests for the significance of groups of coefficients. Tests for stability in single coefficients may be achieved by reducing the subset of coefficients to one and following the same procedures, or alternatively by setting up the regressions in a slightly different way using slope dummies, and examining the appropriate standard errors (Johnston, 1972, p. 204).

In such cases where time-series data are limited, a test for temporal stability in relations may be made using a procedure described by Chow (1960) and Fischer (1970). The following discussion refers to individual equations within individual regions.

The test is based on the division of the T time-point observations into two groups or time intervals; the observations of the first time interval are denoted

$$t' = 1, 2, \ldots T'$$

where $T' > K$.

The remaining $(T-T')$ observations, where $(T-T') < K$, make up the second time interval. In essence, the procedure tests for differences in relationships from one time interval to another.

The appropriate test procedure for any region i involves the following steps. To the first T' observations, fit the regression

$$Y_{it'} = \sum_{k=1}^{K} X_{kit'} \hat{\beta}_{kiT'} + e_{it'} \qquad 5.17$$

where $\hat{\beta}_{kiT'}$ denotes the coefficient of the kth variable in the ith region for the T' time point observations.

The residual sum of squares from (5.17) is computed

$$Q_{4i} = \sum_{t'=1}^{T'} e_{it'}^{2} . \qquad 5.18$$

Then fit one regression to all T time point observations

$$Y_{it} = \sum_{k=1}^{K} X_{kit} \hat{\beta}_{ki} + e_{it} \qquad 5.8$$

and compute the residual sum of squares

$$Q_{3i} = \sum_{t=1}^{T} e_{it}^2 \; . \qquad 5.13$$

The test of the null hypothesis that in region i the (T-T') observations obey the same relation as the T' observations is given by

$$\frac{(Q_{3i} - Q_{4i}) \;/\; (T - T')}{Q_{4i} \;/\; (T' - K)} = F_{4i} \qquad 5.19$$

which is distributed as F with (T - T', T' - K) degrees of freedom.

This test requires identifying a subset of time-point observations (T-T'). In this case the years 1971 to 1973 are chosen, for two major reasons. Firstly, it is in these recent years that the values of the variables are most extreme, and thus may strongly influence the estimated relationships for the entire time period. Secondly, if the model is to be used for forecasting or planning, it is important that the relationships among the variables in the most recent time period are consistent with the relationships estimated for the entire time period. Thus, the tests for temporal stability are based upon separate regressions for the period 1946 to 1970 (5.17) and for the entire period 1946 to 1973 (5.8).

5.7 Summary

The theoretical model of farm employment change developed in Section 4.2 has been presented in a form that permits statistical estimation of the parameters. The bloc-recursive model is comprised of a single equation first bloc, which can be estimated using OLS, and a simultaneous, three-equation second bloc, for which 2SLS is the appropriate testing technique. A distributed lag specification of the basic model is introduced in order to determine the speed of adjustment by each of the farm labour components to changes in the predetermined variables, and procedures are described which permit testing the hypotheses that the parameters vary significantly among the regions, but are relatively stable over time within each region.

CHAPTER 6

STATISTICAL RESULTS

The results of the empirical estimation of the equations in the agricultural employment model are presented in this chapter. Although the focus of this study is on the regional differences in the parameter estimates, the model is tested firstly at the national level, using the procedures described in the previous chapter. The statistical results from both the static and distributed lag formulations of the basic model are presented. The estimation of the employment functions for Canada as a whole will permit comparisons with other national level studies. The regional analysis which follows presents the regional level results for each relation in the model in turn. The statistics reported include results from tests for overall model fit, the parameter estimates for each region from both the static and distributed lag specifications, and the results from the covariance tests for regional differences and temporal stability in the estimated relations. The implications of the statistical results are considered in Chapter 7.

It should be pointed out that the reliability of the statistical estimates varies among the regions due to the nature of the regional data. Specifically, the numbers of hired and unpaid family workers in British Columbia and the Atlantic region, especially in recent years, are relatively small, and subject to considerable rounding error. As a consequence, the empirical estimates of the equations pertaining to these components in British Columbia and the Atlantic region are viewed with caution, and the results focus on those relations and regions where this problem does not exist. This difficulty points up a paradox inherent in studies like this one; namely, that while disaggregation, both structural and spatial, is theoretically appealing and should provide more consistent and more readily interpretable results, this very disaggregation reduces the numbers in each of the disaggregated groups and thus invites data problems and difficulties with statistical estimation.

6.1 National Level Results

In general, the statistical results from the model application to the national level data are encouraging. The operator equation R^2 is high, as are those associated with the reduced form equations from the second bloc, with the exception of the hired labour relation (Table 6.1). The reduced form R^2s provide a measure of the overall goodness-of-fit of simultaneous-equations models, and indicate the extent to which the model can predict values of endogenous variables from the

TABLE 6.1

REDUCED FORM R^2s FOR FARM EMPLOYMENT MODEL (STATIC),

1946 TO 1973, CANADA

Reduced Form Equation (OLS)	R^2
Operator Employment	.991
Unpaid Family Employment	.956
Hired Labour Employment	.742
Farm Wage Rate	.966

exogenous variables alone. All the reduced form R^2s are statistically significant at the one percent level. These results on the reduced form indicate that the model would perform particularly well as a predictive model for the operator and unpaid family components, but would provide less accurate predictions of hired labour employment on farms in Canada.[1] The high R^2 associated with the farm wage rate reduced form equation is especially heartening, since it indicates that the estimate $\hat{w}$, used in the second stage of 2SLS, closely resembles the original w.

The estimates of the structural parameters are given in Table 6.2. A disappointing aspect of the results is the lack of statistical significance among several of the regression coefficients. The high intercorrelations among some of the predetermined variables, largely due to a common trend element, has likely reduced the precision of the estimates of the structural parameters, and may account for the nonsignificant coefficients.[2]

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[1] Basmann (1962) has shown that small magnitudes of R^2 for OLS-estimated reduced form equations ought not to be interpreted as due to a failure to include some additional relevant exogenous variable(s) in the model. Thus, the relatively low (but significant) R^2 associated with the hired labour reduced form equation does not necessarily imply a poorly specified submodel.

[2] Rather than arbitrarily dropping variables from the analysis, and thus inviting mis-specification of the model, it is simply recognised that these intercorrelations may result in particular variables picking up the effect of others and thus lead to some nonsignificant coefficients.

TABLE 6.2

ESTIMATES[a] OF STRUCTURAL RELATIONS FOR FARM EMPLOYMENT MODEL (STATIC), 1946 TO 1973, CANADA

							R^{2} [b]	d [c]
Operator Employment (equation 5.1, OLS estimates)								
	constant	adj. nonfarm wage (n')	parity ratio (r)	technology (T)				
	12.51	-.985** (.132)	-.104 (.066)	-.367** (.081)			.991	1.38†
Unpaid Family Employment (equation 5.2, 2SLS estimates)								
	constant	operators (S)	adj. nonfarm wage (n')	farm product price (p)	machinery cost (c)	farm wage ($\hat{w}$)		
	6.70	.429 (.734)	-1.847** (.491)	.014 (.168)	-.642 (.601)	1.279* (.736)	.971	1.55†
Hired Labour Demand (equation 5.3, 2SLS estimates)								
	constant	operators (S)	adj. nonfarm wage (n')	farm product price (p)	machinery cost (c)	farm wage ($\hat{w}$)		
	-34.05	2.503* (.954)	.078 (.631)	.081 (.126)	1.769* (.772)	1.803* (.850)	.763	1.59†
Hired Labour Supply (equation 5.4, 2SLS estimates)								
	constant	adj. nonfarm wage (n')	farm wage ($\hat{w}$)	nonmetrop. labour force (L)				
	9.401	-1.141** (.233)	.613** (.197)	-.373* (.177)			.782	1.55†

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Footnotes to Tables 6.2 and 6.3

[a] Standard deviations of regression coefficients are given in brackets:

** denotes coefficient statistically significant at 1 percent level,

* denotes coefficient statistically significant at 10 percent level.

[b] R^2s serve only as approximate indicators of goodness of fit in 2SLS - estimated equations (see Basmann, 1962).

[c] d is the Durbin-Watson statistic for serial correlation among the calculated residuals:

†† denotes presence of positive serial correlation,

† denotes an inconclusive test,

no asterisk indicates absence of serial correlation.

The Durbin-Watson test for serial correlation in the residuals from the four estimated equations yields an inconclusive result in each case, providing no evidence for either the existence or the absence of serial correlation.

In the operator employment equation, the coefficients of the nonfarm wage variable (n) and the technological change variable (T) have the expected negative sign and are significant at the one percent level. The results imply that the number of farm operators declines as the income and employment prospects in the nonfarm sector improve and as the effects of technological change are experienced in agriculture, *ceteris paribus*. The expected positive relationship between the number of farm operators employed and the relative price of farm products (r) is not found. It would appear that the decisions of farm operators to stay in agriculture or to leave the industry have been influenced by changes in technology and changes in the income prospects in the nonfarm sector, but have been little affected by changes in the relative earnings of agricultural produce.

The results for the unpaid family employment relation also provide some support for the underlying theory. The hypothesized recursive relationship between the number of unpaid family workers employed in agriculture and the number of farm operators (S) is supported by the data to the extent that the sign of the coefficient is positive. The negative and statistically significant relationship between unpaid family employment and the nonfarm wage rate (n) supports the hypothesis that the unpaid family workforce in agriculture declines in periods when nonfarm employment and income opportunities are favourable, *ceteris paribus.* The positive relationship between unpaid family employment and the farm wage rate ($\hat{w}$), representing the price of the labour alternative on farms, is also statistically significant, supporting the notion that increases in the price of hired farm labour result in increases in the utilization of unpaid family labour, *ceteris paribus.* The coefficients of the farm products price variable (p) and the farm machinery cost variable (c) are not statistically significant.

The results for the hired labour demand relation provide only modest support for the theory. The hypothesized recursive relationship between the number of farm operators (S) and the demand for hired farm workers is statistically significant, which supports the hypothesis that as the number of farm operators increases (or decreases), so does the demand for hired farm labour increase (or decrease), *ceteris paribus.* The statistically significant positive coefficient on the machinery price variable (c) is consistent with the hypothesis that farm operators demand more hired labour when the cost of mechanical substitutes is high, *ceteris paribus.* However, a positive coefficient on the farm wage variable ($\hat{w}$) implies increases in demand with increases in price. This result is inconsistent with the theory and likely reflects the strong empirical relationship between hired labour supply and the farm wage rate.[1] The nonfarm wage (n), representing the opportunity cost of unpaid family labour, and the price of farm products (p) seem to have little influence on the demand for hired farm workers.

In the hired labour supply relation, the coefficients of the farm wage rate variable ($\hat{w}$) and the nonfarm wage variable (n) have the expected positive and negative signs respectively, and both are statistically significant at the one percent level. These results support the hypothesis that the supply of hired workers to agriculture expands with increases in the farm wage rate but contracts when nonfarm employment and earnings prospects are favourable, *ceteris paribus*. The negative coefficient associated with the nonmetropolitan labour force variable (L) would suggest that this measure is not a good indicator of the potential suppliers of hired labour to agriculture. The tendency for the supply of hired farm workers to decrease as the nonmetropolitan labour force increases, even after the effects of farm and nonfarm wages have been taken into account, would imply that a decreasing proportion of the nonmetropolitan workforce considers farm labour as an employment possibility.

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[1] The measure of hired farm employment (annual average of monthly estimates of the number of people working in agriculture) is particularly appropriate for labour supply relations, but is less suited to the demand concept, since it does not take into account changes in the nature of the hired farm workforce, such as hours of work, degree of skill, and nature of tasks. It should also be pointed out that while this theoretically inconsistent result is disturbing, it tends to lose significance in the regional analyses.

The distributed lag model yields results similar to the static model (Table 6.3). As would be expected with the inclusion of lagged dependent variables, the R^2s tend to be a little higher and the Durbin-Watson test indicates an absence of serial correlation in all equations. In general, the results from the distributed lag model reflect the static model results, but the magnitude of the regression coefficients and their levels of statistical significance decline with the inclusion of the lagged dependent variable. The coefficients of the lagged dependent variables are positive and statistically significant in all equations except the hired labour demand relation. When ten percent confidence intervals are set for this coefficient, it is found that the coefficient is significantly less than one in all equations. The adjustment coefficients indicate that the family labour components (operators and unpaid family) are relatively slow in adjusting to changes in economic conditions, whereas hired farm workers respond more rapidly to changes in the economic environment.

6.1.1 Evaluation of National Level Results

Overall, the model performs reasonably well when applied to the national level data. Although a number of coefficients are not statistically significant, particularly in the distributed lag specification, the main hypothesized relationships are supported by the results, and the significant R^2s attest to the

TABLE 6.3

ESTIMATES[a] OF STRUCTURAL RELATIONS FOR FARM EMPLOYMENT MODEL (DISTRIBUTED LAG), 1946 TO 1973, CANADA

								R^2 [b]	d [c]
Operator Employment (equation 5.1 d.l., OLS estimates)									
constant	n'	r	T	S_{t-1}	adjustment coefficient				
5.240	-.362*	-.004	-.255**	.552**	.448			.994	2.09
	(.195)	(.057)	(.070)	(.136)					
Unpaid Family Employment (equation 5.2 d.l., 2SLS estimates)									
constant	S	n'	p	c	$\hat{w}$	F_{t-1}	adjustment coefficient		
-12.66	1.135	-.813	-.024	.650	.176	.582**	.418	.981	2.16
	(.801)	(.649)	(.141)	(.522)	(.109)	(.213)			
Hired Labour Demand (equation 5.3 d.l., 2SLS estimates)									
constant	S	n'	p	c	$\hat{w}$	H_{t-1}	adjustment coefficient		
-21.09	1.774*	.022	.064	1.089	1.880*	.264	.736	.701	1.61
	(.936)	(.488)	(.171)	(.732)	(.990)	(.216)			
Hired Labour Supply (equation 5.4 d.l., 2SLS estimates)									
constant	n'	$\hat{w}$	L	H^*_{t-1}	adjustment coefficient				
6.662	-.624*	.269	-.242	.263*	.737			.683	1.72
	(.342)	(.264)	(.190)	(.143)					

Footnotes on page 130.

overall adequacy of the model. The performance of the family labour equations and the support for the hypothesized interdependencies among the components of the farm workforce are particularly encouraging. Unpaid family employment and the demand for hired labour are shown to be positively related to the number of farm operators, and evidence for the interdependence between unpaid family labour and the hired component is given in the positive relationship between unpaid family employment and the cost of hiring farm labour.

It is difficult to compare these results with those from other studies because of differences in the underlying models, the measures used, the methods of estimation, and the countries and time periods to which the data refer. However, some cursory comparisons between the results from this analysis and those from two others follow.

The study of Tyrchniewicz and Schuh (1969) is one of the few that disaggregates the farm workforce into three components and considers interdependencies among these. The Tyrchniewicz model, when applied to United States data for the period 1929 to 1961, performs well in that the R^2s are all high and only a few of the regression coefficients are not statistically significant. For the farm operator component, both the Tyrchniewicz study and this study point up the importance of nonfarm income and employment opportunities. However, the Tyrchniewicz estimates of the coefficient of adjustment for farm operators are negative, implying an over-adjustment on the part of farm operators to changing economic conditions, whereas this study suggests that Canadian farm operators react cautiously to economic shifts.

The Tyrchniewicz study does not test for the recursive relationship between unpaid family workers and farm operators, but it does find an interdependence between the demand for unpaid family labour and the number of hired workers employed. The negative coefficient implies that these two components tend to act as substitutes, a finding which is consistent with the positive relationship between unpaid family employment and the price of hired workers found in this study. This relationship implies that when the cost of hiring labour increases farm families employ more of their own 'unpaid' labour. Relatively small coefficients of adjustment for unpaid family workers are yielded in both analyses.

In the hired labour demand equation, Tyrchniewicz reports a negative coefficient on the farm operator variable, implying an increase in hired labour as the number of operators declines. This tendency for substitution between operators and hired workers is not found in this study, where the demand for hired labour is positively related to the number of operators. This difference is likely due to differences in the organization of farming between the two countries. A positive relationship is expected where owner-operator units are the predominant form of farming operation, as in Canada, and the substitution effect would be expected where corporate farming is more common, as in the United States. Also in contrast with this study, Tyrchniewicz finds a theoretically consistent negative relationship between hired labour demand and the farm wage rate. Since Tyrchniewicz's hired demand relation and his empirical measure of hired labour are similar to those used in this study, the constrasting results suggest some peculiarity in this segment of the Canadian farm labour market.

The results from the hired labour supply relations are similar in the two investigations. Farm workers are shown to respond to both farm and nonfarm wages in the expected manner and the adjustment by hired workers is more rapid than that for unpaid family workers.

It should be pointed out that statistically significant results from United States national level data are not restricted to the Tyrchniewicz model. Highly aggregate mobility models such as Sjaastad (1961) and Bishop (1961) yield significant and usually theoretically consistent results when applied to United States' data. The disaggregated econometric models of Schuh (1962) and Johnson (1961) also produce convincing statistical estimates.

However, similar models applied to Canadian data have yielded less satisfactory results. Yeh and Li (1966) have estimated a partly disaggregated model of the farm labour market at the national level for Canada, using data for the period 1946 to 1962. Yeh and Li group operators and unpaid family workers into a single category, and the question of interdependencies between the components of the farm workforce is not addressed. In these respects their study resembles that of Johnson (1961), although they use OLS to estimate the equations.

However, the statistical results of Yeh and Li are disappointing. Although the R^2s for the family labour component are high, those for the hired labour component are low, and very few of the regression coefficients are statistically significant. The only significant coefficients in the family labour equations are those associated with the lagged dependent variable and none of the coefficients are statistically significant at the ten percent level in the hired labour equations. In light of these results, those derived in this study are considered particularly satisfying. However, the improvement in model performance cannot be attributed entirely to the differences in the model specification; this study has eleven additional observations, a difference which can often account for slight improvements in levels of significance in regression coefficients. Certainly, there are some similarities in the results of the two studies. It is noteworthy that Yeh and Li's analysis of hired labour demand (using hired labour data similar to that employed in this study) also yielded a theoretically inconsistent sign on the wage rate variable. Hired farm labour supply was shown in both analyses to be positively related to the farm wage rate and negatively related to a measure of the nonfarm wage rate adjusted for the level of unemployment. Both studies also found the rate of adjustment to changes in economic conditions to be relatively slow for family labour, but much faster for hired farm labour.

Besides providing quantitative estimates of employment functions for three types of farm labour, the empirical analysis provides a test of a body of theory on farm labour employment. The premise that the employment of different types of labour is determined by different, though related, processes is tested in the empirical analysis. The general employment model set forth is quite successful in this study. With few exceptions (notably the wage rate in hired labour demand), the signs of the coefficients are consistent with the theory underlying the model.

6.2 Regional Level Results

In addition to estimating the employment functions for Canada as a whole, the model is estimated for each of the five regions of Canada. Although the regional data are still highly aggregated, the regional analysis does present the response to the important variables on a less aggregated scale than that presented nationally. In addition, the regional analysis permits the consideration of regional differences in the forces which influence the employment of the three types of farm labour.

In general, the regional level results are satisfactory. In all regions, the R^2s for the reduced form relations are high and statistically significant, with the exception of the hired labour reduced form in Quebec, British Columbia and the Atlantic regions (Table 6.4). The reduced form R^2s indicate that the model provides accurate predictions for the operator and unpaid family labour components in all regions, but is limited as a predictor of hired farm labour employment. The model yields particularly inadequate predictions of hired labour employment in the Atlantic region, Quebec, and British Columbia. However, in all regions, the reduced form R^2s are high for the farm wage rate equation, indicating that the estimates $\hat{w}$, used in the second stage of the 2SLS procedure, are closely proportional to the actual w, a feature which improves the reliability of the structural parameter estimates.

The regional level statistical estimates of the structural parameters of the model are presented equation by equation.

6.2.1 Farm Operator Employment

The statistical results for the farm operator relation (static) are given in Table 6.5. Before examining individual structural parameter estimates, it is useful to determine whether significant regional differences are apparent in the performance of the submodel.[1] The covariance test for differences in the

[1] The covariance tests for regional and temporal stability in estimated relations are outlined in Section 5.5, and the test results are reported in Table 6.5.

TABLE 6.4

REDUCED FORM R^2s FOR FARM EMPLOYMENT MODEL

(STATIC), 1946 TO 1973, CANADA AND REGIONS

Reduced Form Equation (OLS)	Canada	Atlantic	Quebec	Ontario	Prairies	B.C.
Operator Employment	.991	.964	.981	.980	.978	.861
Unpaid Family Employment	.956	.959	.952	.890	.944	.626
Hired Labour Employment	.743	.476	.261	.798	.608	.154
Farm Wage Rate	.966	.897	.903	.957	.965	.937

TABLE 6.5

STATISTICAL RESULTS FOR FARM OPERATOR EMPLOYMENT EQUATION

(5.1, STATIC), 1946 TO 1973, CANADA AND REGIONS

OLS estimates[a]	Canada	Atlantic	Quebec	Ontario	Prairies	B.C.
adjusted nonfarm wage (n')	-.985** (.132)	-1.384** (.361)	-1.487** (.106)	-.513* (.226)	-1.034** (.073)	-.554** (.190)
parity ratio (r)	-.104 (.066)	-.078 (.145)	.114 (.119)	.271* (.152)	-.033 (.050)	-1.485** (.285)
technology (T)	-.367** (.081)	-.476** (.152)	-.108 (.148)	-.930** (.173)	-.098* (.054)	-1.113** (.197)
constant	12.51	11.55	10.66	10.16	10.36	17.27
R^2 [b]	.991	.964	.981	.980	.978	.861
d[c]	1.38†	1.15†	1.69†	1.12†	1.77†	1.82†
Tests for Regional and Temporal Stability[d]:						
RSS all years (Q_{3i})		.261	.069	.071	.032	.233
RSS 1946-1970 (Q_{4i})		.214	.063	.062	.028	.211
F_{4i} (3,22)		1.62	.69	1.07	1.00	.76

Pooled regions RSS (Q_1) = 134.4
Pooled regions, differential intercepts RSS (Q_2) = 1.868
Sum of regional RSS (Q_3) = 0.666
F_1 (12,125) = 2220**
F_2 (8,125) = 28.33**
F_3 (4,133) = 2366**

Footnotes on page 144.

Footnotes to Tables 6.5 - 6.12

[a] Standard deviations of regression coefficients are given in brackets:
** denotes coefficient statistically significant at 1 percent level,
* denotes coefficient statistically significant at 10 percent level.

[b] R^2s serve only as approximate indicators of goodness of fit in 2SLS - estimated equations (see Basmann, 1962).

[c] c is the Durbin-Watson statistic for serial correlation among the calculated residuals:
†† denotes presence of positive serial correlation
† denotes an inconclusive test,
no asterisk indicates absence of serial correlation.

[d] Q_{3i} is the residual sum of squares for region i when all years are included (see section 5.6).
Q_{4i} is the residual sum of squares for region i when years 1946 to 1970 are included (see section 5.6).
F_{4i} is the F value which tests for temporal stability in the relation in region i (see section 5.6):
** denotes significant temporal differences at 1 percent level,
* denotes significant temporal differences at 5 percent level.
Q_1 is the residual sum of squares from the regression in which the regional and time-series data are pooled (see section 5.5).
Q_2 is the residual sum of squares from the regression in which the regional and time-series data are pooled, but regions have different intercepts (see section 5.5).
Q_3 is the sum of the regional residual sums of squares (Q_{3i}).
$F_{1,2,3}$ represent F values for tests for regional differences in the estimated relationships. F_1 represents the test for differential slopes and intercepts;
F_2 represents the test for differential slopes; F_3 represents the test for differential intercepts (see section 5.5):
** denotes significant regional differences at 1 percent level,
* denotes significant regional differences at 5 percent level.

complete relation (F_1) demonstrates that significant differences in the operator employment function do exist among the regions. The covariance tests for differences in slope coefficients (F_2) and intercepts (F_3) indicate that differences are due both to scale factors, picked up in the constant terms, and to differences in the responses to exogenous forces, as measured by the regression coefficients. In other words, considerable differences in the numbers of farm operators exist among the regions (as is readily apparent), and the effects of the variables which influence changes in these numbers also appear to differ from region to region.

The covariance tests for temporal stability in the relations (F_{4i}) indicate that, for all regions, the estimated farm operator employment relationships do not vary significantly over time. Specifically, the tests indicate that the relationships are not significantly changed by the omission of the 1971 and 1973 observations, implying that the operator employment relationships in recent years are consistent with the relationships estimated for the entire period.

In all regions, the hypothesized negative relationship between operator employment and the adjusted nonfarm wage rate (n) is statistically significant. The numbers of farm operators decline with increases in nonfarm wages and alternative employment prospects, *ceteris paribus*. This result implies that in all regions farmers tend to leave the industry, or fewer new farm operators enter the industry, in periods when job opportunities and income prospects in the nonfarm sector are favourable. This influence of nonfarm income opportunities on operator employment is especially important in Quebec and the Atlantic provinces, and is less pronounced in Ontario.

The effect of technological change in agriculture on the number of farm operators is also similar among the regions. The hypothesized negative association between the technology variable and operator employment is found in all regions, although the coefficient is not statistically significant in Quebec. The trend toward larger farms as technological developments are adopted in agriculture results in a displacement of farm operators, *ceteris paribus*, either as farms become amalgamated or as marginal operations are abandoned. The response of farm operators to these effects of technological change in agriculture is greatest in Ontario and British Columbia.

Changes in the relative profitability of farming, as measured by the parity ratio, seem to have little influence on operator employment in most regions. The direction of the relationship varies among the regions, and, with the exception of British Columbia, the coefficients are small. Only in Ontario does a statistically significant and theoretically consistent coefficient emerge, supporting the hypothesis that, *ceteris paribus*, farmers tend to remain in agriculture in periods when the prices received for farm products are favourable relative to the cost of items required for agricultural production. There is little support for this hypothesis in other regions, however. In fact, the results for several provinces indicate that the number of farm operators declines in periods when farm prices are relatively high. This result might arise in situations where farm consolidation and amalgamation are important processes influencing changes in farm operator numbers, and where decisions to absorb another farm or enlarge an operation tend to be made when the relative prices of farm products are high and agriculture's economic prospects appear favourable. In general, however, the influence of farm prices on operator employment would seem to be less important than technological changes and nonfarm income and employment opportunities.

The regional level results for the distributed lag specification of the operator submodel are presented in Table 6.6. The results are remarkably consistent with those from the static formulation, supporting the conclusions reached therein and attesting to the stability of the underlying model. The coefficient for the lagged dependent variable is significantly different from both zero and one in all regions except British Columbia. The coefficient of adjustment is smaller in the Atlantic, Quebec, and Prairie regions than in Ontario, indicating a more rapid adjustment to changes in technology and economic

TABLE 6.6

STATISTICAL RESULTS FOR FARM OPERATOR EMPLOYMENT EQUATION

(5.1, DISTRIBUTED LAG), 1946 TO 1973, CANADA AND REGIONS

	Canada	Atlantic	Quebec	Ontario	Prairies	B.C.
OLS estimates[a]:						
adjusted nonfarm wage (n')	-.362** (.195)	-.750* (.361)	-.982* (.334)	-.246 (.235)	-.466* (.193)	-.561* (.204)
parity ratio (r)	-.004 (.057)	-.082 (.127)	.069 (.121)	.245* (.134)	-.016 (.045)	-1.429** (.316)
technology (T)	-.255** (.070)	-.252* (.142)	-.182 (.157)	-.851** (.201)	-.087* (.048)	-1.156** (.215)
farm operators lagged (S_{t-1})	.552** (.136)	.509** (.164)	.403* (.203)	.287* (.143)	.522** (.167)	-.058 (.142)
adjustment coefficient	.448	.491	.597	.713	.478	-
constant	5.240	6.076	7.725	6.724	5.025	17.40
R^2 [b]	.994	.975	.981	.983	.982	.876
d[c]	2.09	1.97	2.02	1.47†	2.51	1.90

Footnotes on page 144.

conditions by Ontario farmers.

Overall, the results for the operator component support the underlying model, and demonstrate that, despite substantial regional differences in the structure and organisation of farming, the basic determinants of operator employment and the responses to these forces are relatively consistent among the regions.

6.2.2 Unpaid Family Labour Employment

The empirical estimates of the unpaid family relation (static) at the regional level are given in Table 6.7. The covariance tests indicate significant regional differences in the results for the submodel. The regional variation is apparent for both the intercept terms and the vector of slope coefficients in the relation, signifying significant regional differences not only in the numbers of unpaid family workers employed in agriculture, but also in the nature of responses in unpaid family employment to changes in the predetermined variables. The estimated unpaid family employment relations are stable over time in all regions except the Prairies. The test for the Prairie region indicates that the omission of the 1971 to 1973 observations results in a change in the overall fit of the equation that is significant at the 5 percent level. This result demonstrates that the estimated unpaid family employment relationships are influenced by recent trends more in the Prairies than in the other regions.

TABLE 6.7

STATISTICAL RESULTS FOR UNPAID FAMILY EMPLOYMENT EQUATION

(5.2, STATIC), 1946 TO 1973, CANADA AND REGIONS

	Canada	Atlantic	Quebec	Ontario	Prairies	B.C.
2SLS estimates[a]:						
farm operators (S)	.429	1.909*	.964*	1.778*	3.929**	1.779**
	(.734)	(.929)	(.478)	(.757)	(1.249)	(.445)
adjusted nonfarm wage (n')	-1.847**	5.296	-.249	-1.860**	-1.941*	.256
	(.491)	(6.555)	(.646)	(.613)	(1.134)	(3.545)
farm product prices (p)	.014	.303	-.226	-.308	-.014	3.729**
	(.168)	(.557)	(.344)	(.440)	(.389)	(1.202)
farm machinery prices (c)	-.642	-3.152	-1.067	1.179	1.094	-1.768
	(.601)	(2.795)	(.761)	(1.129)	(.984)	(1.305)
farm wage rate ($\hat{w}$)	1.279*	-3.275	.982*	2.842**	4.489*	2.860
	(.736)	(3.917)	(.576)	(.671)	(1.786)	(3.997)
constant	6.700	3.397	3.225	-15.31	-40.07	-29.63
R^2 [b]	.970	.957	.952	.901	.898	.742
d[c]	1.55†	1.38†	1.23†	1.16†	1.30†	1.74
Tests for Regional and Temporal Stability[d]:						
RSS all years (Q_{3i})		.613	.259	.309	.297	1.641
RSS 1946-1970 (Q_{4i})		.554	.187	.214	.097	1.292
F_{4i} (3,20)		.67	2.55	2.96	13.95*	1.80

Pooled regions RSS (Q_1) = 21.43
Pooled regions, differential intercepts RSS (Q_2) = 11.86
Sum of regional RSS (Q_3) = 3.119
F_1 (20,115) = 33.78**
F_2 (16,115) = 20.14**
F_3 (4,131) = 26.59**

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Although the hypothesized recursive relationship between unpaid family employment and the number of farm operators was supported only weakly at the national level, the hypothesized interdependence is given strong statistical support at the regional level. In all regions, the positive relationship between unpaid family and operator numbers is statistically significant. The relatively large coefficient in the Prairie region indicates a proportionally greater decline in unpaid family employment with a given decrease in the number of farm operators in the Prairies than in other regions, *ceteris paribus*. This result might be interpreted as reflecting the relatively larger size of farm families in the Prairies. However, large families are also characteristic of farms in Quebec, and the coefficient for Quebec is the smallest of all regions. This result might follow from regional differences in farm production functions, such as if the respective marginal productivities of family labour are such that family members in Quebec leave agriculture at lower levels of return than in the Prairies. The result would also follow if those farmers who leave agriculture in the Prairies tended to have several unpaid family members assisting on the farm, whereas those in Quebec who sellout usually had only small amounts of unpaid family labour. Such interpretations are consistent with the tendency for farms in Quebec to be small (and often uneconomic) in comparison with those of the Prairies.

Unpaid family employment decreases in periods when non-farm income and employment opportunities are favourable, *ceteris paribus*, in Quebec, Ontario and the Prairie provinces, although the relationship is statistically significant only in Ontario and the Prairies. The responses of unpaid family workers to changes in the adjusted nonfarm wage rate variable in these two regions reflect the national level result. Positive, but not statistically significant, coefficients on this variable are found in the Atlantic region and British Columbia.

The prices of farm products and farm machinery seem to have little effect on the employment levels of unpaid family workers in all regions, although the coefficient on farm product prices is significant in British Columbia.

However, changes in the farm wage rate, measuring the cost of hired farm labour, do seem to have a significant effect on unpaid family employment in Quebec, Ontario, and the Prairie region. The positive and statistically significant coefficients in these regions imply that unpaid family labour tends to substitute for hired labour in periods when the cost of hired labour is high relative to other costs and prices. Apparently, this substitution between different types of labour on farms does not occur in the Atlantic provinces.

The distributed lag specification of the unpaid family employment relation yields results that are consistent with the static formulation results (Table 6.8). The inclusion of the

TABLE 6.8

STATISTICAL RESULTS FOR UNPAID FAMILY EMPLOYMENT EQUATION

(5.2, DISTRIBUTED LAG), 1946 TO 1973, CANADA AND REGIONS

	Canada	Atlantic	Quebec	Ontario	Prairies	B.C.
2SLS estimates[a]:						
farm operators (S)	1.135 (.801)	1.667* (.750)	1.258* (.523)	2.110* (1.156)	2.745** (.951)	1.851** (.394)
adjust nonfarm wage (n')	-.813 (.649)	6.642 (5.437)	-.435 (.726)	-2.553* (1.415)	-.108 (.776)	-1.362 (1.985)
farm product prices (p)	-.024 (.141)	.402 (.558)	-.368 (.390)	-.769 (.745)	-.043 (.235)	3.319** (1.168)
farm machinery prices (c)	.650 (.522)	-3.258 (2.236)	-.220 (.939)	1.078 (1.197)	.789 (.550)	-1.362 (1.472)
farm wage rate ($\hat{w}$)	.176 (.109)	-4.260 (3.377)	1.643 (1.088)	3.722** (1.857)	2.522** (1.123)	4.559* (2.282)
unpaid family employment lagged (F_{t-1})	.582** (.213)	.332 (.321)	.455* (.201)	.032 (.319)	.534** (.149)	.102 (.158)
adjustment coefficient	.418	.668	.545	.968	.466	.898
constant	-12.66	3.020	-9.611	-15.31	-29.31	-31.84
R^2[b]	.981	.954	.963	.915	.937	.754
d[c]	2.16	1.53†	1.64	1.86	1.79	1.83

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lagged dependent variable tends to reduce levels of significance of the coefficients on the other predetermined variables, but the directions of the relationships and the regional differences in the effects of particular variables remain essentially the same. As expected, the inclusion of the lagged dependent variable also increases the R^2 and ensures the removal of any serial correlation effects that may have existed in the static form residuals.

The coefficient associated with the lagged dependent variable is significantly different from zero only in Quebec and the Prairie region. These results, and the associated adjustment coefficients, indicate that employment of unpaid family labour on farms responds quite slowly in Quebec and the Prairies to the combined effects of changes in the predetermined variables, whereas the response to these changes is more rapid in the other regions of Canada. This finding is consistent with that from the operator results, which indicate that Ontario farmers, in particular, tend to adjust to changes in technology and economic conditions more rapidly than farmers in Quebec and the Prairie provinces.

The premises underlying the unpaid family labour submodel are given more support in the Quebec, Ontario and Prairie regions than they are in the Atlantic region and British Columbia. The hypothesized recursive relationship between the number of unpaid

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family workers and the number of farm operators is supported in all regions under both the static and the distributed lag specifications. Apart from this aspect, the sub-model does not perform well in the Atlantic provinces and British Columbia. In the Atlantic regions, no other relationship is statistically significant in either formulation of the submodel, and several of the coefficients, notably those on the farm and non-farm wage variables, have signs opposite to those hypothesized. The results for British Columbia are more in accord with the underlying theory, but as with the Atlantic region, there are notable inconsistencies between the static and the distributed lag results, indicating a lack of stability in the estimated parameters in those regions.

On the other hand, the results for Quebec, Ontario, and the Prairies are particularly encouraging. In each case, the empirical analysis supports the hypothesized relationships between unpaid family employment and the number of farm operators, the cost of hired farm labour, and the wage levels and availability of jobs in the nonfarm sector. The high degree of consistency between the static and the distributed lag specifications indicates that the estimated relationships are relatively stable and not greatly influenced by minor differences in model specification.

6.2.3 Hired Labour Demand

The statistical results at the regional level for the hired farm labour demand relation are presented in Table 6.9. Regional differences in the empirical estimates, both slopes and intercepts, are shown to be statistically significant by the co-variance tests, and the estimated relationships are shown to be temporally stable in all regions. However, the statistical results provide minimal support for the underlying theory of hired labour demand. Theoretically inconsistent and statistically nonsignificant coefficients are yielded in all regions, and the overall fit of the submodel to the data is poor in most regions.

One encouraging result is the general support for the postulated interdependence between the demand for hired workers in agriculture and the number of farm operators. The hypothesized recursive relationship between hired labour demand and the number of farm operators is statistically significant only in Ontario, although positive coefficients are found for all regions except British Columbia. This result indicates that, in Ontario especially, as farm operator numbers decrease, so too does the demand for hired labour in agriculture, *ceteris paribus*. The alternative hypothesis, that declines in farm numbers might result in increases in hired labour demand because of increases in mean farm size, is not supported in this analysis, although the small and statistically nonsignificant coefficients in several of

TABLE 6.9

STATISTICAL RESULTS FOR HIRED LABOUR DEMAND EQUATION

(5.3, STATIC), 1946 TO 1973, CANADA AND REGIONS

	Canada	Atlantic	Quebec	Ontario	Prairies	B.C.
2SLS estimates[a]:						
farm operators (S)	2.503*	.115	.076	1.030**	1.018	-.021
	(.954)	(.655)	(.641)	(.427)	(.982)	(.582)
adjusted nonfarm wage (n')	.078	-2.091	-1.942	-.005	-.632	2.682
	(.631)	(4.324)	(.875)	(.359)	(.826)	(4.635)
farm product prices (p)	.081	-.132	-.032	-.636*	-.144	.112
	(.126)	(.367)	(.466)	(.275)	(.281)	(1.057)
farm machinery prices (c)	1.769*	1.873	1.755*	.190	.071	-.988
	(.772)	(1.484)	(.923)	(.704)	(.710)	(1.705)
farm wage rate ($\hat{w}$)	1.803*	1.034	2.091*	.738	1.489	-2.210
	(.850)	(2.584)	(1.066)	(.419)	(1.289)	(5.255)
constant	-34.05	-4.169	-6.812	-3.350	-7.307	6.126
R^2[b]	.764	.469	.463	.781	.685	.424
d[c]	1.59†	1.76	1.68	1.59†	1.80	1.44†

Tests for Regional and Temporal Stability[d]:

	Atlantic	Quebec	Ontario	Prairies	B.C.
RSS all years (Q_{3i})	.434	.454	.151	.266	1.012
RSS 1946-1970 (Q_{4i})	.383	.387	.111	.224	.999
F_{4i} (3,20)	.88	1.15	2.37	1.25	.09

Pooled regions RSS (Q_1) = 8.717

Pooled regions, differential intercepts RSS (Q_2) = 4.159

Sum of regional RSS (Q_3) = 2.316

F_1 (20,115) = 16.00**

F_2 (16,115) = 5.726**

F_3 (4,131) = 17.97**

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the regions might follow from the joint effects of both of these processes.

The coefficient on the price of machinery variable is positive in all regions bar British Columbia, and is statistically significant in Quebec, thus providing some support for the hypothesis that farm operators tend to demand more hired labour in periods when the cost of machinery substitutes is high, *ceteris paribus*. However, a theoretically inconsistent, though generally nonsignificant, negative relationship between the price of farm products and the demand for hired labour is found in all regions save British Columbia.

Also with the exception of British Columbia, the coefficients on the nonfarm wage and farm wage rate variables although not statistically significant, are at odds with the theory. The hypothesized interdependence between the demand for hired labour and the employment of unpaid family labour operates through the 'prices' of these two types of labour. Employment of unpaid family labour was shown to increase when the cost of hired labour increases, *ceteris paribus*, in every region except British Columbia. The demand for hired workers was expected to expand with increases in the opportunity cost of unpaid family workers, that is, the adjusted nonfarm wage rate. The lack of statistical support for this hypothesis in the regions implies that hired labour demand is not related in this way to the 'cost' of unpaid family labour. The results also imply that except in British Columbia, the demand for hired farm labour does not decrease in periods when farm wages increase, *ceteris paribus*. Although the theoretically inconsistent coefficient is statistically significant only in Quebec, these results are disturbing.[1] It has already been noted that such results may reflect the nature of the employment data used; changes in hours worked and in the composition of the hired farm workforce are not reflected in these data, and there is some evidence that the proportion of the hired workforce that is 'permanent' has declined over time (Dawson and Freshwater, 1975).

The results from the distributed lag specification are given in Table 6.10. Apart from the coefficients on the lagged dependent variable, the only statistically significant estimate in the dynamic specification is the recursive relationship between hired labour demand and the number of farm operators in Ontario. The coefficients of adjustment indicate that hired labour demand responds quite rapidly to changes in the economic and organizational environment. In Ontario, where the demand for hired labour is closely related to the number of farm operators, the adjustment is particularly rapid.

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1 Theoretically inconsistent, though statistically nonsignificant, demand elasticities for hired farm labour are also found in Yeh and Li's (1966) regional analysis, indicating that these demand relationships are not peculiar to a particular model specification.

TABLE 6.10

STATISTICAL RESULTS FOR HIRED LABOUR DEMAND EQUATION (5.3, DISTRIBUTED LAG), 1946 TO 1973, CANADA AND REGIONS

	Canada	Atlantic	Quebec	Ontario	Prairies	B.C.
2SLS estimates[a]:						
farm operators (S)	1.774* (.936)	-.156 (.832)	-.401 (.620)	.775* (.412)	1.027 (.890)	.073 (.303)
adjusted nonfarm wage (n')	.022 (.488)	-4.555 (7.592)	-1.073 (.870)	.235 (.384)	-.513 (.817)	.652 (1.648)
farm product prices (p)	.064 (.171)	-.380 (.750)	.570 (.496)	-.422 (.281)	-.081 (.321)	-.827 (.834)
farm machinery prices (c)	1.089 (.732)	3.064 (3.055)	.913 (.648)	.243 (.495)	.006 (.675)	-.442 (.958)
farm wage rate ($\hat{w}$)	1.880* (.990)	2.401 (3.914)	-.051 (1.409)	.155 (.404)	1.467 (1.276)	-.416 (1.945)
hired labour lagged (H_{t-1})	.264 (.216)	-.159 (.551)	.241* (.120)	.178* (.094)	.213 (.207)	.476* (.223)
adjustment coefficient	.736	-	.759	.822	.787	.524
constant	-21.09	-4.155	1.920	2.482	-7.819	5.760
R^2[b]	.712	.497	.432	.753	.629	.620
d[c]	1.62	1.68	2.03	1.97	1.80	2.30

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6.2.4 Hired Labour Supply

The statistical results of the hired labour supply relation at the regional level are presented in Table 6.11. Significant differences in the empirical estimates, both in the intercept terms and the slope coefficients, are evident among the regions. The covariance tests indicate that statistically significant regional differences exist in the levels of hired farm worker supply and in the effects of changes in the predetermined variables on that supply. Although the estimated hired labour supply relationships vary among the regions, they are stable over time within each region.

Overall, the hired labour supply relation fits the data better in Ontario, the Prairies, and Quebec than in British Columbia and the Atlantic region. In Ontario, Quebec and the Prairies, the statistical results are generally in accord with the hypothesized relationships, and the estimated R^2s are higher than in the other regions.

The hypothesized positive relationship between the supply of hired labour and the farm wage rate is found in Quebec, Ontario and the Prairies, and is statistically significant in Quebec and Ontario. In these regions, increases in wages in agriculture are associated with increases in the supply of hired farm workers, *ceteris paribus*. The response of hired labour supply to changes in the farm wage rate is particularly noticeable in Quebec.

TABLE 6.11

STATISTICAL RESULTS FOR HIRED LABOUR SUPPLY EQUATION

(5.4, STATIC), 1946 TO 1973, CANADA AND REGIONS

	Canada	Atlantic	Québec	Ontario	Prairies	B.C.
2SLS estimates[a]:						
adjusted nonfarm wage (n')	-1.141** (.238)	-.354 (.303)	-.934** (.316)	-.592* (.283)	-.481 (.346)	2.617 (4.186)
farm wage rate (ŵ)	.613** (.197)	-.359 (.385)	.923* (.458)	.250* (.135)	.128 (.945)	-2.695 (4.988)
nonmetropolitan labour force (L)	-.373** (.177)	-.669* (.292)	-.511 (.327)	.035 (.234)	.994* (.536)	.466 (.821)
constant	9.401	9.421	5.500	5.706	-.772	2.467
R^2 [b]	.782	.414	.504	.621	.653	.403
d[c]	1.55†	1.47†	1.73	1.09†	1.82	1.43†
Tests for Regional and Temporal Stability[d]:						
RSS all years (Q_{3i})		.488	.453	.261	.233	1.067
RSS 1946-1973 (Q_{4i})		.440	.409	.239	.217	1.034
F_{4i} (3,22)		.08	.79	.67	.54	.23

Pooled regions RSS (Q_1) = 17.185
Pooled regions, differential intercepts RSS (Q_2) = 4.002
Sum of regional RSS (Q_3) = 2.500
F_1 (12,125) = 1036**
F_2 (8,125) = 9.325**
F_3 (4,133) = 151.5**

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Theoretically inconsistent, but statistically non-significant relationships are found in the Atlantic region and British Columbia.

Wage levels and the availability of nonfarm jobs in the nonfarm sector appear to influence the supply of hired labour in the hypothesized direction in all regions except British Columbia. The negative relationship between the adjusted nonfarm wage variable and hired labour supply is particularly strong in Quebec and Ontario. As nonfarm wage levels and employment prospects improve, the supply of hired labour to agriculture decreases, *ceteris paribus*. It would appear that potential hired farm workers in Quebec and Ontario are more responsive to changes in the farm and nonfarm labour markets than are workers in other regions.

The hypothesized relationship between hired labour and the potential hired farm workforce measure is supported at a statistically significant level only in the Prairie region, although the coefficients in Ontario and British Columbia are also positive. It would seem that changes in the nonmetropolitan workforce in the Prairie provinces closely reflect changes in the potential hired farm labour supply, but elsewhere in Canada the situation is more complex. The results indicate that in the Atlantic region and Quebec, the supply of hired farm workers declines as the nonmetropolitan labour force expands, *ceteris paribus*, implying that potential suppliers of hired labour to agriculture comprise a decreasing proportion of the nonmetropolitan workforce.

The statistical results from the distributed lag specification of the hired labour supply relation are consistent with the results from the static formulation (Table 6.12). The inclusion of the lagged dependent variable reduces the significance levels of the other coefficients, increases the R^2s, but leaves the directions of the relationships and the regional differences in the effects of the variables essentially the same. The adjustment coefficients indicate that, with the exception of British Columbia, the supply of hired farm labour responds quickly to changes in farm and nonfarm economic conditions. In the Atlantic, Quebec, and Prairie regions this rapid adjustment on the part of hired workers is in contrast to the relatively slow response to changes in the economic and technological environment on the part of farm operators and unpaid family workers. In Ontario, adjustments to changes in the exogenous forces are rapid for all components of the farm workforce.

The theory which forms the basis of the hired farm labour supply submodel is not well supported by the data in the Atlantic region nor in British Columbia. In these regions the estimated relationships are either at odds with the theory, or are not statistically significant, and the overall fit to the data is poor. However, in Quebec, Ontario, and the Prairie region the

TABLE 6.12

STATISTICAL RESULTS FOR HIRED LABOUR SUPPLY EQUATION (5.4, DISTRIBUTED LAG), 1946 TO 1973, CANADA AND REGIONS

	Canada	Atlantic	Quebec	Ontario	Prairies	B.C.
2SLS estimates[a]:						
adjusted nonfarm wage (n')	-.624* (.342)	-.048 (.402)	-.391 (.423)	-.013 (.326)	-.070 (.761)	.985 (1.840)
farm wage rate ($\hat{w}$)	.269 (.264)	-.558 (.458)	.633 (.465)	.017 (.214)	.139 (.685)	-.858 (2.191)
nonmetropolitan labour force (L)	-.242 (.190)	-.344 (.333)	-.272 (.293)	.012 (.207)	.943 (.606)	-.127 (.333)
hired labour lagged (H_{t-1})	.263* (.145)	.218* (.118)	.156 (.127)	.387* (.163)	.105 (.181)	.664* (.283)
adjustment coefficient	.737	.782	.844	.613	.895	.336
constant	6.662	6.717	4.308	3.356	-.967	1.788
R^2[b]	.683	.531	.306	.710	.634	.570
d[c]	1.72	1.56†	1.84	1.99	1.82	2.25

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empirical results generally support the conceptual model of hired labour supply.

6.3 Regional Differences

It was shown in the preceding sections that significant regional differences in the results are apparent in all equations of the farm employment model. In this section the results are summarized region by region, and an attempt is made to interpret these regional differences in the statistical results.

Changes in the size and composition of the farm labour force in the Atlantic region appear to be related less to changes in prices and costs than to changes in the structure of agriculture and the economy generally. Only the family labour equations provide a reasonable overall fit to the data, but even there, many of the hypothesized relationships are not supported statistically. Changes in the number of farm operators in the Atlantic provinces are most strongly associated with variations in the effects of technological developments in agriculture and with changes in the availability of, and wage levels in, jobs and nonfarm sector. Improvements in the relative profitability of farming are not associated with the retention of self-employed operators in Atlantic agriculture. Changes in unpaid family employment in the Atlantic provices reflect changes in the number of farm operators, but are not related to the cost of hired labour and alternative income prospects as they are in other regions of Canada. The hypothesized interdependencies between unpaid farm labour employment and hired labour supply and demand are not sustained in the statistical analysis, and the results suggest that the underlying theories of hired labour supply and demand are not appropriate in the Atlantic region. This lack of significant economic relationships may follow from the fact that a large proportion of farm operations in the Atlantic region are not commercial enterprises. However, such conclusions must remain speculative since the statistical results for the hired component may be biased by data rounding errors.

Data errors due to rounding also affect the results for British Columbia, and may account for the generally poor performance of the model in that region. Results from the self-employed operator equation, for which data are comparatively reliable, provide evidence that decreases in the number of operators are related, as hypothesized, to the effects of technological developments and increases in nonfarm income opportunities. But the results also indicate that, other things being equal, decreases in operator numbers occur in periods when farming is relatively profitable in British Columbia. This result suggests that increases in the relative profitability of farming facilitate the consolidation of farm holdings, especially by encouraging the purchase of marginal farms by 'enlargers', and thus reduce the number of farm operators. As with the Atlantic region results, few of the hypothesized relationships in the unpaid family and hired labour equations in British Columbia are theoretically consistent and statistically significant, with the notable exception of the dependence of unpaid family employment on the number of farm operators. While the high proportion of non-commercial farms in British Columbia may account for the lack of statistical support for the hypothesized economic relationships, the results may reflect errors due to rounding in the data.

Changes in the employment of labour on farms in Quebec appear to be influenced by economic variables as hypothesized in the model, with the exception of hired labour demand. Farm operator employment responds noticeably to changes in nonfarm job opportunities and income levels. Changes in agricultural technology and changes in the relative prices of farm products appear to have only minor impacts on changes in the number of farm operators. These results suggest that operator labour in Quebec is underemployed in agriculture in the sense that many operators are prepared to leave agriculture, and do so when nonfarm opportunities arise. Changes in the number of unpaid family workers in Quebec reflect changes in the number of farm operators and changes in the farm wage rate, thus supporting the hypothesized interdepencies among the components of the farm workforce. The results indicate that unpaid family employment in Quebec is largely a function of the number of farms and the cost of hired labour, for which unpaid family labour acts as a substitute, and is little influenced by changes in farm product and machinery prices or nonfarm income opportunities. Once the effect of changes in the number of farm families have been accounted for, increases in unpaid family employment seem to result from the utilisation of available family members when the cost of hired labour is high, rather than from shifts by farm family members between nonfarm and farm employment in response to changes in farm product prices or nonfarm wages. The hired labour demand equation provides a poor fit to the data in Quebec, and the results seem to reflect labour supply rather than demand relationships. Hired farm labour supply is shown to increase when agricultural wages increase, and decrease when nonfarm wage levels and employment opportunities increase. The results imply that levels of hired labour employment largely reflect these supply relationships. In Quebec, therefore, the nonfarm economy has an important effect on levels of operator and hired farm labour employment, but unpaid family employment depends largely upon the number of operators and the cost of hired labour.

In the Prairie region, the family components of the farm labour force demonstrate significant, though conservative, responses to changes in the economic and technological environment. The number of farm operators in Prairie agriculture varies with technological developments and changes in nonfarm wage levels and job opportunities, but the rate of adjustment in operator employment to these shifts is slow compared with that in Quebec and Ontario. Changes in the number of unpaid family workers in the Prairies reflect changes in the number of farm operators, and are also related to changes in nonfarm wages, job opportunities, and the farm wage rate, thus supporting the hypothesized interdependence between unpaid family employment and the cost of hired labour. Hired labour employment in the Prairies does not seem to vary as expected in response to changes in wages and other prices and costs. Hired farm labour supply is shown to be related to farm and nonfarm wages, but the coefficients on these variables are smaller in the Prairies than in any other region, and none of the hired labour demand coefficients are statistically significant. The major changes in labour employment in Prairie agriculture have been in the family labour components, and it is these components that are most influenced by changes in economic conditions in the farm and nonfarm sectors in the Prairies. There is a considerable lag, however, in the response of family labour to these changing economic conditions. These results likely reflect the predominance of commercial family farm enterprises in the Prairie provinces.

The hypothesized relationships incorporated in the farm employment model are given more empirical support in Ontario than in any other region. The reduced form R^2s are high for all equations, attesting to the model's predictive power for all labour force components in Ontario. Farm operator employment is significantly related to the level of agricultural technology, to nonfarm income levels and the availability of nonfarm jobs, and to the relative profitability of farming as measured by the parity ratio. Farm operators in Ontario are thus responsive to both structural adjustments in the organization of agriculture, and to changes in levels of return in both the farm and nonfarm sectors. The rate of adjustment in operator employment to changes in these variables is also more rapid in Ontario than in any other region. As hypothesized, unpaid family employment in Ontario is positively related to the number of farm operators. In addition, the results indicate that more unpaid family labour is employed when the cost of hired labour is high, but less unpaid labour is employed when higher paying job opportunities exist in the nonfarm sector. As does operator labour, unpaid family labour responds to changes in the structure of agriculture and to changes in economic conditions in both the farm and nonfarm sectors, and the rate of adjustment in unpaid family employment to these changes is very rapid. As with other regions, hired labour employment in Ontario seems to be influenced more by supply forces than by demand factors, although the hypothesized relationship between hired labour demand and the number of farm operators is significant. The supply of hired labour to agriculture in Ontario varies with the farm wage rate and with nonfarm wages and employment opportunities. Thus, variations in employment of hired farm workers in Ontario reflect changes in the number of farms which demand hired labour and changes in the important labour supply variables of farm and nonfarm wages.

To the extent that Ontario represents the centre of urban-industrial development in Canada, Schultz's 'urban-industrial' hypothesis seems to have some application in this investigation. The farm labour market, as described by the model, appears to work better in Ontario than in any other region, and seems to perform least well in the Atlantic region and British Columbia. In Ontario, where urban-industrial activities are widespread and occupational shifts into and out of agriculture are facilitated by the number and extent of urban-industrial concerns, all categories of farm labour are responsive to changes in economic conditions in the farm and nonfarm sectors. In the Prairie region, employment of hired farm labour is not associated with wages and nonfarm job opportunities to the extent that it is in Ontario and Quebec. It is possible that this tendency reflects the degree of spatial separation of the farm and nonfarm sectors in the Prairies. In Quebec it is the unpaid family workers who do not seem to respond to changes in the nonfarm labour market, although this is likely related more to the structure of the farms and the nature of unpaid family labour in Quebec than to the proximity of urban-industrial activity.

Regional differences in the performance of the model might also be related to differences in the nature of the agricultural industry among the regions. The model yields more theoretically consistent results, especially for the family labour components, in those regions where the relative importance of 'non-commercial' farms is the lowest. Since the model is based upon assumptions of profit maximization on the part of farm families, it would be expected to fit the data better in regions where most farms are commercial operations. Non-commercial farm enterprises are proportionately least numerous in the Prairies and Ontario, and it is in these regions that the hypothesized family employment relationships are best maintained in the empirical analysis. Non-commercial operations are proportionately most numerous in the Atlantic region and British Columbia, regions where the statistical results provide the least support for the model.

6.4 Summary of Results

When applied to the national level data, the farm employment model developed in Chapter 4 yields results that generally conform to the hypothesized relationships. However, the regional-level analysis clearly demonstrates that the effects of the various determinants of changes in farm labour employment differ from one region of Canada to another. Thus, the research strategy of applying the model to each region separately is vindicated.

At both levels of aggregation, the results provide empirical support for the two innovative characteristics of the farm employment model itself. Firstly, the disaggregation of the labour force and the specification of submodels specifically for the family labour components is validated by the general theoretical consistency of the estimated relationships in the family labour equations. Although the hired labour supply estimates generally conform to the hypothesized relationships, the hired labour demand relation does not fit the data well, and yields some notably inconsistent and nonsignificant results at both levels of spatial aggregation. However, the underlying premise that the processes influencing changes in farm labour employment differ among the types of farm labour is supported in the statistical results. Secondly, the hypothesized interdependencies among the components of the agricultural workforce are substantiated in most cases. In particular, the recursive relationship between unpaid family labour and farm operators, and the relationship between unpaid family employment and the cost of hiring farm labour are found to be significant in most regions. The estimated relationships are shown to be stable over time, and the hypothesis that employment adjustments take place after a lag is given statistical support in most components and regions.

Explanations for the regional differences in the parameters of the employment relations remain speculative. However, the results indicate that regional differences in employment relations might reflect differences in the structure of agriculture, especially the relative importance of commercial family farms in the agricultural economy. At the same time, the regional differences may be related to differences in the degree of urban-industrial development among the regions. In any event, the theoretical model generally fits the data well in Ontario, has minor limitations in the Prairie region and Quebec, but performs poorly in the Atlantic region and British Columbia.

CHAPTER 7

IMPLICATIONS AND CONCLUSIONS

7.1 Economic Implications of Results

The employment model developed and tested in this study contributes to our understanding of the agricultural labour market and has implications for employment and manpower policy. The results indicate that the effects of changes in economic variables on employment in the categories of farm labour differ among the regions of Canada. However, several of the empirical relationships are relatively consistent among groups of regions.

Changes in farm operator numbers are shown to be related to changes in agricultural technology and nonfarm income opportunities, though changes in the relative price of farm products seem to have little effect on operator employment in agriculture. The declining trend in farm operator employment is associated with steady improvements in agricultural technology. It is not surprising that developments in agricultural technology are found to be related to declines in farm operator numbers, since technological innovations have invariably benefitted the larger operations, placing the smaller units at a competitive disadvantage, and thereby encouraging farm consolidation. As long as technological developments continue to have this effect, it would seem that the number of farms and the number of farm operators will continue to diminish.

Fluctuations in this general downward trend in operator employment are related to changes in employment and income opportunities in the nonfarm sector. Technological developments gradually reduce agriculture's operator requirements, but the number of operators declines most markedly in periods when nonfarm income opportunities are favourable. High unemployment rates and low nonfarm wages have the effect of sustaining the ranks of the farm operators, most likely by reducing off-farm mobility. For policy makers wishing to inhibit the decline in the farmer population, neither reducing the level of nonfarm wages nor increasing the unemployment rate would appear to be attractive policies. A more practical approach to retaining operators on farms, and one frequently espoused, is to support price levels of agricultural products. However, the results from this study indicate that improvements in prices for farm products (relative to prices of products used in production) have little impact upon the number of farmers employed in most regions. Such price supports would benefit large operations as much as, if not more than the smaller farms, and hence the tendency for farm consolidation would be likely to continue. The results from the operator submodel in this study suggest that a continued decline in farm operator numbers can be expected in all regions, particularly in periods when the nonfarm economy is buoyant, unless technological innovations are developed for small or medium-sized farms, such that they can compete with the larger operations.

The results for the unpaid family and hired labour components of the farm workforce are less consistent among the regions, although the results for Quebec, Ontario, and the Prairies are similar in many respects. In all regions, the number of unpaid family workers in agriculture is clearly linked to the number of farmers, but in Quebec, Ontario, and the Prairies, unpaid family employment also varies with the cost of hired labour. In these regions, it would seem that increases in farm wage rates encourage operators to employ members of their family on the farm rather than to hire additional paid labour. However, the hired labour demand analysis indicates that increases in the farm wage rate do not seem to dampen the demand for hired workers. The results from the hired labour supply equation imply that by increasing the wage they offer farm workers, farm operators can increase the supply of hired agricultural labour. However, it would appear that once this wage reaches some critical level, operators prefer to utilize more fully the labour resources of their families rather than employ extra paid labour. At the same time, the supply of hired farm labour seems limited, and potential hired workers are unwilling to work in agriculture for the wages farm operators are prepared to offer. No doubt, characteristics of employment in agriculture other than wages are important in this regard. Changing lifestyle preferences on the part of potential hired farm workers may be responsible for the supply and demand relationships with respect to the farm wage rate. Nevertheless, the results from the hired labour supply equation in Quebec, Ontario, and the Prairies imply that hired worker supply would increase if the returns to hired labour in agriculture were raised, as long as farm operators are willing and able to offer such increases.

Another empirical result that has broad implications is that in most regions, fluctuations in employment in all components of the farm workforce are related to changes in wage levels and the availability of jobs in the nonfarm sector. During periods when the nonfarm economy is depressed, particularly in Quebec, Ontario, and the Prairies, operators tend to remain in agriculture, unpaid family employment in agriculture is bolstered, and more hired workers find farm employment. Thus, agriculture has a tendency to act as a reservoir which retains surplus labour until such times as the nonfarm sector requires it, or can absorb it. However, farm enterprises can hardly be organized to make maximum use of this labour in the long term, since when the nonfarm economy recovers, employment in agriculture declines at an increasing rate.

Thus, little stability can be expected in agricultural employment as long as unemployment levels and returns to labour in the non-farm sector continue to fluctuate.

The empirical analysis supports the hypothesis that the relationships embodied in the agricultural employment model differ among the regions of Canada. In some cases, the differences are of degree, but in others more fundamental regional variations in employment relationships are apparent. The obvious implication from this result is that the effects on employment in agriculture of changes in certain economic variables differ from one region to another. For example, in Ontario, an increase in nonfarm income opportunities would be expected to reduce the number of unpaid family workers in agriculture, but such an increase in the Atlantic provinces would be as likely to result in an increase in family employment on farms. Thus, a manpower policy which proves successful in either retaining labour in agriculture or facilitating off-farm mobility in one region may have quite a different effect in another region. However, regional differences in the magnitude of employment responses to changes in economic stimuli are more common than differences in the direction of the effect on employment. The speed of adjustment in agricultural employment to changing economic and technological conditions also varies among the regions of Canada. Clearly, the formulation and evaluation of manpower policies affecting agricultural employment requires recognition of these regional differences.

7.2 Conclusions

This investigation represents an attempt to increase our knowledge of the Canadian agricultural labour market. The general aim of the study was to describe and account for changes in the size and composition of the farm labour force in the regions of Canada over the period 1946 to 1973. Employment in agriculture and patterns of change in the size and composition of the farm workforce are shown to differ from one region of the country to another. In order to analyse these employment changes and to investigate regional differences in the forces affecting employment in agriculture, an econometric model of the farm labour market is developed, and is estimated for each of the regions.

The employment model developed in this study exhibits some notable characteristics. It is a disaggregated macromodel, comprised of three submodels, each pertaining to a distinct component of the farm workforce. Unlike other disaggregated models, the fundamental processes that determine levels of employment in agriculture are not assumed to be the same for all types of labour. Instead, the submodels for operator employment, unpaid family employment, and hired labour employment have different conceptual bases and structural forms, thus incorporating important elements of the heterogeneity of the farm labour force within the model. In addition, the model recognises that the farm labour components are unlikely to vary independently of each other. Whereas other disaggregated models have either made the simplifying assumption that there is no interaction among the components or have specified interdependencies on an *ad hoc* basis, the interrelations among the components in this model follow directly from the theoretical derivation of the submodels. The resultant simultaneous-equations model has a bloc-recursive structure, and is estimated in both static and distributed lag forms.

In general, the theoretical model is supported in the empirical analysis. In particular, the disaggregation of the labour force and the specification of separate submodels for the two family labour components are corroborated by the general theoretical consistency of the estimated relationships in the family labour equations. It is apparent that the general theories of labour supply and demand need to be modified when applied to family labour in agriculture. The hypothesized interdependencies among the components of the agricultural workforce are also substantiated in most cases.

However, the presence of non-significant coefficients and some theoretically inconsistent estimates indicates that the model has shortcomings. Further theoretical and empirical work appears warranted for all components of the farm workforce. For instance, the theoretical base of the farm operator submodel might be expanded in order to isolate the differential effects of changes in farm profitability. The unpaid family submodel might be extended to incorporate changes in family size and the participation choice, especially on the part of operators' spouses. The hired labour demand relation requires attention in light of the statistical results. Perhaps further disaggregation is necessary here since, while the demand for 'permanent' hired farm labour might be elastic, it is possible that 'seasonal' labour is price inelastic, and operators have little choice but to pay the going rate at harvest time. Disaggregation by type of farm for all components would further improve the consistency of the conceptual models. However, such continued disaggregation would increase data requirements to the extent that empirical testing to the models would hardly be feasible. There also comes a point where the benefits of this sort of disaggregation are outweighed by losses in the generality of the results.

The statistical analysis also provides support for the fundamental premise that the processes influencing changes in farm labour employment differ among the regions. Results from the covariance tests indicate that significant regional variation exists in each of the employment relations. While such testing for spatial variation in time-series-estimated models represents a notable extension of previous econometric studies, the analysis of regional differences also requires further attention. In particular, more detailed study is needed of the reasons for the observed regional differences in farm employment relations.

BIBLIOGRAPHY

ARDA (1972) Planning for Agriculture in Southern Ontario, ARDA Project No. 85057, Guelph: Centre for Resources Development.

Altman, S.H. and R.J. Barro (1970) 'Estimation of a Nursing Labor Supply Function', Econometric Society World Congress, Cambridge.

Andarawewa, A.G. (1970) The Structure of the Canadian Agricultural Labor Force, Canada Department of Agriculture, Economics Branch, Research Publication No. 6.

Basmann, R.L. (1962) 'Letter to the Editor', Econometrica, Vol. 30, pp. 824-826.

Bassett, K. and P. Haggett (1971) 'Towards Short-Term Forecasting for Cyclic Behaviour in a Regional System of Cities', in M. Chisholm, A.E. Frey and P. Haggett, eds. Regional Forecasting, London: Butterworths.

Bassett, K. and R. Tinline (1970) 'Cross Spectral Analysis of Time Series and Geographical Research', Area, Vol. 2, pp. 19-24.

Bauer, L.L. (1969) 'The Effect of Technology on the Farm Labor Market', American Journal of Agricultural Economics, Vol. 51, pp. 605-618.

Baumgartner, H.W. (1965) 'Potential Mobility in Agriculture: Some Reasons for the Existence of the Labor Transfer Problem', Journal of Farm Economics, Vol. 47, pp. 74-82.

Bennett, R.J. (1975) 'Dynamic Systems Modelling of the North-West Region: 4. Adaptive Spatio-Temporal Forecasts', Environment and Planning, Vol. 7, pp. 887-898.

Bishop, C.E. (1961) 'Economic Aspects of Changes in Farm Labor Force', in E.O. Heady, ed., Labor Mobility and Population in Agriculture, Ames: Iowa State University Press.

Bishop, C.E. (1967) 'Dimensions of the Farm Labor Problem', in C.E. Bishop, ed., Farm Labor in the United States, New York: Columbia University Press.

Bogue, D.J. and M.J. Hagood (1953) Subregional Migration in the United States, 1935-1940, Vol. II, Differential Migration in the Corn and Cotton Belts, Oxford, Ohio: Scripps Foundation.

Bowles, G.K. (1956) Net Migration from the Rural Farm Population, 1940-1950, United States Department of Agriculture, Statistical Bulletin No. 176.

Brechling, F. (1967) 'Trends and Cycles in British Regional Unemployment', Oxford Economic Papers, Vol. 19, pp. 1-21.

Buchanan, D.R. (1960) Trends in the Agricultural Labour Force in Canada, from 1921-1959, Canada Department of Labour, Economics and Research Branch.

Chow, G.C. (1960) 'Tests of Equality Between Sets of Coefficients in Two Linear Regressions', Econometrica, Vol. 28, pp. 591-605.

Clawson, M. (1963) 'Aging Farmers and Agricultural Policy', Journal of Farm Economics, Vol. 45, pp. 13-30.

Cliff, A.D., P. Haggett, J.K. Ord, K. Bassett, and R. Davies (1975) Elements of Spatial Structure, Cambridge University Press.

Cliff, A.D. and K. Ord (1971) 'A Regression Approach to Univariate Spatial Forecasting', in M. Chisholm, A.E. Frey and P. Haggett, eds. Regional Forecasting, London: Butterworths.

Courchene, T. (1970) 'Interprovincial Migration and Economic Adjustment', Canadian Journal of Economics, Vol. 3, pp. 550-576.

Cowling, K. and D. Metcalf (1968) 'Labour Transfer from Agriculture: a Regional Analysis', Manchester School of Economic and Social Studies, Vol. 36, pp. 27-48.

Cowling, D., D. Metcalf and A.J. Rayner (1970) Resource Structure of Agriculture: an Economic Appraisal, London: Pergamon.

Cramer, J.S. (1971) Empirical Econometrics, Amsterdam: North-Holland.

Dawson, D.A. and D. Freshwater (1975) Hired Farm Labour in Canada, Food Prices Review Board Publication.

Diehl, W.D. (1966) 'Farm-Nonfarm Migration in the Southeast: a Cost Returns Analysis', Journal of Farm Economics, Vol. 48, pp. 1-11.

Fischer, F.M. (1970) 'Tests of Equality between Sets of Coefficients in Two Linear Regressions: an Expository Note', Econometrica, Vol. 38, pp. 361-366.

Fleisher, B.M. (1970) Labor Economics: Theory and Evidence, Englewood Cliffs: Prentice-Hall.

Fletcher, R.K. (1966) Agriculture and the Atlantic Economy, Atlantic Provinces Economic Council Pamphlet No. 10.

Fuller, V. and W. Van Vuuren (1972) 'Farm Labor and Labor Markets', in A.G. Ball and E.O. Heady, eds., Size, Structure, and Future of Farms, Ames: Iowa State University Press.

Gallaway, L.E. (1967a) 'Mobility of Hired Agricultural Labour: 1957-1960', Journal of Farm Economics, Vol. 49, pp. 32-52.

Gallaway, L.E. (1967b) 'Industry Variations in Geographic Mobility Patterns', Journal of Human Resources, Vol. 2, pp. 461-474.

Gallaway, L.E. (1968) 'Geographical Flows of Hired Agricultural Labor: 1957-60', American Journal of Agricultural Economics,

Gallaway, L.E., R.F. Gilbert, and P.E. Smith (1967) 'The Economics of Labor Mobility: an Empirical Analysis', Western Economic Journal, Vol. 5, pp. 211-223.

Gardner, B.L. (1972) 'Minimum Wages and the Farm Labor Market', American Journal of Agricultural Economics, Vol. 54, pp. 473-476.

Gardner, B.L. (1974) 'Farm Population Decline and the Income of Rural Families', American Journal of Agricultural Economics, Vol. 56, pp. 600-606.

Gasson, R. (1970) 'Structural Reform and the Mobility of the Small Farmer', Land Reform, Vol. 12, pp. 1-20.

Gasson, R. (1974) 'Turnover and Size of Labour Force on Farms', Journal of Agricultural Economics, Vol. 25, pp. 115-127.

Gilchrist, V. (1963) 'A Pilot Study of Income Alternatives Affecting the Movement of Farm Operators out of Agriculture', Canadian Journal of Agricultural Economics, Vol. 11, pp. 9-21.

Gisser, M. (1965) 'Schooling and the Farm Problem', Econometrica, Vol. 33, pp. 582-592.

Grant, E.K. (1973) Migration as an Investment in Human Capital, University of Essex, Unpublished Ph.D. Thesis.

Green, H.A. (1964) Aggregation in Economic Analysis: an Introductory Survey, Princeton: Princeton University Press.

Griliches, Z. (1959) 'The Demand for Inputs in Agriculture and a Derived Supply Elasticity', Journal of Farm Economics, Vol. 41, pp. 309-322.

Griliches, Z. (1961) 'A Note on Serial Correlation Bias in Estimates of Distributed Lag', Econometrica, Vol. 29, pp. 65-72.

Grunfeld, Y. and Z. Griliches (1960) 'Is Aggregation Necessarily Bad?', Review of Economics and Statistics, Vol. 42, pp. 1-13.

Guither, H.D. (1963) 'Factors Influencing Farm Operators' Decisions to Leave Farming', Journal of Farm Economics, Vol. 65, pp. 567-576.

Gupta, K.L. (1969) Aggregation in Economics: a Theoretical and Empirical Study. Rotterdam: Rotterdam University Press.

Gupta, K.L. (1972) 'Bias of Technical Change in Short-Run Employment Models', Metroeconomica, Vol. 24, pp. 91-92.

Hammonds, T.M., R. Yadav and C. Vathana (1973) 'The Elasticity of Demand for Hired Farm Labor', American Journal of Agricultural Economics, Vol. 55, pp. 242-245.

Hathaway, D.E. (1964) 'Urban-Industrial Development and Income Differentials Between Occupations', Journal of Farm Economics, Vol. 46, pp. 56-66.

Hathaway, D.E. (1967) 'Occupational Mobility from the Farm Labor Force', in C.E. Bishop, ed., Farm Labor in the United States, New York: Columbia University Press.

Hathaway, D.E. and B.B. Perkins (1968) 'Farm Labor Mobility, Migration and Income Distribution', American Journal of Agricultural Economics, Vol. 50, pp. 342-352.

Heady, E.O., W.B. Back and G.A. Peterson (1953) Interdependence Between the Farm Business and the Farm Household with Implications on Economic Efficiency, Iowa Agricultural Experimental Station, Research Bulletin No. 398.

Heady, E.O. and L.G. Tweeten (1963) Resource Demand and Structure of the Agricultural Industry, Ames: Iowa State University Press.

Heckman, J. (1974) 'Shadow Prices, Market Wages, and Labor Supply', Econometrica, Vol. 42, pp. 679-694.

Henderson, J.M. and R.E. Quandt (1971) Microeconomic Theory, New York: McGraw-Hill.

Hill, L.D. (1962) 'Characteristics of the Farmers Leaving Agriculture in an Iowa County', Journal of Farm Economics, Vol. 44, pp. 419-426.

Ichimura, S. (1966) 'An Econometric Analysis of Domestic Migration and Regional Economy', Regional Science Association Papers, Vol. 16, pp. 67-76.

Johnston, J. (1972) Econometric Methods, New York: McGraw-Hill.

Johnson, S. (1961) An Econometric Analysis of the Demand for and Supply of Farm Labor, Iowa State University, Unpublished Ph.D. Thesis.

Johnson, S. and E.O. Heady (1962) Demand for Labor in Agriculture, Iowa State University, CAEA Report No. 13-T.

Jones, B. (1966) 'Impact of Government Subsidized Farm Operating Loans on Family Labor Employment in Agriculture', Journal of Farm Economics, Vol. 48, pp. 1216-1221.

King, L., E. Casetti and D. Jeffrey (1969) 'Economic Impulses in a Regional System of Cities: a Study of Spatial Interaction', Regional Studies, Vol. 3, pp. 213-218.

Koopmans, T.C. and W.C. Hood (1953) 'The Estimation of Simultaneous Linear Relationships', in T.C. Koopmans and W.C. Hood, eds., Studies in Econometric Method, New York: Wiley.

Lave, L.B. (1966) Technological Change: its Conception and Measurement, Englewood Cliffs: Prentice Hall.

Lianos, T.P. (1972) 'Impact of Minimum Wages upon the Level and Composition of Agricultural Employment', American Journal of Agricultural Economics, Vol. 54, pp. 477-484.

Luebke, B.H. and J.F. Hart (1958) 'Migration from a Southern Appalachian Community', Land Economics, Vol. 34, pp. 44-53.

Macmillan, J.A., F.L. Tung and J.R. Tulloch (1974) 'Migration Analysis and Farm Number Projection Models: a Synthesis', American Journal of Agricultural Economics, Vol. 56, pp. 292-299.

Marschak, J. (1953) 'Economic Measurements for Policy and Prediction', in T.C. Koopmans and W.C. Hood, eds., Studies in Econometric Method, New York: Wiley.

Mumey, G.A. (1959) 'The Parity Ratio and Agricultural Out-Migration', Southern Economic Journal, Vol. 25, pp.

Nerlove, M. (1958) 'Distributed Lags and the Estimation of Long Run Supply and Demand Elasticities: Theoretical Considerations', Journal of Farm Economics, Vol. 40, pp. 301-311.

Nicholls, W.H. (1961) 'Industrialization, Factor Markets, and Agricultural Development', Journal of Political Economy, Vol. 59, pp. 319-340.

Ostry, S. (1968) The Occupational Distribution of the Canadian Labour Force 1961, Dominion Bureau of Statistics, 1961 Census Monograph.

Parnes, H.S. (1960) 'The Labor Force and Labor Markets', in A.G. Heneman et. al., eds., Employment Relations Research, New York: Harper.

Perkins, B.B. (1973) 'Farm Income and Labor Mobility', American Journal of Agricultural Economomics, Vol. 55, pp. 913-920.

Perkins, B.B. and D.E. Hathaway (1966) The Movement of Labor between Farm and Nonfarm Jobs, Michigan Agricultural Experimental Station, Research Bulletin No. 13.

Putnam, D.F. and R.G. Putnam (1970) Canada: a Regional Analysis, Canada: Dent.

Reynolds, L.G. (1951) The Structure of Labor Markets, Westport: Greenwood Press.

Robb, A.L. (1975) 'A Note on Participation Rates', McMaster University, Department of Economics, mimeo.

Ryan, J.G. and R.C. Duncan (1974) 'Effects on Farm Incomes and Rural Labour of a Relative Increase in Wages', Australian Journal of Agricultural Economics, Vol. 18, pp. 193-207.

Schuh, G.E. (1962) 'An Econometric Investigation of the Market for Hired Labor in Agriculture', Journal of Farm Economics, Vol. 44, pp. 307-321.

Schuh, G.E. and J.R. Leeds (1963) 'A Regional Analysis of the Demand for Hired Agricultural Labor', Papers and Proceedings of the Regional Science Association, Vol. 11, pp. 295-308.

Schultz, T.W. (1953) Economic Organisation of Agriculture, New York: McGraw-Hill.

Sisler, D.G. (1959) 'Regional Differences in the Impact of Urban-Industrial Development on Farm and Nonfarm Income, Journal of Farm Economics, Vol. 41, pp. 1100-1112.

Sjaastad, L. (1961) 'Occupational Structure and Migration Patterns', in E.O. Heady, ed., Labor Mobility and Population in Agriculture, Ames: Iowa State University Press.

Sjaastad, L.A. (1962) 'The Costs and Returns of Human Migration', Journal of Political Economy, Vol. 70, pp. 80-93.

Solow, R.M. (1957) 'Technical Change and the Aggregate Production Function', Review of Economics and Statistics, Vol. 39, pp. 312-320.

Speare, A. (1971) 'A Cost-Benefit Model of Rural to Urban Migration in Taiwan', Population Studies, Vol. 25, pp. 117-130.

Statistics Canada (1965) Canadian Labour Force Survey - Methodology (Cat. No. 71-504).

Statistics Canada (decennial) Census of Canada: Population; Labour Force; Population; Agriculture; various years.

Statistics Canada (annual) Yearbook, various years.

Statistics Canada (quarterly) Quarterly Bulletin of Agricultural Statistics (Cat. No. 21-003).

Statistics Canada (quarterly) Farm Input Price Indexes (Cat. No. 62-004).

Statistics Canada (monthly) Prices and Price Indexes (Cat. No. 62-002).

Statistics Canada (monthly) The Labour Force (Cat. No. 71-001).

Statistics Canada (monthly) Employment Earnings and Hours (Cat. No. 72-002).

Statistics Canada (occasional) Index Numbers of Farm Prices of Agricultural Products (Cat. No. 62-529).

Statistics Canada (occasional) Handbook of Agricultural Statistics, Part II: Farm Income (Cat. No. 21-511).

Szabo, M.L. (1965) 'Depopulation of Farms in Relation to the Economic Conditions of Agriculture on the Canadian Prairies', Geographical Bulletin, Vol. 7, pp. 187-202.

Szabo, M.L. (1966) 'Area-Differential Productivity of Agricultural Resources and Off-Farm Migration on the Canadian Prairies', Geographical Bulletin, Vol. 8, pp. 113-133.

Taeuber, K.E. (1967) 'The Residential Redistribution of Farm-Born Cohorts', Rural Sociology, Vol. 32, pp. 20-36.

Tang, A.M. (1958) Economic Development in the Southern Piedmont 1860-1950: its Impact on Agriculture, Chapel Hill: University of North Carolina Press.

Theil, H. (1954) Linear Aggregation of Economic Relations, Amsterdam: North-Holland.

Tolley, G.S. and B.M. Farmer (1967) 'Farm Labor Adjustments to Changing Technology', in C.E. Bishop, ed., Farm Labor in the United States, New York: Columbia University Press.

Tyler, G.J. (1972) 'Factors Affecting the Size of the Labour Force and the Level of Earnings in U.K. Agriculture 1948-65', Oxford Agrarian Studies, Vol. 1, pp. 20-45.

Tyrchniewicz, E.W. (1967) An Econometric Study of the Agricultural Labor Market, Purdue University, Unpublished Ph.D. Thesis.

Tyrchniewicz, E.W. and G.E. Schuh (1966) 'Regional Supply of Hired Labor to Agriculture', Journal of Farm Economics, Vol. 48, pp. 537-556.

Tyrchniewicz, E.W. and G.E. Schuh (1969) 'Econometric Analysis of the Agricultural Labor Market', American Journal of Agricultural Economics, Vol. 51, pp. 770-787.

Vanderkamp, J. (1968) 'Interregional Mobility in Canada: a Study of the Time Pattern of Migration', Canadian Journal of Economics, Vol. 2, pp. 595-608.

Wallace, T.D. and D.M. Hoover (1966) 'Income Effects of Innovation: the Case of Labor in Agriculture', Journal of Farm Economics, Vol. 48, pp. 325-336.

Weatherford, W.D. (1957) Geographical Differentials of Agricultural Wages in the United States, Cambridge: Harvard University Press.

Winkelmann, D. (1966) 'A Case Study of the Exodus of Labor from Agriculture: Minnesota', Journal of Farm Economics, Vol. 48, pp. 12-21.

Wolfson, R.J. (1958) 'An Econometric Investigation of Regional Differences in American Agricultural Wages', Econometrica, Vol. 26, pp. 225-257.

Wonnacott, R.J. and T.H. Wonnacott (1970) Econometrics, New York: Wiley.

Yeh, M.H. (1967) 'The Labor Market with Particular Reference to Canadian Agriculture', Journal of Farm Economics, Vol. 49, pp. 1257-1267.

Yeh, M.H. and L-K. Li (1966) 'A Regional Analysis of the Supply and Demand of Farm Labour in Canada', Canadian Journal of Agricultural Economics, Vol. 14, pp. 15-31.

Yeh, M.H. and L-K. Li (1968) Technological Change in Canadian Agriculture, University of Manitoba, Faculty of Agriculture and Home Economics, Research Report No. 15.

APPENDIX 1

SOURCES AND DEFINITIONS OF DATA

This Appendix supplements Section 4.4 by providing more specific information on the nature and sources of data used in the empirical analysis.

Farm Employment

The farm employment data are supplied by the Labour Force Survey Division of Statistics Canada. Employment estimates are based upon information obtained through sample surveys of households, conducted at quarterly intervals from 1946 to 1952, and at monthly intervals since 1952. The sample used in the surveys is designed to represent all persons in the population 14 years of age and over residing in Canada, with the exception of residents of the Yukon and Northwest Territories, Indians living on reserves, inmates of institutions, and members of the armed forces. A comprehensive description of the Labour Force Survey can be found in Statistics Canada (1965) Canadian Labour Force Survey - Methodology, (Cat. No. 71-504).

The survey-based data are likely to contain both sampling and non-sampling errors. However, some of the employment series have been compared with census data for reliability. The Labour Force Survey Division has revised total and paid farm employment estimates for the period 1946 to 1966. The estimates for self-employed and unpaid family employment were then checked to ensure that the sum of the components equalled total farm employment for each year. In the few instances where adjustments were necessary, the revised paid worker estimate was retained, and the self-employed and unpaid family estimates were adjusted such that their relative proportions remained the same.

Farm Wages

The measure used in this study, average wages of male farm help per month, without board, is published in Statistics Canada (quarterly) Quarterly Bulletin of Agricultural Statistics, (Cat. No. 21-003). Alternative measures available at the regional or provincial level (wages per day, or wages per month with board), vary almost identically with the measure used in this study. Where the data are available only at the provincial level (Prairie and Atlantic provinces prior to 1953), regional averages are computed using hired farm employment as provincial weights.

Nonfarm Earnings

Statistics Canada (monthly) Employment, Earnings and Hours, (Cat. No. 72-002) publishes the measure 'industrial composite average weekly earnings', based upon reports from firms employing 20 persons or more in any month of the year. The industrial composite measure includes all industries except agriculture, fishing and trapping, education and related services, religious organisations, private households, and public administration and defense. The term 'earnings' is used to denote both weekly wages and salaries. Publications prior to 1971 use the term 'average weekly wages and salaries'. A limitation of the measure might be the industrial bias introduced by restricting the survey of firms to those employing 20 persons or more.

Unemployment

The unemployment rate, representing the number of unemployed persons as a percent of the total civilian labour force, is published in Statistics Canada (monthly) The Labour Force, (Cat. No. 71-001).

Farm Prices Received

Information on the prices received by farmers for the products they sell is obtained by Statistics Canada's Agriculture Division, primarily from reports furnished monthly by volunteer farm correspondents who are asked to report the average prices prevailing in their neighbourhoods, taking into account the various grades of each commodity marketed. Based on this information, Statistics Canada (occasional) Index Numbers of Farm Prices of Agricultural Products, (Cat. No. 62-529) publishes the measure 'index numbers of farm prices for agricultural products'. The index used in the study is the revised index with a weight base 1960-62 = 100, and a time base 1961 = 100. Averages for the Atlantic and Prairie regions are computed by weighting the provincial index with the total farm income values for the respective provinces.

Farm Prices Paid

Farm input price indexes relating to commodities and services used in farming are published annually for Eastern, Western and all Canada by Statistics Canada (quarterly) Farm Input Price Indexes, (Cat. No. 62-004) and Prices and Price Indexes (Cat. No. 62-002). The annual average input price indexes are based upon quarterly estimates of input prices. This study uses the revised index, and index numbers for the period 1961 are rebased to 1961 = 100. The farm input price indexes are designed to measure the movements of prices paid by farmers for inputs into farm production. Each of the two regional indexes and the composite Canada index measure the impact of price change on the cost of purchasing a constant 'basket' of inputs corresponding to the respective regions and Canada. The basket for each region represents the annual rate of use of inputs in farm operations in the region in a specified base year. The Canada basket is the composite of the two regional ones. The Western Canada index is used for the Prairie region and British Columbia, while the Eastern Canada index is used for Ontario, Quebec, and the Atlantic region.

Machinery Input Price

The price index for the input component 'farm machinery and motor vehicles' is published by Statistics Canada (quarterly) Farm Input Price Indexes, (Cat. No. 62-004) and Prices and Price Indexes (Cat. No. 62-002). Index numbers rebased to 1961 = 100 are used in this study, with the Western Canada index representing British Columbia and the Prairies, and the Eastern Canada index employed for Ontario, Quebec, and the Atlantic region.

Consumer Price Index

The 'consumer price index' is published by Statistics Canada (monthly) Prices and Price Indexes, (Cat. No. 62-002), as a measure of the change in the cost of living in urban areas. The use of the urban-based index as a deflator of both farm and nonfarm prices and wages might be considered a rather serious deficiency as the difference between the farm and nonfarm costs of living may have become smaller over time as farm families have produced more consumer goods and services. This proposition was tested by comparing the consumer price index with the 'farm family living index', a measure published by Statistics Canada (monthly) Prices and Price Indexes, (Cat. No. 62-002). The farm family living index and the consumer price index for Canada are practically identical for the years when both indexes are available, 1949 to 1969. Annual averages of the consumer price index with a time base 1961 = 100 are published for regional cities. The regional indexes used in this study are the weighted (by city population) averages of cities for which data are supplied: Atlantic (Saint John, Halifax), Quebec (Montreal), Ontario (Toronto, Ottawa), Prairies (Winnipeg, Saskatoon, Regina, Edmonton, Calgary), British Columbia (Vancouver).

Value of Farm Output, Material Inputs, and Capital Stock

Historical data on the value of gross farm output and the value of material inputs into agriculture are published by Statistics Canada (occasional) Handbook of Agricultural Statistics, Part II: Farm Income (Cat. No. 21-511). Data on the value of capital stock in agriculture are published by Statistics Canada (quarterly) Quarterly Bulletin of Agricultural Statistics (Cat. No. 21-003). These values are deflated by the appropriate price indexes from Statistics Canada (quarterly) Farm Input Price Indexes (Cat. No. 62-004) and Prices and Price Indexes (Cat. No. 62-002). The regional value measures are taken as the sums of the appropriate provincial values.

Civilian Labour Force

Civilian labour force data are published by Statistics Canada (monthly) The Labour Force (Cat. No. 71-001). The estimates used are annual averages based on the same Labour Force Survey that provides estimates of employment in agriculture. The labour force represents that portion of the civilian noninstitutional population 14 years of age and over who, during the survey period, were employed or unemployed. Annual estimates of the labour force in urban areas are interpolated from decennial census data published by Statistics Canada, Census of Canada, Labour Force.

APPENDIX 2

AGGREGATION BIAS

An important implication of constructing macromodels by analogy with a micromodel is that the inference that the empirically estimated macroparameters reflect the corresponding microparameters may be invalidated by aggregation bias.[1] In order to examine the effects on macroparameter estimation (and interpretation) of constructing macromodels from microtheories by analogy, consider a simple model of farm labour demand.

Assume that for each individual farm f (f = 1,2, ..., S) the demand for labour, y_f, depends linearly upon the 'exogenous' variables, the price of labour, x_{1f}, and the price of machinery inputs, x_{2f}, at that farm f. Assume this dependence holds exactly.[2] Observing this relation over time and attaching the symbol t to each of the variables, the micromodel may be expressed:

$$y_{ft} = b_{1t}\, x_{1ft} + b_{2f}\, x_{2ft} \qquad \text{A2.1}$$

where b_{1f} and b_{2f} are microparameters.

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[1] The procedure by which theories about individuals are transformed into theories about aggregates has other implications; see Green (1964), Gupta (1969), Grunfeld and Griliches (1960).

[2] The results are essentially the same if individual random disturbances are introduced; see Thiel (1954).

If time-series data for individual farms exist, it is possible, making some simplifying assumptions (eg. b_{1f} and b_{2f} do not change over the time period considered), to estimate b_{1f} and b_{2f} for each farm f. More commonly, however, the model is translated into a macromodel so that it can be tested using aggregate data, which are more readily available than those for individuals.

By analogy, the corresponding macromodel is:

$$Y_t = b_1 x_{1t} + b_2 X_{2t} \qquad \text{A2.2}$$

where $Y_t = \sum_{f=1}^{S} y_{ft}$; A2.3

$$X_{1t} = \sum_{f=1}^{S} x_{1ft}; \qquad \text{A2.4}$$

$$X_{2t} = \sum_{f=1}^{S} x_{2ft} \qquad \text{A2.5}$$

and b_1 and b_2 are the macroparameters corresponding to b_{1f} and b_{2f} respectively.

The meaning of these macrovariables in our example is obvious: Y_t is total demand for labour in agriculture, X_{1t} is n times the average wage in agriculture,[1] X_{2t} is n times the

1 The difficulties of this sort of multiplication may be shown to be of a trivial nature, and the macrovariable may be interpreted as the average price. The discussions of b_1 and b_2 can be applied when the macrovariables are simple sums or weighted averages of the microvariables; see Thiel (1954).

price of machinery inputs (eg. a machinery input price index).

Macromodels of the type (A2.2) are frequently tested in econometric analyses of farm labour, giving estimates for the macroparameters b_1 and b_2. The question of aggregation bias turns on the relationship between these macroparameters b_1 and b_2 and the microparameters b_{1f} and b_{2f}. In order to facilitate the expression of the macroparameters in terms of the microparameters, the following auxiliary equations are defined (after Thiel, 1954)

$$x_{1ft} = B_{1f} X_{1t} + B_{2f} X_{2t} \qquad \text{A2.6}$$

$$x_{2ft} = B_{3f} X_{1t} + B_{4f} X_{2t}. \qquad \text{A2.7}$$

That is, the microvariables x_{1f} and x_{2f} are considered as linear functions of the macrovariables X_1 and X_2 during the period $t = 1, \ldots, T$. No economic meaning should be attached to these relations; they are entirely formal.

Once the auxiliary equations are defined it can be shown that:

$$b_1 = \frac{1}{S} \sum_{f=1}^{S} b_{1f} + S\left[\text{cov}\ (b_{1f}, B_{1f}) + \text{cov}\ (b_{2f}, B_{3f})\right] \qquad \text{A2.8}$$

$$b_2 = \frac{1}{S} \sum_{i=1}^{S} b_{2f} + S\left[\text{cov}\ (b_{1f}, B_2 f) + \text{cov}\ (b_{2f}, B_{4f})\right]. \qquad \text{A2.9}$$

The terms in the square brackets are defined as the aggregation bias. The importance of this aggregation bias for parameter estimation is as follows. The macroparameter b_1 depends not only on the 'corresponding microparameters' b_{1f}, but also on the other 'noncorresponding microparameters' b_{2f}. The same applies to b_2. In our example, this means that the parameter describing the influence of the machinery input index on the total demand for farm labour is dependent not only on the way individual farmers react to the price of machinery, but also on the way individual farmers react to changes in the prices of farm labour.

It should be pointed out that this definition of aggregation bias depends upon the definition of the macrovariables in A2.3, A2.4, A2.5, and upon the definition of the auxiliary equations A2.6 and A2.7. Under certain conditions relating to the macrovariables or the auxiliary equations, the aggregation bias in A2.8 and A2.9 will vanish:

(i) If all the coefficients of the microequations are constant, that is,

$$b_{1f} = b_1 \quad \text{and}$$
$$b_{2f} = b_2 \quad \text{for all } f,$$

the covariance terms in A2.8 and A2.9 equal zero, and the aggregation bias terms vanish. In our example, this implies that all individual farmers have identical demand functions.

(ii) If all the coefficients in the auxiliary equations are constant, that is,

$$B_{1f} = B_1$$

$$\vdots$$

$$B_{4f} = B_4 \text{ for all } f,$$

then the aggregation bias vanishes along with the covariance terms in A2.8 and A2.9. A special case of this condition is that in which the 'non-corresponding coefficients' in the auxiliary equation are zero, that is,

$$B_{2f} = B_{3f} = 0 \text{ for all } f.$$

Under this condition, the noncorresponding macrovariables are not correlated with the microvariables among the individuals, and the relation between x_{1f} and X_1 is the same for all individuals, f, implying, for instance, that prices and wages are the same for all individuals.

(iii) If the macrovariables are defined as weighted sums

$$X_{1t} = \sum_{f=1}^{S} \lambda_{1f} x_{1ft}$$

$$X_{2t} = \sum_{f=1}^{S} \lambda_{2f} x_{2ft}$$

then the micromodel becomes

$$y_{ft} = \frac{b_{1f}}{\lambda_{1f}} (\lambda_{1f} x_{1ft}) + \frac{b_{2f}}{\lambda_{2f}} (\lambda_{2f} x_{2ft})$$

and it can be shown that

$$b_1 = \frac{1}{S} \sum_{f=1}^{S} \frac{b_{1f}}{\lambda_{1f}} + \left[\text{cov}\left(\frac{b_{1f}}{\lambda_{1f}}, \lambda_{1f} B_{1f}\right) + \text{Cov}\left(\frac{b_{2f}}{\lambda_{2f}}, \lambda_{2f} B_{3f}\right)\right]$$

$$b_2 = \frac{1}{S} \sum_{i=1}^{S} \frac{b_{2f}}{\lambda_{2f}} + \left[\text{cov}\left(\frac{b_{1f}}{\lambda_{1f}}, \lambda_{1f} B_{2f}\right) + \text{Cov}\left(\frac{b_{2f}}{\lambda_{2f}}, \lambda_{2f} B_{4f}\right)\right]$$

where the terms in the square brackets constitute the aggregation bias, and vanish when

$$\frac{b_{1f}}{\lambda_{1f}} = \frac{b_1}{\lambda_1} \quad \text{and}$$

$$\frac{b_{2f}}{\lambda_{2f}} = \frac{b_2}{\lambda_2} \quad \text{for all f.}$$

Note that (i) is a special case of (iii), in which

$$\lambda_{1f} = \lambda_{2f} = 1 \quad \text{for all f.}$$

A consequence of the nonfulfillment of the above conditions is that there will be a discrepancy between the estimated parameters of the macroequation and the simple or weighted averages of the corresponding microparameters.[1] In other words, only under certain conditions can the macroparameter estimates be interpreted as reflecting the analogous microparameters describing the behaviour of individuals.

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[1] This is ignoring other sorts of bias that may enter into the macroparameter estimates.

APPENDIX 3

THE STATISTICAL MODEL AND IDENTIFICATION

This Appendix considers the properties of the statistical model described in Chapter 5, and establishes the identification of the simultaneous equations. The model (5.1 to 5.4), which assumes that the levels of employment in each of the components (S^*, F^*, H^*) and the farm wage rate (w^*) are determined endogenously within the system, can be presented in matrix form

$$\begin{bmatrix} S^* & F^* & H^* & W^* \end{bmatrix} \begin{bmatrix} 1 & -b_4 & -b_9 & 0 \\ 0 & 1 & 1 & 0 \\ 0 & 0 & 0 & 1 \\ 0 & -b_5 & -b_{10} & -b_{14} \end{bmatrix} + \begin{bmatrix} 1 & r^* & n^* & T^* & p^* & c^* & L^* \end{bmatrix} \begin{bmatrix} -a_1 & -a_2 & -a_3 & -a_4 \\ -b_1 & 0 & 0 & 0 \\ -b_2 & -b_7 & -b_{12} & -b_{15} \\ -b_3 & 0 & 0 & 0 \\ 0 & -b_6 & -b_{11} & 0 \\ 0 & -b_8 & -b_{13} & 0 \\ 0 & 0 & 0 & -b_{16} \end{bmatrix}$$

$$= \begin{bmatrix} u_1 & u_2 & u_3 & u_4 \end{bmatrix} \qquad \text{A3.1}$$

The model (A3.1) represents a 'bloc recursive' system. A bloc recursive system is one that has a special combination of zero coefficients attached to the endogenous variables, and the assumption that every error term is independent of errors in another bloc (Wonnacott and Wonnacott, 1970, p. 195). The first column of the matrix of coefficients associated with the endogenous variables in (A3.1) has zero values in all but the first row, indicating that the endogenous variable S^* is determined independently of the other endogenous variables. The errors u_1 associated with the first equation are thus assumed independent of the errors u_2, u_3, u_4, associated with the remaining equations in the system.

Thus the single equation for S^* comprises the first bloc. The value for S^* then becomes a predetermined variable in the second bloc of three equations in which F^*, H^*, and w^* are determined simultaneously. Therefore, the model (A3.1) may be reformulated as a system comprised of two blocs

$$S^* + \begin{bmatrix} 1 & r^* & n^* & T^* \end{bmatrix} \begin{bmatrix} -a_1 \\ -b_1 \\ -b_2 \\ -b_3 \end{bmatrix} = u_1$$

and

$$\begin{bmatrix} F^* & H^* & w^* \end{bmatrix} \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 1 \\ -b_5 & -b_{10} & -b_{14} \end{bmatrix} + \begin{bmatrix} 1 & S^* & p^* & n^* & c^* & L^* \end{bmatrix} \begin{bmatrix} -a_2 & -a_3 & -a_4 \\ -b_4 & -b_9 & 0 \\ -b_6 & -b_{11} & 0 \\ -b_7 & -b_{12} & -b_{15} \\ -b_8 & -b_{13} & 0 \\ 0 & 0 & -b_{16} \end{bmatrix} = \begin{bmatrix} u_2 & u_3 & u_4 \end{bmatrix} \qquad \text{(A3.3)}$$

The first bloc (A3.2) determines the value of S^*. In the second bloc (A3.3) the value of S^* is predetermined and thus exogenous to the system which determines the values of F^*, H^*, w^*.

The simultaneous system of structural relations which comprise the second bloc (A3.3) may be written

$$y\Gamma + xB = u \qquad \text{(A3.4)}$$

where y = the vector of endogenous variables (F^*, H^*, w^*);

Γ = the matrix of coefficients associated with the endogenous variables;

x = the vector of exogenous variables (S^*, p^*, n^*, c^*, L^*);

B = the matrix of coefficients associated with the exogenous variables;

u = vector of error terms (u_2, u_3, u_4).

The system (A3.4) may be solved for the jointly dependent variables y to obtain the reduced form

$$y = -xB\Gamma^{-1} + u\Gamma^{-1} . \qquad \text{(A3.5)}$$

This is written simply as

$$y = x\pi + \nu \qquad \text{(A3.6)}$$

where

$$\nu = u\Gamma^{-1} \qquad \text{(A3.7)}$$

and

$$\pi = -B\Gamma^{-1} . \qquad \text{(A3.8)}$$

The reduced form is the explicit solution of the structural form (A3.4) for y, and represents an alternative way to expressing the model embodied in (A3.4). The basic characteristic of the reduced form is that the original system has been solved to express the values of the endogenous variables as functions of all the other variables in the system, so that each equation of the reduced form contains only one endogenous variable. The reduced form coefficients π, associated only with exogenous variables, can be seen from (A3.8) to be composites of the structural coefficients B and Γ.

Provided there is sufficient independent variation of the elements of x from one observation to another, there will be no difficulty in determining the coefficients of π. The identification problem turns on the question whether or not the coefficients of a particular structural relation, that is, a column of B and Γ, can be unambiguously inferred from the reduced form coefficients π. Lack of identification is indicated by the fact that a structural coefficient cannot be deduced from the reduced form, but it has the much wider implication that the structural coefficient can in no way be inferred from the observed data.

It might well be asked why an effort is made to identify the structural relations, since the reduced form coefficients, which are readily estimated, determine the value of the endogenous variables for any given value of the predetermined variables.

Surely the reduced form coefficients supply all the necessary information about the process under review for purposes of prediction and policy?

The reasons why they do not, and why it is necessary to try to establish the structural coefficients have been given by Marschak (1953). The fundamental argument is that, by its very definition, each structural relation describes a specific and distinct link in the process of concern, in this case farm labour employment. This autonomy means that a change in one structural relation does not affect the operation of the others. Thus, a change in the response of hired farm labour to farm and nonfarm income opportunities will affect the hired labour supply relation, but will not affect the hired labour demand relation or the unpaid family employment relation. If it is known what happens to the hired labour supply relation, the corresponding column of coefficients of the structural model may be adjusted accordingly while leaving all other coefficients unchanged. However, if the structural coefficients are not known, it is not possible to indicate in what way a change in hired labour responses will affect the reduced form. Hence, reduced form coefficients can be safely used for prediction only if it is certain that there are no changes in structure; and reduced form coefficients are of very limited use in policy formulation since, by themselves, they provide no information on the particular processes determining employment change.

The autonomous character of structural relations also means that the structural coefficients are more stable, more like physical constants, than are the reduced form composites. Structural coefficients are therefore more easily judged by intuition, and their values and changes better capable of reasonable discussion and interpretation than is the case with reduced form coefficients (Cramer, 1971). In fact, the only way to provide a reasonable test of a model is to compare the estimated structural relations with the hypothesized relationships.

Operationally, there are necessary, and necessary and sufficient conditions which must be met in order that a structural relation be identified (Koopmans and Hood, 1953). The necessary (order) condition for identification is that the total number of predetermined variables excluded from the equation must be at least as great as the total number of endogenous variables in the equation less one. That is

$$m_o > q - 1$$

where m_o = number of predetermined variables excluded from an equation;

q = number of endogenous variables included in the equation.

This order condition is met in each of the three structural relations in the bloc (A3.3).

Order Condition on Structural Equations

of Bloc A3.3

	m_o (exog. vars. excl.)	q - 1 (endog. vars. incl.) -1
unpaid family	1	1
hired demand	1	1
hired supply	3	1

The necessary and sufficient (rank) condition is that the coefficient matrices for the variables omitted from the equation, Γ_o and B_o, form a matrix that is of full rank. That is,

$$\text{rank} \begin{bmatrix} \Gamma_o \\ B_o \end{bmatrix} = Q - 1$$

where Γ_o = matrix of coefficients from Γ for variables excluded from the equation;

B_o = matrix of coefficients from B for variables excluded from the equation;

Q = number of equations.

Under the maintained hypotheses the rank condition is met in each of the three structural equations of the bloc A3.3[1].

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[1] It is possible that the coefficients, once estimated, are so related as to make the matrix less than full rank. However, no such relation is known to exist *a priori*, and for such a relation to hold by coincidence would be practically impossible (Wonnacott and Wonnacott, 1970).

Rank Condition on Structural Equations

of Bloc A3.3

Equation	matrix of coeffs for vars. excl. from equation	rank	Q - 1
unpaid family	$\begin{bmatrix} 1 & 1 \\ 0 & -b_{16} \end{bmatrix}$	2	2
hired demand	$\begin{bmatrix} 1 & 0 \\ 0 & -b_{16} \end{bmatrix}$	2	2
hired supply	$\begin{bmatrix} 1 & 0 \\ -b_4 & -b_9 \\ -b_6 & -b_{11} \\ -b_8 & -b_{13} \end{bmatrix}$	2	2

The rank and order conditions are met in each of the three structural relations in the bloc (A3.3). The unpaid family employment equation and the hired labour demand equation are exactly-identified, and the hired labour supply equation is over-identified. Thus, all structural coefficients can be determined, or are identified, but the value of those in the hired labour supply relation can be ascertained independently from the reduced form coefficients (π) by alternative routes. In such over-identified models, where there are more exogenous variables than necessary to identify the relation, 2SLS provides an efficient estimating technique. 2SLS estimates were calculated using the 'Dynamic 2S3S Least Squares' program on the McMaster University CDC 6400 computer facility.