RURAL ECONOMY

Science, Technology, and Competitiveness in Alberta's Agriculture and Food Sector

T.S. Veeman, Y. Peng, and A.A. Fantino

Project Report 97-04

Alberta Agricultural Research Institute Project No. 940519

PROJECT REPORT

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Table of Contents

List of Tables

List of Figures

Abstract

This project addresses several issues related to efficiency, productivity, and competitiveness in Alberta's agriculture and food sector, in both its primary agricultural sector and its secondary processing industry related to food and beverages. A major underlying theme of this work is that the competitiveness and economic sustainability of Alberta's agriculture and food sector is considerably driven by long run trends in productivity.

Two emerging trends in Alberta's agriculture and food sector are initially documented: the increasing role of specialty crop production and the rising importance of value added production. Productivity trends and competitiveness issues are examined for Alberta's primary agricultural production sector. Index numbers for agricultural output, aggregate input, and (total factor) productivity were constructed, using Tornqvist-Theil indexing procedures, for both Alberta and the Prairies for the period 1948 to 1994. Alberta's annual output growth rate of 2.43 percent and its productivity growth rate in agriculture of 1.9 percent over this time period closely mirror output and productivity performance for the entire Prairies. Since 1978, however, both output growth and productivity performance in Alberta has been somewhat slower than in the prairie region as a whole.

The foregoing aggregate productivity trends in primary agriculture mask considerably different trends for the crops sector in Alberta versus the livestock sector. Both crop output growth and crop productivity growth have been consistently stronger than output and productivity growth in the livestock sector. Productivity, for example, has grown annually at 2.75 percent in the crop sector but only at 0.81 percent per year in the livestock industry in Alberta. Alberta's lagging agricultural productivity performance since 1980, albeit with some modest recovery in the 1990s, is largely attributable to negative productivity growth in the livestock sector. Historical productivity performance in the crops and livestock sectors in Alberta roughly parallels experience in nearby American states.

A simple econometric model was constructed to explore the relationship between total factor productivity (TFP) in primary agriculture and proxies for expenditures on research and development (R&D). Lagged R&D expenditures are found to be a statistically significant influence on productivity, lending empirical credence to the widely held belief that expenditures on R&D are vital to productivity growth in agriculture.

The Alberta food and beverage industry is one of the largest manufacturing industries in the province, and it has been greatly influenced by the implementation of recent trade agreements, as well as rapidly changing global business environments, changing consumer preferences, and rising living standards. Therefore, the performance of the industry is critical to Alberta's economy. In the thirty-two year period of 1961-1993, the Alberta food and beverage industry has experienced fundamental structural changes toward greater scale economies featured by higher levels of concentration and larger facilities. The number of plants has been reduced by 40%. On the other hand, the industry's total value added rose 2.6 times. As a result, the average value added per establishment has been growing at an annual compound rate of 4.67%, so that the 1993 level is 4 times the level in 1961. Despite this gain, the average scale of production is larger at the

national level, and the difference between the two tends to be wider in the last ten years of the study. The competitiveness assessment of the food and beverage industry shows the overall Canadian sector performed better in terms of profitability and market share.

Total factor productivity, measured by the index number approach, has been used to assess the performance of the food and beverage industry in both Alberta and Canada in this report. Although both output and inputs grow faster in Alberta than in Canada, Alberta's TFP growth in the processing sector has been sluggish, if not negative. In the period of 1961-1974, TFP climbed marginally at annual rates of 0.33% for Alberta and 0.35% for Canada. But in the period of 1974-1993, with annual decreasing rates of 1.52% and 1.15% respectively, the food and beverage industries in both Alberta and Canada suffered from a loss of productivity, with the Canadian sector in a relatively better position. Factors which affect the growth of TFP include: lagging research and development, excessive cost of inputs, and sluggish market demand.

In comparison to the food processing industry overall, Alberta's slaughtering and meat processing industry shows much more promising performance. Overall it is in the strongest position among all Alberta food and beverage industries, and it is also more competitive than its Canadian counterpart. The red meat industry in Alberta, especially the beef packing subsector, has benefited from structural change in the industry, the exploitation of economies of scale, and increases in labour productivity.

Finally, it is important to note the beneficial impacts that productivity improvement in primary agriculture has on the processing sector, and vice versa. Gains in productivity in primary production may be transferred to the processing sector in the form of cheaper inputs. Conversely, efficiency gains in the processing sector result in an increased derived demand for the products of primary agriculture. Policies which encourage productivity growth in either sector can increase the competitiveness of both sectors. Further, policies which stimulate increased expenditure on research and development lie at the heart of productivity enhancement in both primary agriculture and the food processing sector.

Introduction

Nature and Scope of the Problem

The objective of this research is to address a number of issues related to efficiency, productivity, and competitiveness in Alberta's agriculture and food sector. These issues are important to the Alberta economy and to the viability of agriculture and food industries within the province. This is particularly true of industries that are attempting to penetrate the increasingly competitive international market. Overall economic efficiency in production is the result of both technical and allocative efficiency. Technical efficiency is closely linked to productivity, where total productivity is defined as the ratio of physical output produced to the quantity of all inputs used in production. Allocative efficiency deals with the correct allocation of resources in production; this can be an important consideration in cases of subsidies or protective barriers.

The measurement and assessment of agricultural productivity is essential not only for a better understanding of agricultural growth but also for understanding issues of long run competitiveness and economic sustainability. Measurement of productivity and the analytical study of productivity variation over time and across regions are both useful tools for policy makers and other economic agents. Total factor productivity is the measure of choice, avoiding the distortions found in partial measures due to substitution and other factors. This study looks at total factor productivity in both the primary agriculture industry as a whole in the prairie region and in Alberta and also for individual sectors within the industry. Both the crop and livestock sectors in Alberta are examined and compared, giving an example of the relative rates of total factor productivity for each area.

The food and beverage industry is one of the largest manufacturing industries in Alberta, whether measured by the amount of value-added, the value of shipments, or by the number of employees. In recent years, all three of these indicators have consistently increased in the food and beverage sector. Changing global and domestic markets, along with increased competition and market availability made possible by recent trade agreements, combine to make efficiency and competitiveness of increasing importance for the food and beverage sector. In this work, we consider the competitiveness of food and beverage industries in both Alberta and in Canada as a whole. Using a framework developed by Van Duren *et al* (1991) for diagnosing the competitiveness of a firm or industry, profitability and market share are analysed to give an indication of the competitiveness of the Canadian and Albertan sectors. In order to fully realize the efficiency and competitiveness of the food and beverage industries being considered here, it is necessary to adopt the concept of total factor productivity. Defined as the aggregated output quantity index divided by the aggregated input quantity index, total factor productivity is measured in this study using the Tornqvist-Theil index.

Better understanding the competitiveness, efficiency and, accordingly, productivity, of the agriculture sector in Alberta aids in the planning and implementation of strategies best suited for the changing face of agriculture and food industries today. The complex relationship between value-added industries, specialty crops, food and beverage manufacturing, and farm gate production all combine to make Alberta agriculture and food production unique. Analysis of these structures contributes to a better understanding of the future of agriculture and food industries in Alberta and their role in both the international and domestic markets.

Objectives

The general objective of this research is to assess the competitiveness of Alberta's agriculture and food industry, emphasizing the role that scientific advance, research funding, and productivity improvement play in determining our domestic and global competitiveness and in enhancing our possibilities for increased value-added. The study centred initially on the primary farming sector (both crops and livestock) and then, to a lesser degree, addresses the secondary processing sector. The specific research objectives of the research are:

1. To provide an overview of the system for research agriculture in Canada and in Alberta.

2. To analyze changes in the output mix in farming and agricultural processing in Alberta, emphasizing the roles of specialty crops, value-added products and high technology inputs.

3. To provide an evaluation of the technical efficiency of Alberta agriculture, assessing measures of partial productivity (such as output per person and yield) as well as estimates of total factor productivity for Alberta agriculture and its major sub-sectors, crops and livestock.

4. To test the following hypotheses: (a) that livestock productivity has lagged behind crop productivity (parallelling what has occurred in the United States) and (b) that the rate of productivity advance has slowed down in recent years.

5. To make comparisons of relative (technical) efficiency levels and productivity growth between Alberta and some of its major competitors who also produce crops and red meats.

6. To document and analyze the research and development effort related to Alberta agriculture and to examine the major scientific and technological advances which have influenced efficiency in agriculture in Alberta, with major emphasis on crop improvement.

7. To assess qualitatively and to estimate econometrically the contributions that research, schooling, and other socio-economic factors might have made to agricultural productivity.

8. To examine trends in technical efficiency in the agricultural and food processing sector and briefly assess the impact of government policy, particularly research and development policy, on the sector.

9. To make policy recommendations regarding the role that science, technology and research play in improving the technical efficiency and competitiveness of Alberta's agriculture and food sector.

The technical review committee adjudicating this project recommended that attention be paid to the value-added and processing components of this study and this advice has been followed in the ensuing report. Accordingly, more attention was paid to Objectives 2 and 8.

Format of the Report

The report is presented in four further sections. In the first section, a brief overview is given of the increasing roles of the specialty crop production in Alberta primary agriculture and the increasing importance of value added production. In the second section, productivity trends and competitiveness are discussed for primary agriculture in Alberta and the Prairies, and productivity growth is analyzed separately for the crops and livestock sectors in Alberta. An econometric model is estimated to show the influence of lagged R&D expenditures on productivity. In the third section, the competitiveness of Alberta's secondary food and beverage industries is analyzed in terms of profitability proxies and changing market share, and compared with its overall Canadian counterpart. Productivity growth is also estimated and assessed in the processing sector, parallelling and complementing the productivity analysis conducted for the primary agriculture. Finally, in the last section, a summary and the conclusions of the report are stated.

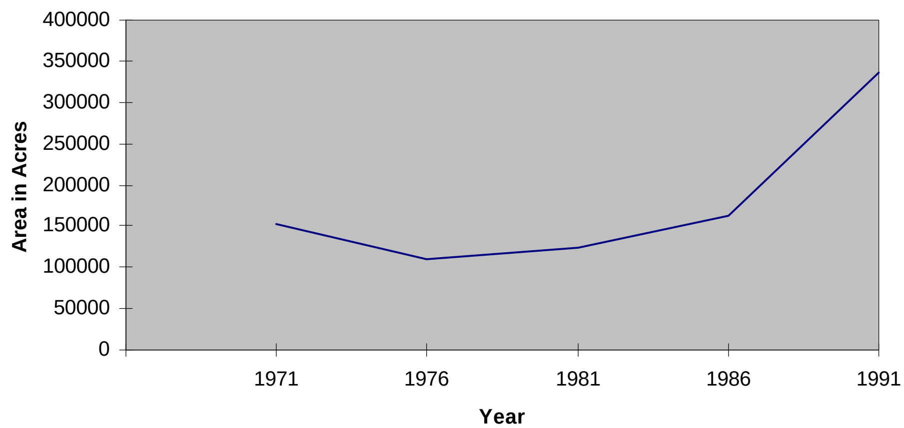
Recent Changes in Alberta Agriculture: The Increasing Roles of Specialty Crops and Value-Added Production

Specialty Crops[1]

Specialty crop production has become increasingly important in Alberta. The amount of land devoted to producing specialty crops--defined here as soybeans, corn, sugar beets, potatoes, vegetables, apples, other fruit trees, strawberries, other berries and grapes, floriculture and nursery, tobacco, ginseng, mustard seed, sunflower seed, lentils, canary seed, dry beans, dry peas, forage and grass seed, hay and clover, maple products, and miscellaneous crops--has more than doubled since 1971. As shown in Figure 1, specialty crop production in 1991 encompassed 336 thousand acres of farm land in Alberta. In 1995, roughly 750,000 acres were provisionally estimated to be planted to specialty crops (Alberta Agriculture Statistics Yearbook, 1995). Early 1996 Agriculture Census figures for Alberta indicate that five major specialty crops alone--field peas (286,000 acres), mustard seed (nearly 92,000 acres), sugar beets (36,000 acres), potatoes (31,000 acres), and dry field beans (28,000 acres)--accounted for nearly half a million acres.

Figure 1

Area Growing Specialty Crops In Acres in Alberta

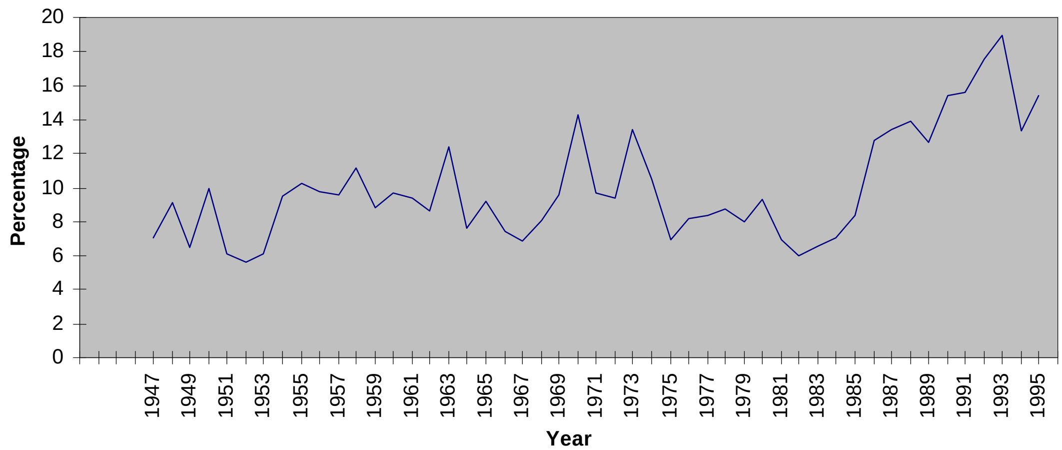


Although specialty crops accounted for only 0.653 % of total agricultural land use, in 1991 their production was responsible for 15.6% of total cash receipts received by crop growers. Since 1982, the percentage of cash receipts derived from specialty crop production has steadily risen, until, in the early 1990s, specialty crops consistently account for about 15% of total cash receipts. In years such as 1993, when total cash receipts are low in real dollars, specialty crops account for

[1] The data for this section and the included graphs were obtained from Statistics Canada

an even higher percentage of total receipts, this figure reaching 18.9% in 1993. Figure 2 illustrates the trend of specialty crop cash receipts as a percentage of percentage of total cash receipts.

Figure 2
Specialty Crop Cash Receipts as a Percentage of Total Cash Receipts, Alberta

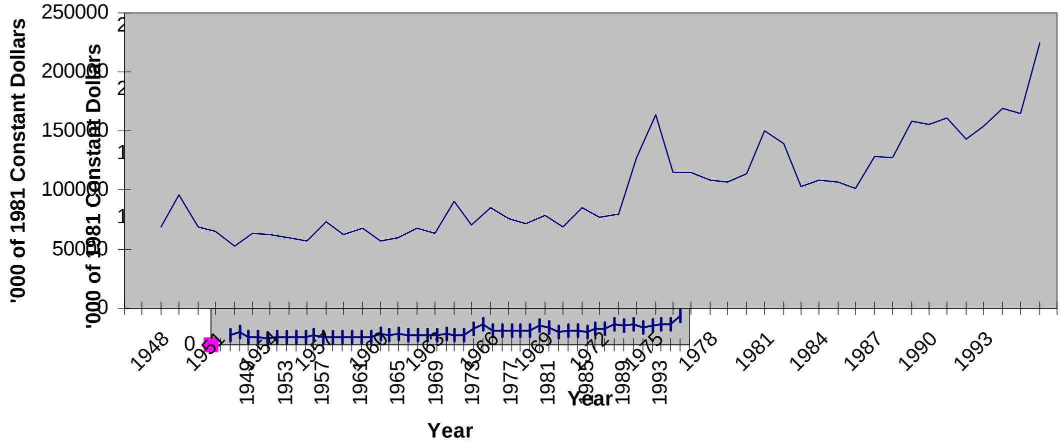


Considering the total cash receipts from all crop production combined, and specialty crop cash receipts in constant dollars, two trends emerge. Primarily, it would seem that total cash receipts have fluctuated over the period of 1947 to 1995, as shown in Figure 3.

Figure 4

Specialty Crop Cash Receipts in 1981 Constant Dollars, Alberta, 1947-95

Specialty and Total Crop Cash Receipts in 1981 Constant Dollars, Alberta, 1947-95



Indeed, since reaching a peak in 1981, total cash receipts have fallen, reaching their lowest levels since 1973, in 1992. Although an increase is seen in the last two years for which data was available, in real terms, agricultural crop cash receipts are, in 1995, still below what they were in the early 1980s. Conversely, cash receipts for specialty crops in constant dollars exhibit a fairly steady increase over the 48 year period. Figure 4 reveals that cash receipts for specialty crops reached their highest observed level in 1995.

Since 1971, the acreage devoted to specialty crops has increase greatly, and the cash receipts derived from their production, have tripled in real terms. It is not surprising that the production of crops which require less than 2% of the land base to produce more than 15% of total cash receipts from crop production has been increasing. Indeed, the trend of increasing amounts of land being devoted to specialty crop production seems to be continuing. Similarly, specialty crops in Alberta are accounting for more and more of the total income received from crop production. Given these observations, it is clear that specialty crops are of increasing importance in the Alberta agricultural sector, both in term of income and land use.

Value-Added Products[2]

Growing incomes and populations have led to increasing demand for consumer orientated food products. The main focus of this increase has been in manufactured food products, and in industrial products made with food and fibre ingredients. Value-added in the food and beverage

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[2] This section was developed using information and data from Statistics Canada and from *Change Course! The Value-Added Agri-Food & Fibre Strategy for Alberta*, a Toma & Bouma (1996) report.

sector has become increasingly important on the international and domestic market, conversely, the demand for bulk foods with low processing has been stable or declining. Alberta is the largest provincial producer of agri-food products at the farm gate. However, the food processing sector in Alberta lags behind that of many other provinces. Indeed, as Table 1 shows, the ratio of manufactured shipments to farm gate receipts in Alberta has grown only marginally in the ten year period between 1984 and 1994. This figure implies the relative level of processing taking place in Albert in relation to agricultural production, shown here as almost one to one.

Table 1. Ratio of Manufacturing Shipments to Farm Gate Receipts

Province or Region	1984	1994
Atlantic	3.47	4.22
Quebec	3.16	2.88
Ontario	2.72	3.41
Manitoba	0.83	0.70
Saskatchewan	0.20	0.21
Alberta	0.95	1.04
British Columbia	2.73	2.75
Canada	1.77	1.8

Source: Toma and Bouma (1996), p.8, based on Statistics Canada.

Value-added in the food and beverage sector in Alberta is low in comparison to Ontario and the Atlantic provinces. For every dollar of farm cash receipts, Alberta industry adds $0.24 to the value, where the Atlantic provinces add $1.79 and Ontario adds $1.39. However, when considering the other prairie provinces, Alberta's value-added sector compares favourably. Recently, Alberta has experienced a marked growth in agri-food exports. Overall, agri-food exports grew by 33% from 1990 to 1994. Within this total export growth, the growth of exports of consumer oriented products has been extremely large. The value of these exports has nearly doubled since 1990, a total increase of $538 million in value. These results are illustrated in Table 2.

Table 2. Alberta Agri-Food Exports by Product Class and Value ($M)

Product Class	1990	1994	Absolute Change	Percent Change
Bulk Products	$1 999	$2 335	$336	+16.8
Intermediate	$156	$180	$24	+15.4
Consumer Oriented	$544	$1 082	$538	+98.9
TOTAL	$2 699	$3 597	$898	+33.3

Source: Toma and Bouma (1996), p.9, based on Statistics Canada.

The consumer oriented sector of the food and beverage industry is growing rapidly, and concurrently, the demand for agricultural products with a considerable amount of value added. Alberta is a large producer of raw agricultural products, but, when compared with Ontario and the Atlantic provinces, it lacks the value-added dimension necessary to take full advantage of the new product markets. As food markets open in Asia and other areas, the demand for consumer oriented food and fibre products stands to increase even further. The growth in value added processing on a global level is a continuing trend. Alberta has yet to seize the full potential of this growing market but certainly, the possibility is there for marked increases in the amount of value added in the agri-food sector in Alberta.

Productivity Growth in Prairie Agriculture: The Primary Sector

Agricultural Productivity: Its Importance and Measurement

The measurement and assessment of agricultural productivity is essential not only for better understanding of agricultural growth but also for the issues of longer run competitiveness and economic sustainability. Comparisons of productivity over time are obviously important in assessing whether trends in the technical efficiency of production are increasing or decreasing. Productivity comparisons across regions, or industries, are also important. The agricultural sector is the focus of this research. Measurement of productivity and the analytical study of productivity variation over time and across regions are useful to policy makers and the economic agents involved. Moreover, an increased understanding of the factors that affect productivity and impinge on the ability of sectors or regions to remain productive are of critical relevance to competitiveness and economic well-being. This section is devoted to the measurement of agricultural productivity in the Province of Alberta by means of the methodology used in previous research commissioned under Farming for the Future and the Alberta Agricultural Research Institute--see Veeman, Fantino and Rahuma(1989), Veeman and Fantino(1994) and Veeman, Fantino and Peng(1995, Section IV).

Much productivity analysis and comparisons are based on partial productivity measures such as yield per acre (land productivity) or output per person (labour productivity). Such partial productivity measures, although useful for some purposes and contexts, may offer a distorted picture of the productive process when rapid increases in output are related to increased usage of other inputs, such as capital or fertilizer. In fact, partial productivity measures can be seriously misleading if considerable input substitution is taking place. A conceptually superior way to estimate productivity is to measure total factor productivity (TFP)--the ratio of aggregate output over the aggregate of all inputs used in agricultural production.

Total factor productivity is the focus of this paper. Construction of index numbers for output, inputs and productivity is the measurement methodology. Among the most important and most difficult issues in measuring productivity by the index number route is the choice of an appropriate index number methodology to combine several agricultural outputs into an aggregate output index or to combine several farm inputs, suitably weighted, into an aggregate input index. Most published work on agricultural productivity in Canada, until recently, has involved Laspeyres index number methods--for example, Brinkman and Prentice (1983) and Nayaranan and Kizito (1992). Such indexing procedures, wherein base period prices are used as weights in aggregation, imply that the underlying production function is linear and that inputs in the production process are perfect substitutes. Economists have shown that there is an exact correspondence between a given indexing procedure and the specific functional form of the aggregate production function which the index number procedure implies. The most desirable index, the Divisia continuous index, is approximated by the discrete Tornqvist-Theil index, a “superlative” index which is appropriate to represent production/productivity under a more general “flexible form” production function. A detailed discussion of the advantages and properties of this index can be found in Fantino and

Veeman(1994).

Estimation and Data

In using the index number approach to estimate productivity, total factor productivity (TFP) is estimated as the ratio of the measured aggregate output index to the measured aggregate input index. The growth of total factor productivity can then be estimated as the residual difference between the rate of growth of the aggregate output and the rate of growth of the aggregate input. The first step in estimating productivity, therefore, is constructing indexes of aggregate output and aggregate input. Necessary data for this procedure are production and average prices paid to farmers, as well as input quantities used or (if quantities are unavailable) annual dollar expenditures on inputs. The data set used in previous studies was updated, corrected and extended to cover additional output and inputs for the years 1940 to 1995. Data was obtained from several published and unpublished sources, the main sources being Statistics Canada and Agriculture Canada.

Output is composed of all major crops, including wheat, barley, rye, mixed grain, corn, flax, soybeans, potatoes, hay, rapeseed, and sugar beets, while livestock items include cattle and calves, sheep and lambs, pigs, chickens, turkeys, eggs, and dairy. Inputs include the broad input categories of capital, labour, and intermediate inputs or materials: capital involving land and buildings, summer fallow land, machinery and livestock capital; labour comprising hired workers, unpaid farm operators, and family workers; and material items including fertilizer, pesticides, fuel and oil, electricity, seeds, animal feeds, and irrigation.

The construction of the index for aggregate input involves many conceptual and empirical problems. The major difficulty is that several "durable" inputs, such as land and machinery, are used in production. The best measure of input use is represented by the service flows provided by the stocks, rather than the stocks themselves. The annual service flows of the land, buildings, and livestock capital items were assumed to be opportunity costs imputed as 4 percent of their respective nominal values. For machinery, depreciation and repairs were assumed to be measures of the relevant service flow. The labour input was available in terms of the more appropriate measure of man-hours worked since 1966, and extrapolated for early years on the basis of employment figures. For inputs with an imputed service flow or an actual annual expenditure (such as most material items), an implicit quantity index was computed by dividing the value of the service flow or expenditure by an appropriate price index.[3]

Agricultural Productivity Estimates for Canada and the Province of Alberta

Indexes of output, inputs and total factor productivity calculated according to the methodology described in the previous paragraphs for the aggregated agricultural industry in the Province of Alberta were derived. For the purpose of comparison, similar indexes were calculated

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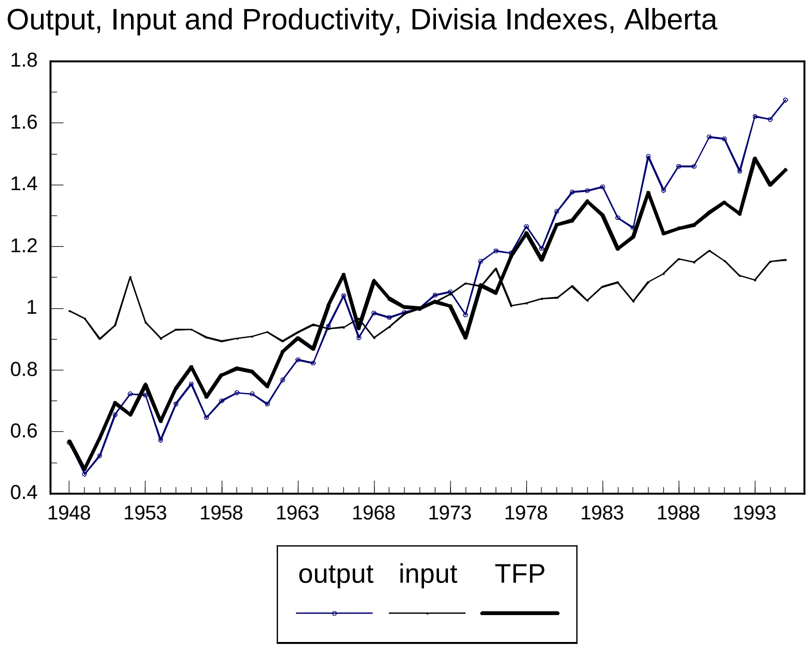
[3] Additional details on data construction and methodology can be found in Veeman and Fantino (1994a), and in Fantino and Veeman (1994).

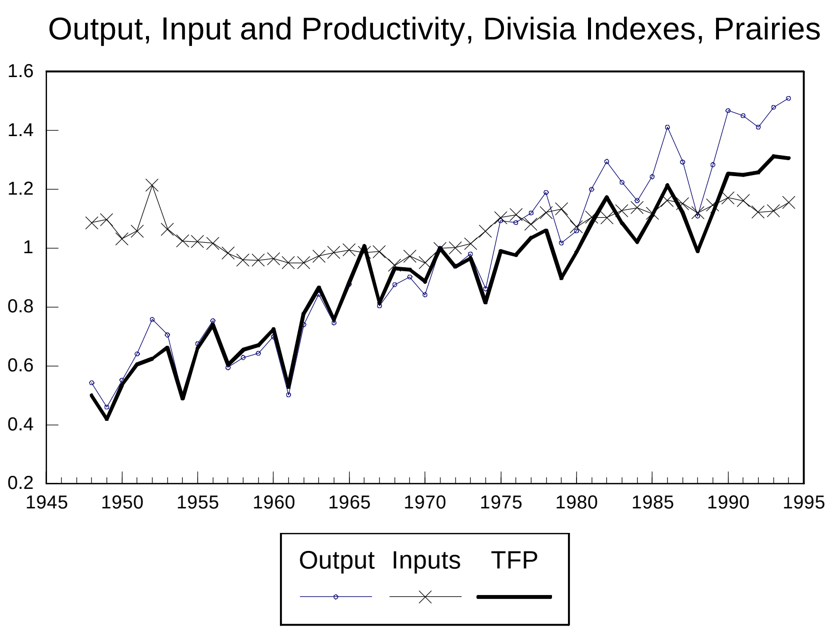
Figure 5



for the Prairie provinces of Western Canada. The measured indexes are presented in Figure 5 and 6 for Alberta and the Prairies, respectively.

The analysis of trends is made difficult by the large yearly fluctuations of the output and productivity indexes which are clearly related to weather and other environmental conditions.[4] Inspection of these charts indicates that, in agreement with previous results, agricultural output and productivity have been growing more or less steadily for the last four decades in both Alberta and the Prairies. The input index exhibits a more complicated time path composed of a downward trend in the 1950s and early 1960s and re-assuming growth afterwards. While the former may be linked to substitution of capital for agricultural labour through mechanization, the latter may be interpreted as the process of intensification in agriculture of the 1970s and early 1980s. Interestingly, the tendency in the late 1980s and early 1990s is for the input index to oscillate while output and productivity continue to grow. There are indications of technical change broadly interpreted so as to include economies of scale, increased technical efficiency and other factors that

Figure 6



are not “pure” technical change[5].

[4] In previous research work for Farming for the Future, the influence of weather on productivity was systematically studied. Yearly fluctuations in output and productivity weather has been shown to be strongly correlated with rainfall and temperature variables; see Veeman and Fantino(1085) and Veeman and Fantino(1990).

[5] “Pure” technical change is defined as any technological improvement or change that shifts a neo-classical cost function. These are changes such as improvements in techniques and

It is nevertheless to be noticed that while during the first half of the period the output and productivity indexes move very closely to each other, the situation changes in the second half of the period where the indexes diverge and a considerable gap appears between them. In the latter, the input index reassumes growth and the output index remains above the productivity index implying that in this period output was growing faster than productivity. The relative behaviour of the indexes in the late 1980s and early 1990s results in a large gap between the output and productivity indexes indicating higher input utilization and a lower incidence of productivity on the important rise in output in the last years of the whole period under analysis.

Computation of rates of index growth over time may be used for a more quantitatively accurate analysis. The estimated rates in Table 3 provide additional clarification of the time path of output, inputs and productivity described in the previous paragraph. The first part of the table presents annual compound rates of growth by decade of output, inputs and total factor productivity for Alberta and the Prairies.

cultural practices, new or improved inputs, introduction of innovations such as new varieties or vaccines, etc.

Table 3. Annual Rates of Growth of Output, Inputs, and Total Factor Productivity(TFP), Alberta and Prairies, Selected Periods, Percent Per Year

PERIOD	ALBERTA			PRAIRIES		
	OUTPUT	INPUTS	TFP	OUTPUT	INPUT	TFP
1950-1960	1.836	-0.764	2.620	0.635	-1.445	2.111
1960-1970	3.761	0.530	3.213	2.622	0.846	1.761
1970-1980	2.894	0.311	2.575	2.230	1.489	0.730
1980-1990	1.253	1.295	-0.040*	1.598	0.638	0.954
1980-1994	1.396	0.756	0.636*	1.938	0.338	1.595
1948-1994	2.430	0.497	1.924	2.279	0.3	1.972
1958-1994	2.321	0.719	1.591	2.345	0.646	1.688
1968-1994	2.038	0.647	1.381	2.071	0.687	1.375
1978-1994	1.527	0.780	0.741	1.926	0.247	1.675

*Estimates are not statistically significant.

In the first decade, the 1950s, both the Prairies and Alberta experience growth in output and a large drop in inputs which is associated largely with the intense process of mechanization that took place at the time. This resulted in significant growth in productivity, averaging more than 2 percent (compound) per year for the Prairies and 2.6% for Alberta agriculture. In the 1950s, agricultural output grew faster in Alberta than in the Prairies as a whole, but input use declined more slowly. Agriculture in Alberta experienced rapid growth in the 1960s with output and productivity growing at a rate greater than 3% per year, much larger rates than experienced by the entire Prairie region. In the third decade, growth continued although at a more moderate pace, the striking feature being the disparity in input growth between the two regions, the small growth for Alberta resulting in an important annual increase in productivity of 2.6%. In the last decade the situation reverses as the Prairies exhibits a modest growth in productivity, whereas Alberta exhibits a growth in input use that more than compensates the 1.25% per year growth in output which results in zero productivity change in the decade.

The second half of Table 3 presents rates of growth for the period ending in 1994, the most recent year covered in this study, with different initial years. The results indicate a clear decreasing trend in the rate of growth in productivity in Alberta, the rates in each subsequent sub-period being smaller, while the same tendency for the prairies is reversed in the last sub-period 1978-1994. Inclusion of the 1990s, however, leads to somewhat higher productivity performance at both the Alberta and Prairie regional levels.

All in all, productivity can be said to be experiencing an overall important improvement in both Prairie and Alberta agriculture in the period under study, although there are signs of a tendency toward a slowdown in productivity growth, particularly for Alberta, at least until the 1990s. The numbers in Table 3 suggest that the historical slowdown, perhaps reversed slightly in the 1990s, is the result of increases in input use leading to a less than proportionate increase in output and therefore a slower pace of productivity improvement.

Sectoral Productivity: The Crop and Livestock Sectors

In this section we turn our attention to the estimation of productivity for particular agricultural sub-sectors. The estimates in the previous section correspond to the whole agricultural sector in that all output and inputs used in agriculture are aggregated. These aggregate measurements give a clear indication of the development of the agricultural sector as a whole and are very useful as such.

However, aggregate measures only give a very general picture of the changes in agriculture, and obviously changes in particular sub-sectors may be obscured by the process of aggregation. In many practical instances a general picture may be insufficient. A detailed knowledge of productivity and other indexes for Canadian agriculture as a whole is of interest in itself but may throw only a dim light to the behaviour of agriculture in a particular geographical region or province. Disaggregation is necessary in order to have a clearer description of the output and productivity trends within different areas of agriculture. For any disaggregation to be effected, complete and adequate data on output and inputs for one or more sectors should be available. In the previous sections estimates were obtained at two levels of geographical aggregation, the Prairies and the Province of Alberta in Western Canada, since the appropriate data is readily available.

This is not the case for most other specific sectors. For example, if Canada’s cereal sector is targeted for productivity measurement, cereal output data is available and plentiful whereas cereal input data is simply not readily available. All agricultural input data is collected in an aggregated form since it would be extremely difficult and costly to determine the specific use of every portion of input. Even if such information exists at a farm or district level or made available in the future, long historical series of sectoral input use will remain unavailable. In the case that a more detailed disaggregation is desired, even the sectoral output data may not exist. Indirect method should therefore be used in dealing with disaggregation, which in turn means that the estimates would be approximations. An important set of sectors in Canadian agriculture is the crop and livestock sectors. Although some econometric methodologies were suggested in the past, they are heavily data demanding and are based on strong assumptions. In this research a method of sectoral input apportionment was used to estimate input and, thence, productivity indexes for the crop and livestock sectors.

Methodology Relating to Sectoral Productivity Measurement

Sectoral output data for the crops and livestock sector is available for each province of Canada; therefore, the apportioning of output to each sector is unambiguously straightforward and output indexes for each sector can therefore be constructed without difficulty. Some inputs can also be unambiguously apportioned to one sector or the other, for example, seeds and irrigation to the crop sector and feeds to the livestock sector. For some inputs, some direct apportionment is possible.

Land used in the crop sector is available as seeded or harvested area, as is summer fallow land. The remaining area was regarded as livestock land and differential land prices were constructed to reflect the higher average price of crop land. Although chemicals are used in both sector, since the bulk of them are involved in crop production, it was assumed that fertilizers and pesticides are inputs for the crop sector. The remaining inputs, particularly important ones such as labour and durables, or machinery, remain difficult to allocate accurately. For these inputs the apportionment was based in the proportion of farms devoted mainly to crops or mainly to livestock in the Census of Canada. Census fractions for all the censuses since 1951 to 1991 were calculated and linearly interpolated in between census years. The fractions obtained in this manner are then utilized to apportion the following flow inputs: labour, fuel and oil, electricity and telephone.

The treatment of durable inputs in terms of opportunity costs and depreciation is the same as described earlier. While the opportunity cost of livestock capital is entirely livestock related, machinery related items are apportioned by means of census fractions. Two inputs series for the crop and livestock sector are so obtained and can be used to calculate TFP, Terms of Trade, and Returns-to-Cost-Ratio indexes.

Empirical Results

The indexes of output, inputs and Total Factor Productivity calculated according to the methodology just described are presented in Figures 7 and 8 for the crops and livestock sectors, respectively, of the Province of Alberta.

Figure 7 reveals that in the first half of the period, output and TFP move close to each other in the crop sector. Both indexes exhibit a rising trend associated with a declining trend of the crop input index. The separation between output and productivity closes out at the base year of 1971 indicating that productivity was growing faster than output in that period. After the base year, however, both indexes diverge again following a rapid rise in the input index. The large, growing gap between the output and productivity indexes suggests that in the second period increases in crop output were the result of increased input use along with improvements in productivity. The period around the base year 1971 is a transition characterized by a steep increase in input use and reduced productivity growth.

Similarly, Figure 8 also suggests two distinct periods for the livestock sector with the transition in the inflationary 1970s. In this case, however, changes in output are less pronounced

Figure 7
Alberta Crop Sector: Output, Inputs and TFP

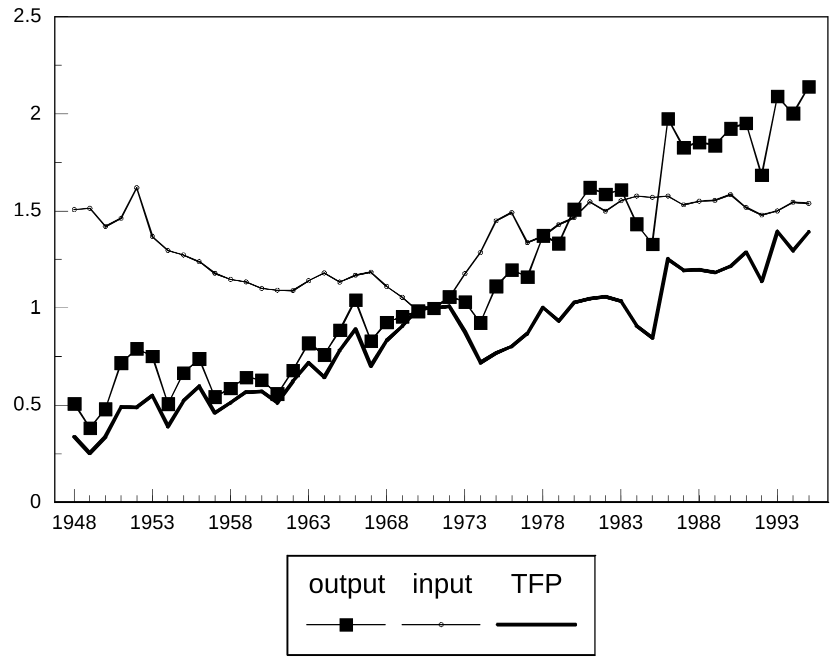
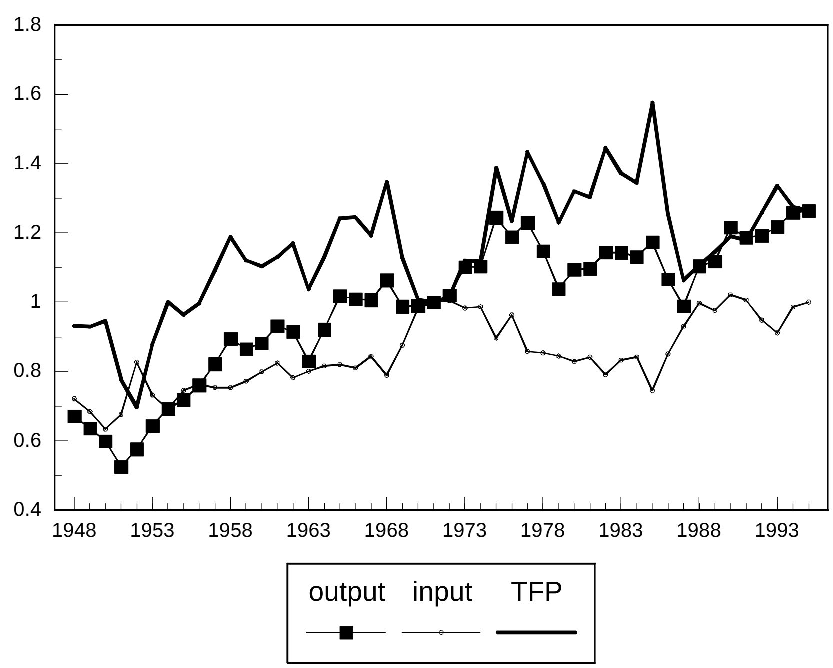


Figure 8
Alberta Livestock Sector: Output, Inputs and TFP



than in the crop sector as are the levels of input use. Two major increases in livestock input use are observed beginning in 1969 and in 1985, respectively, which are correlative to a slow growth in output and productivity. Annual fluctuations of the indexes in Figure 4 may be due to the incidence of the cattle output cycle which also appears to influence productivity. Such fluctuations may also arise due to errors of measurement resulting from inadequate allocation of inputs in each period.

As before, annual rates of growth for all indexes were calculated. These rates provide additional information on the movements of the various indexes in different time sub-periods, and also illustrate the changing patterns to be observed in the crop and livestock sectors. Table 4 presents annual compound rates of growth for output (Y), inputs (X), Total Factor Productivity (Y/X), terms of trade (P_Y/P_X) and returns-to-cost ratio (P_YY/P_XX) for the crop and livestock sectors in the Province of Alberta. Several observations can be made on the results in the table. First, as rates in Table 4 indicates, output and productivity since 1948 for both sectors have grown in the period under study, but they did so at very different rates of growth with the crop sector rates being much higher. The disparity in growth rates is striking for the whole period and each sub-period.

Output growth rates in the crop sector in Alberta are more than double those in the livestock sector. The difference in productivity growth is even more remarkable; crop productivity has grown at more than three times the pace of productivity in the livestock sector. For some sub-periods in the table the difference is even more striking: for 1960-1995, productivity in the crop sector was growing more than five times faster than in the livestock sector. These results are consistent with estimates of agricultural productivity in the United States which also shows the livestock sector lagging behind the crop sector in terms of rate of growth of sectoral productivity (Huffman and Evenson, 1993).

Second, all the production indexes (output, inputs and productivity) exhibit a definite trend for the crop sector while there is no clearly discernible trend in the livestock sector. For the crop sector, output and productivity grew considerably and steadily over the whole period. Nevertheless, despite lower output and productivity growth rates, the livestock sector faced much less intense cost-price (term of trade) pressures than the crop sector and experienced greater growth in its returns-to-cost ratio, a crude indicator of the sector's welfare position over time.

Much faster output growth in the crop sector suggests a higher flexibility of the crop sector resulting from both a more rapid conversion of inputs to be used in the sector and a much higher rate of productivity growth. The role of technological change, including economies of scale, and the introduction of new inputs along with the intensification of their use are important in this regard. These factors in turn increase the long run elasticity of crop supply relative to that of livestock supply. These same factors, on the other hand, also impinge on the economics of agriculture, on agricultural markets, and on the profitability of farming operations. Clearly, however, as the superior returns-to-cost position of the livestock sector demonstrates, relative property of a sector also depends on its market situation--in particular, whether it is influenced by international conditions or merely continental pressures and whether it is afforded some degree of protection.

Table 4. Annual Rates of Growth for the Crop and Livestock Sectors, Alberta Agriculture, 1948-1994, Percent Per Year

Period	Sector	Output	Inputs	TFP	Terms of Trade	Return-to-Cost Ratio
1948-1994	Crop	3.246	0.481	2.752	-3.147	-0.482
	Livestock	1.464	0.564	0.805	0.735	1.545
1950-1994	Crop	3.172	0.629	2.527	-3.124	-0.676
	Livestock	1.429	0.634	0.790	0.797	1.593
1960-1994	Crop	3.486	1.357	2.101	-3.617	-1.592
	Livestock	0.790	0.398	0.391	1.480	1.877
1970-1994	Crop	3.334	1.521	1.785	-4.416	-2.711
	Livestock	0.458	-0.017*	0.475	2.123	2.609
1980-1994	Crop	2.187	0.001*	2.187	-3.208	-1.092
	Livestock	0.757	1.670	-0.898	2.554	1.633
1985-1994	Crop	2.376	-0.429	2.817	-1.642	1.129
	Livestock	1.701	1.943	-0.237*	1.927	1.686

* Estimates are not statistically significant.

Cross-Border Productivity Growth Comparison

An important question is how productivity growth in Alberta's crop and livestock sectors compares with productivity trends in nearby competitors, particularly adjacent states in the United States. Huffman and Evenson (1993) report productivity growth rate of 2.05 percent per year in the crop sector and 0.81 percent per annum in the livestock sector over the period 1950-1982 for the Northern Plains states of North Dakota, South Dakota, Nebraska, and Kansas. The corresponding annual growth rates for the Mountain States which include Montana, Idaho, and Colorado are 0.99 percent for crops and 0.70 percent for livestock. Alberta's productivity growth rates over a somewhat longer time frame, 1950 to 1994, are 2.53 percent per year for crops and 0.79 for livestock. Alberta's growth rates to 1982 would be even higher, since productivity performance, particularly in livestock, has been weaker since the early 1980s, albeit recovering somewhat in the 1990s. It is fair to conclude that Alberta's historical productivity performance in crops and livestock has largely mirrored American experience and, if anything, has been slightly stronger.

Assessing the Contribution of Research and Development to Productivity Growth in Prairie Agriculture

Although it is well known that research and development (R&D) plays an important role in increasing agricultural productivity, little effort has been made to quantitatively assess the relative contribution of R&D to the growth of productivity in prairie agriculture. In this section, a simple econometric model, which assumes that TFP is a function of R&D expenditure, agricultural education and other economic factors such as the term of trade, is constructed and estimated empirically to determine to the impact of R&D on TFP growth.

The Data and Model

Time series data of expenditures on research (public and private) and expenditures on agriculture education in constant dollars for Canada are readily available for 1945-1980, and was proxied by ourselves for the period 1981-1995. Since the same data is not available at the western Canada level, the data for Canada is used as a crude proxy for the relevant prairie figures. Data on the TFP index and the terms of trade have been estimated for the prairies and used for the model.

Since research effort may or may not be productive and it takes time for productive research to be translated into technology which is developed, tested, applied and diffused, its impact will not be immediate. Another point of view is that productivity is affected by a stock of knowledge about technology which is a weighted aggregation of investment in R&D over a period of time in the past. These imply that there exists a lag structure of R&D expenditure when investigating its effect on TFP growth. Several lag structures are applied in this study, which are (i) unrestricted lags, (ii) second order polynomial distributed lags, and (iii) second order polynomial distributed lags with endpoint restrictions. The eight year lag period is considered to be appropriate for the models. The log-log functional form is chosen for the three models and the sum of lag coefficients in any model is the total elasticity of TFP with respect to R&D, which is sometimes called the rate of return of TFP to R&D.

The Estimated Results

The three models are estimated using OLS and reported in Table 5. The education variable is not significant and is removed from the models. The term of trade has a negative effect on TFP in all three equations. F-test results show that the restrictions imposed on the coefficients of lagged R&D variables can not be rejected for either model (ii) or (iii) . The percentage effect on TFP of increasing R&D expenditure by one percent is specified by the sum of lag coefficients, which are 0.32%, 0.28% and 0.32%, respectively across the three models, and are statistically significant. Even this relatively simple set of models suggests a positive influence of R&D expenditures on TFP growth. This issue will be explored further using more sophisticated and disaggregated data set, in our next Farming For the Future technical report.

Table 5. Estimated Results of R&D Models for Prairie Agriculture, 1953-1995

	Unrestricted		Second Order Polynomial		Second Order Polynomial with End Points	
Variables	Parameter	Std. Error	Parameter	Std. Error	Parameter	Std. Error
R&D expenditure(t)	-0.093	0.560	-0.216	0.223	0.017	0.002
R&D exp.(t-1)	0.555	0.636	-0.060	0.122	0.031	0.004
R&D exp.(t-2)	-0.915	0.624	0.057	0.067	0.040	0.005
R&D exp.(t-3)	0.057	0.571	0.132	0.072	0.046	0.006
R&D exp.(t-4)	0.651	0.586	0.167	0.088	0.048	0.006
R&D exp.(t-5)	0.135	0.574	0.161	0.089	0.046	0.006
R&D exp.(t-6)	-0.538	0.523	0.114	0.074	0.040	0.005
R&D exp.(t-7)	0.929	0.509	0.027	0.072	0.031	0.004
R&D exp.(t-8)	-0.457	0.323	-0.102	0.126	0.017	0.002
Terms of Trade	-0.231	0.097	-0.284	0.089	-0.261	0.086
Constant	3.194	0.666	3.403	0.579	3.219	0.176
Sum of Lag Coef's or R&D Elasticity	0.324	0.136	0.279	0.118	0.315	0.041
R^2	0.881		0.860		0.854	
Calculated F-value			0.9395 (df1,2=6,32)		0.9301 (df1,2=8,32)	

Competitiveness and Productivity in Alberta's Food and Beverage Industries

An Overview of Food and Beverage Industries in Alberta

Food is essential to life. The performance of the food processing industry affects consumers' well-being. The food and beverage industry is one of the biggest manufacturing industries in Alberta whether measured by the value added, the value of shipments, or the number of employees. With the implementation of the Canadian-U.S. Free Trade Agreement and the North American Free Trade Agreement, the shift in consumer demand towards more natural and healthy products, as well as the rapidly changing global business environment and economic conditions, Canadian food and beverage industries face challenges and pressures which are stronger than ever.

Table 6 shows the trends of value added, the number of employees and the number of establishments in the food and beverage industry, as well as in total manufacturing, for specific years. To take inflation into consideration, the value added data is deflated to 1986 constant dollar values. The value added for both food and beverage and total manufacturing shows consistently increasing trends. In 1993, value added in the food and beverage sector was 2.58 times its 1961 level, an average annual increase of 3.22%. Similarly, in the manufacturing sector, value added in 1993 was 4.27 times the 1961 level, an annual average increase of 2.46%. On the other hand, the percentage of value added for food and beverage industries as a total of manufacturing has decreased from 28.7% in 1961 to 17.35% in 1993. The decreasing trend has also been supported by the declining percentage of personal disposable income spent on food and beverage consumption. The increased absolute value and the decreased proportion of costs reflect the rising living standard in Alberta, on the other hand, these also impose stronger pressures and challenge the competitiveness of the food and beverage industry. Over the 32 years, the number of employees in the food and beverage industry has increased at an annual rate of 0.87%, while employment in manufacturing industries has been increasing at the annual rate of 2.62%. The fact that value added grows faster than employment indicates growing labour productivity, and possibly a substitution of capital for labour. The number of establishments in the food and beverage industry has dropped dramatically in the 32 years, and the average value added per establishment has increased at 4.8% per annum, indicating the existence of economies of scale in the production structure of Alberta food and beverage businesses.

Table 6. Value Added, Number of Employees and Number of Establishments of Food and Beverage and Total Manufacturing Industries in Alberta for Specified Years

Year	Value added, 1986 constant $, (,000,000)			Number of employees			Number of establishments		
	Food and beverage (1)	Manufa-cturing (2)	(1) as % of (2)	Food and beverage (3)	Manufa-cturing (4)	(3) as % of (4)	Food and beverage (5)	Manufa-cturing (6)	(5) as % of (6)
1961	444.19	1546.95	28.71	13108	39913	32.84	450	1628	27.64
1965	528.36	2035.05	25.96	13367	45435	29.42	471	1774	26.55
1970	654.32	2489.18	26.29	13307	51331	25.92	443	1813	24.44
1975	772.55	3237.84	23.86	15330	64678	23.7	412	1821	22.63
1980	792.51	4485.75	17.67	16133	81206	19.87	394	2388	16.5
1985	843.54	5729.55	14.72	14189	71451	19.86	290	2536	11.44
1990	981.33	6481.51	15.14	15266	91404	16.7	307	2827	10.86
1991	1135.93		18.18	15777	91286	17.28	295	2635	11.2
1992	1147.61	6256.16	18.34	17061	88330	19.32	283	2512	11.27
1993	1144.70	6598.29	17.35	17343	91266	19	271	2439	11.11
1993/1961 Ratio	2.58	4.27		1.32	2.29		.60	1.50	
Annual growth rate	3.22%	4.64%		0.87%	2.62%		-1.58%	1.28%	

Tables 7 and 8 summarize the value added and employment profiles of the seven subsectors which compose most of the food and beverage industry in Alberta. Meat slaughtering and processing is the most dominant subsector, taking about a 30 percent share of total value added, and providing more than 31% of total jobs in the industry. Both value added and employment show a steady increase in the 1960s and 1970s, then decline in the 1980s, and gradually recover in the 1990s. The average annual growth rates of 3.01% in value added, and 1.25% in employment show that meat slaughtering and processing has done relatively well in comparison with the other six subsectors.

The brewery sector's share of the provincial food and beverage manufacturing workforce remained fairly stable over the three decades. The number of employees in 1993 was 1.33 times that in 1961. Its share of value added is characterized by a steady decline in the period between the 1960s and the first half of the 1980s. We saw a jump in 1985, and the share has remained around 9% since that time. However, the absolute level climbed to a maximum in 1991, and diminished in the last two years.

Table 7. Real Value Added of Individual Industries ($M), and Their Respective Shares of Real Value-Added in Total Food and Beverage Industries for Alberta

	Meat	Dairy	Brewery	Bakery	Soft drink	Feed	Flour
1961	134.15	69.34	57.38	51.07	23.59	16.35	27.58
(%)	(30.2)	(15.61)	(12.92)	(11.5)	(5.31)	(3.68)	(6.26)
1965	185.98	89.13	53.68	53.73	26.95	21.72	20.87
(%)	(35.2)	(16.87)	(10.16)	(10.17)	(5.1)	(4.11)	(3.95)
1970	232.87	99.98	57.52	56.47	39.13	34.94	21.2
(%)	(35.59)	(15.28)	(8.79)	(8.63)	(5.98)	(5.34)	(3.24)
1975	273.56	104.84	54.7	53.54	33.76	43.88	18.7
(%)	(35.41)	(13.57)	(7.08)	(6.93)	(5.16)	(5.68)	(2.42)
1980	162.94	109.6	43.35	68.47	63.88	57.06	16.64
(%)	(20.56)	(13.83)	(5.47)	(8.64)	(8.06)	(7.2)	(2.13)
1985	207.6		77.69	52.55	56.77	73.47	14.68
(%)	(24.61)		(9.21)	(6.23)	(6.73)	(8.71)	(1.74)
1990	281.64	109.81	95.19	60.06	57.6	67.71	12.66
(%)	(28.7)	(11.19)	(9.7)	(6.12)	(5.87)	(6.9)	(1.29)
1991	312.15	130.86	113.14	59.86	61.23	73.38	20.67
(%)	(27.48)	(11.52)	(9.96)	(5.27)	(5.39)	(6.46)	(1.82)
1992	371.83	74.6	103.97	81.02	67.02	57.61	14.35
(%)	(32.4)	(6.5)	(9.06)	(7.06)	(5.84)	(5.02)	(1.25)
1993	346.16	43.16	99.82	72.92	91.35	67.65	15.68
(%)	(30.24)	(3.77)	(8.72)	(6.37)	(7.98)	(5.91)	(1.37)
1993/1961 Ratio	2.58	0.62	1.74	1.43	3.88	4.14	0.57
Annual growth rate	3.01%	-1.58%	1.75%	1.12%	4.33%	4.54%	-1.74%

The employment situation in the soft drink sector shows a slow but steady improvement from the 1960s to the middle of the 1980s. Employment dropped significantly in the late 1980s and in 1990 and 1991, but recovered in the last two years of the study. The situation of steadily growing value added did not change until the early 1980s when it began to fall and became increasingly volatile. The 1990s saw a strong and remarkable recovery in the term of its value added.

The feed industry in Alberta has been the most rapidly growing sector in the food and beverage industry in terms of value added, growing at 4.54% annually and employment, growing

Table 8. Number of Employees of Individual Industries and Their Respective Shares of Employment in Total Food and Beverage Industries for Alberta

	Meat	Dairy	Brewery	Bakery	Soft drink	Feed	Flour
1961	4078	2811	557	1791	633	393	704
(%)	(31.11)	(21.44)	(4.25)	(13.66)	(4.83)	(3)	(5.37)
1965	4570	2739	632	1747	627	456	633
(%)	(34.19)	(20.49)	(4.73)	(13.07)	(4.69)	(3.41)	(6.33)
1970	4820	2682	562	1630	810	667	477
(%)	(36.22)	(20.15)	(4.22)	(12.25)	(6.09)	(5.01)	(3.58)
1975	5919	2326	731	1612	917	903	447
(%)	(38.61)	(15.17)	(4.77)	(10.52)	(5.98)	(5.89)	(2.92)
1980	5552	2146	584	1826	1111	969	406
(%)	(34.41)	(13.3)	(3.62)	(11.32)	(6.89)	(6.01)	(2.52)
1985	4349		783	1336	1053	988	315
(%)	(30.65)		(5.52)	(9.42)	(7.42)	(6.96)	(2.22)
1990	5303	2306	613	1337	529	1230	346
(%)	(34.74)	(15.11)	(4.02)	(8.76)	(3.47)	(8.06)	(2.27)
1991	4940	2556	640	1171	665	1194	325
(%)	(31.31)	(16.26)	(4.06)	(7.42)	(4.22)	(7.55)	(2.06)
1992	5392	2532	538	1443	1210	1250	267
(%)	(31.6)	(14.84)	(3.15)	(8.46)	(7.09)	(7.33)	(1.57)
1993	6087	1882	742	1376	1111	1158	286
(%)	(35.1)	(10.85)	(4.28)	(7.82)	(6.41)	(6.68)	(1.65)
1993/1961	1.49	0.67	1.33	0.76	1.75	2.94	0.23
Annual growth rate	1.25%	-1.24%	0.9%	-0.85%	1.76%	3.43%	-4.49%

at 3.43% per year. According to an Agriculture Canada's study (1986), the feed milling industry in Alberta has undergone considerable reconstruction, and the secondary mills which prepare feed with purchased premixes have been replaced by larger and more sophisticated primary mills with advanced technology and equipment. Although both value added and employment only accounted for about a 3% share of the total food and beverage industry in 1961, these figures have doubled in 32 years, indicating a stronger position for feed milling in Alberta's economy.

The bakery sector has seen its employment share decline over the thirty year period. Although there has been a recovery in the last two years, the number of employees working in the bakery sector in 1993 is only 76% of the 1961 figure. The same trend is observed in the bakery sector's share of value added.

The results from Tables 7 and 8 show that both employment and value added in the dairy sector, which is highly protected by supply management, and the cereal grain flour sector in Alberta are low. This is true not only of their shares in food and beverage manufacturing, but also of the absolute number figures, reflecting that these two sectors have become less important than other food and beverage industries over the three decades.

Competitiveness of Food and Beverage Industries in Alberta and Canada

Competitiveness, as an important economic concept, has been explained and used in many different ways by researchers and economists. A definition which is often adopted in Canadian studies is the one defined in "Task Force on Competitiveness in Agri-Food Industries" (1991) by Agriculture Canada, in which "Competitiveness is the sustained ability to profitably gain and maintain market share in the domestic and/or export market". By incorporating this definition and three perspectives of competition gleaned from neoclassical economics, industrial organization economics and strategic management, respectively, Van Duren (1991) formed a framework of measuring and diagnosing the competitiveness of a firm or industry in the national or international position.

This framework considers profit and market share as two fundamental indicators of competitiveness, and includes a few variables which can be computed from quantitative and qualitative data available at the firm or industrial level. The profit figure is difficult to measure at the industrial level. Instead, value added, which is the difference between the sales revenue and the cost of raw materials and energy, or alternatively, the value the industry achieved from processing the materials, is used as a proxy. Examples of variables which measure profitability are value added as a ratio of the number of employees, the cost of wages and salaries, the number of establishments, or the value of shipments. Market share is described by trade ratios such as export orientation, import penetration, net export orientation, trade coverage, and the nation's share of sales in the international market. Export orientation measures the domestic industry's exports as a percentage of domestic production, and import penetration measures imports of the industry's products as percentages of domestic consumption. These figures are useful for assessing the position of Canadian food and beverage industries in international trade. Since the focus of this study is the competitiveness of the Alberta food and beverage industry in relation to the Canadian industry, the market share of Alberta's sales as a percentage of Canada's sales for a related industry is an important consideration. In this section, the discussion of competitiveness is focussed on the food and beverage industries of Alberta. Since the red meat processing sector is the largest food industry in Alberta, it has a significant impact on the performance of Alberta's economy. Therefore, its competitive role is also considered.

Profitability

The profit of a manufacturing firm or industry as measured by value added is an absolute measure, which is not comparable with a rival's figure because each firm may have a different production scale and magnitude. On the other hand, value added divided by the number of establishments, the number of employees, the cost of wages and salaries and the value of shipments, is a relative measure which can be compared across different firms, subsectors or industries for a sense of relative profitability.

These measurements of profitability for the Alberta food and beverage industry as well as the red meat processing industry are illustrated in Figures 9 to 12, in which they are also compared with the same classes of Canadian industries. The annual growth rates of the variables are calculated for two segments of the period 1961-1993, and shown in Table 9.

In Figure 9, value added per establishment shifts up consistently for food and beverage industries in both Alberta and Canada. This implies that, on average, the scale of production has increased, although the Alberta gains tend to be less than their Canadian counterpart over the period. The annual growth rates in Table 9 indicate that although Canada has expanded at a faster pace than Alberta, both increased their growth rates in the 1980s and early 1990s. The number of plants participating in the processing of food and beverage has fallen in both Alberta and Canada.

This reveals a fundamental change in the industries' production structures, that is, the trend toward higher levels of concentration and larger facilities serving a wider range of geographical areas. There is a wide range of plant sizes, but in general the largest plants have featured the highest output per person. The emergence of scale economies is the result of mergers and acquisitions. Ernst and Young (1991, 1992) predict that rationalisation and consolidation will continue and that only one or two top brands will survive in each product category. Other firms will have to concentrate on price competition or niche markets.

Although consolidation has resulted in fewer plants in the food and beverage industry in aggregate, the effects for each subsector vary. In Alberta red meat industry, which encompasses the beef cattle, hog, horse and sheep slaughtering and processing industries, the number of establishments increased between 1961 and 1980, and fluctuated around that level since then.

The number of plants in Alberta has increased from 20 in 1961 to 72 in 1980, growing faster than the Canadian figure, which has doubled from its 1961 level of 242 to 547 in 1980. The change in industrial structure has also been accomplished by expansion in the south, the contraction of the central region of the province, and the replacement of small plants with new and modernized larger ones. The example of the beef industry, one of the most important industries in Alberta in terms of the value of production, has seen a trend of beef packing plants being moved to western Canada. By relocation, firms benefit from being closer to cattle production, from access to large feedlots, and from being able to more effectively manage waste. A study by Canadian International Trade Tribunal (CITT, 1993) on the competitiveness of the Canadian cattle and beef industry indicates that the cattle and beef industry in Canada has undergone structural change in recent years, leading to a greater concentration in western Canada,

Figure 9

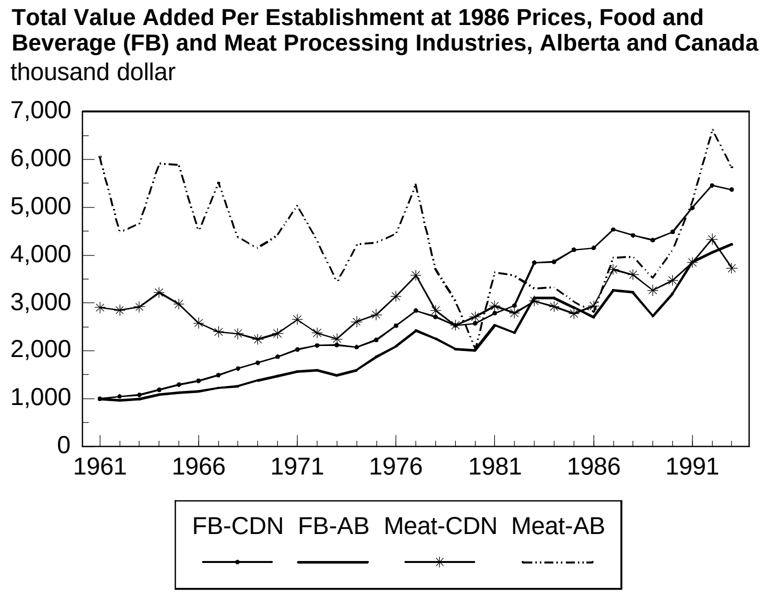


Figure 10

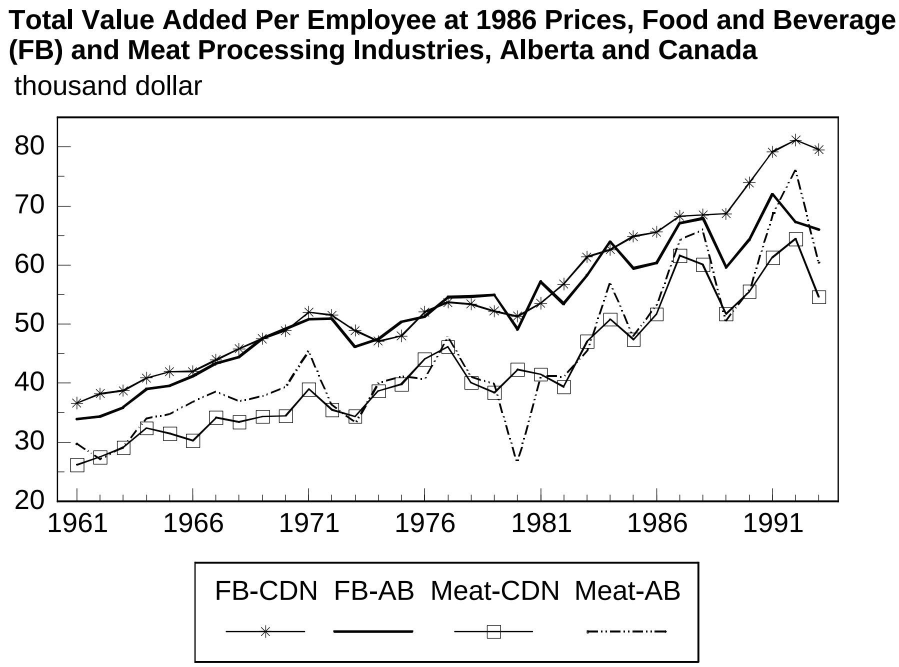


Figure 11

Total Value Added Per Wages & Salaries, Food and Beverage (FB) and Meat Processing Industries, Alberta and Canada

number index

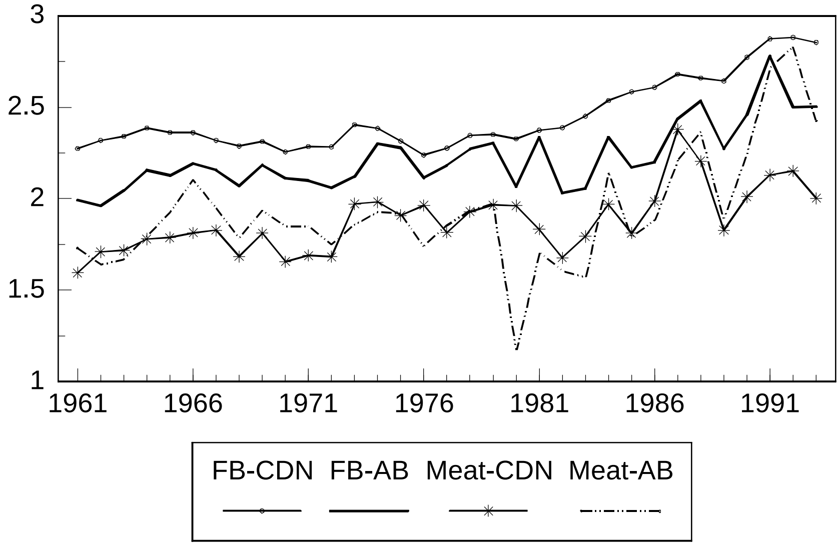
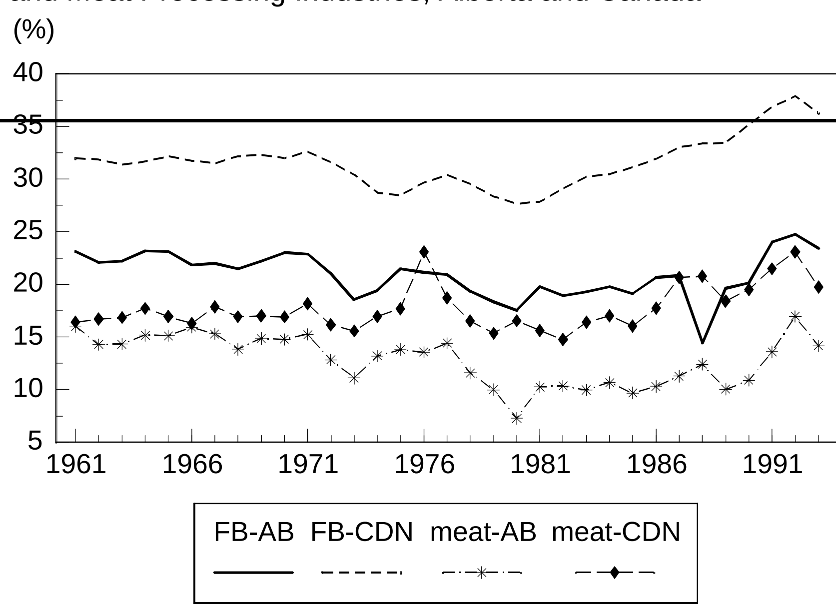


Table 9. Competitiveness of Meat Processing and Food and Beverage Industries: Annual Growth Rates of Value Added Per Establishment, Per Employee, and Per Wages and Salaries, Percent Per Year

Industries	1961-1993		1961-1980		1980-1993	
	Alberta	Canada	Alberta	Canada	Alberta	Canada
Value added per establishment, at 1986 prices						
Food & beverage	4.67	5.37	4.87	5.73	4.31	5.33
Meat processing	-0.79	1.07	-2.81	-0.04	5.98	3.07
Value added per employee, at 1986 prices						
Food & beverage	2.04	2.26	2.39	1.88	2.03	3.41
Meat processing	2.34	2.47	1.25	2.40	5.42	3.19
Value added per wages and salaries, at 1986 prices						
Food & beverage	0.61	0.65	0.44	-0.02	1.72	1.69
Meat processing	0.79	0.65	-0.28	0.83	5.10	1.19

Figure 12

Value Added As Percentage of Total Shipment, Food and Beverage and Meat Processing Industries, Alberta and Canada



particularly in Alberta, and to fewer and larger operations in order to take advantage of economies of scale. In 1992, the four largest beef packing firms accounted for about 53 percent of the cattle slaughter, among which three are located in Alberta. The findings of CITT are supported by our results shown in Figure 9 and Table 9, in which the average value added per establishment of Alberta slaughtering and meat processing has increased dramatically, with an annual growth rate of 5.98 percent for the years between 1980 and 1993. On the other hand, with a 3.07 percent annual growth rate, the Canadian red meat industry is growing the least relative to the other three in Figure 9, for the same period.

Value added per worker measures the ability of an industry to combine technology, capital equipment, and a skilled workforce to produce output. The increasing trends in Figure 10 depict that this ability has risen consistently for all four industries over the thirty year period, and food and beverage industries, in general, have higher output per employee than the red meat sector.

The annual growth rates of constant dollar value added per employee in Table 9 signify that while this variable has grown at a stable and moderate pace for the Alberta food and beverage industry, its Canadian counterpart has improved at a faster rate in the later period, resulting in a larger gap between the two variables since the late 1980s. Compared with the other three industries listed in Table 9, the Alberta red meat sector features two extremes, increasing at the smallest rate of 1.25% in the first period of 1961-1980, and at the fastest of 5.42% in the second period of 1980-1993. This again suggests that the Alberta slaughtering and meat processing industry is becoming more efficient and competitive in terms of labour productivity.

Labour productivity combined with the expenditure on wages and salaries gives output, which in this text is represented by value added per unit of wages and salaries. As illustrated in Figure 11, for each dollar spent on labour, Alberta produces less value added by processing food and beverages than its Canadian counterpart, implying that labour, as a part of production, costs more in Alberta. The annual growth rates of the variables in Table 9 are much less compared with the value added per employee of the same industry, which is the result of an increasing trend in wage and salary rates in these industries.

Value added per dollar of sales measures the proportion of the total shipment achieved by processing purchased raw materials. Figure 12 exhibits that the Canadian food and beverage industry add relatively more value to raw materials over the entire period. On the other hand, the Alberta red meat industry adds the least amongst the four due to the high cost of material inputs, which is mainly feed, and accounts for a significant proportion of the value of market animals. Since red meat is the most important component of the Alberta food and beverage industry, it significantly affects the trend of value added per dollar of sales in the industry, so that these two variables are closely correlated in Figure 12, and that the variable for the Alberta food and beverage industry is much lower than its Canadian counterpart. The increasing cost of energy inputs in the 1970s is another constraint on all manufacturing industries. Despite this, steadily rising trends are observed for all four ratios after the 1980s, implying that these industries are changing toward increased competitiveness in terms of cost efficiency. With an annual growth rate of 4%, the Alberta red meat industry is growing the most rapidly among the four industries.

Market Shares

As pointed out at the beginning of the section, market share in this study measures the share of the value of shipments of the Canadian industry held by the Alberta industry. This measurement is carried out for both the food and beverage, and the red meat industries, and the trends are shown in Figure 13, which enables us to determine whether the industries are gaining or losing in terms of the total sales revenue, and to point out the relative importance and market position of these two industries.

Although the sales ratio of Alberta's red meat industry has experienced ups and downs, overall, it has increased from 18% in 1961 to 29% in 1993. With an annual compound growth rate of 1.13% in terms of market share, Alberta's red meat industry is stronger than ever relative

Figure 13

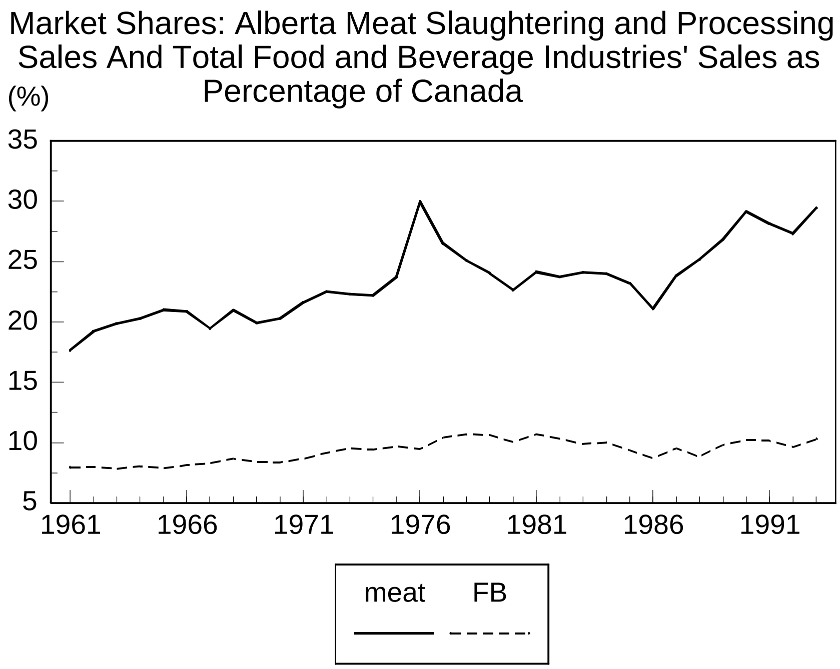
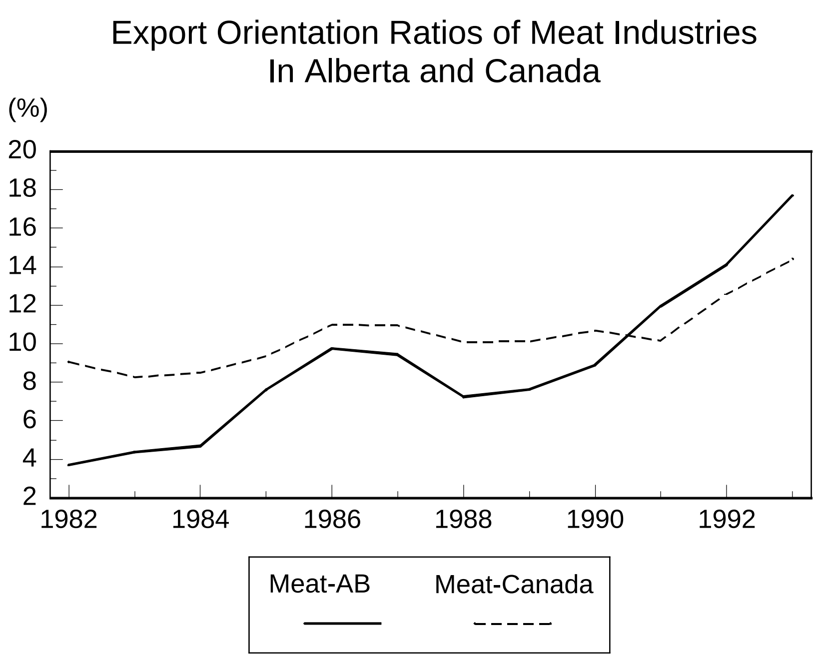


Figure 14



to its Canadian competitors. This conclusion has also been supported by the trade situation in the industry. The export orientation ratio, expressed by the share of out of country exports in total shipment, is calculated for the red meat industries in both Alberta and Canada for the period 1982-1993, and presented in Figure 14. The export ratio has expanded at annual growth rates of 12.64% in Alberta and 3.72% in Canada. Before 1991, although the export ratio grew faster in Alberta than in Canada, it was less by the level of the ratio. But the year of 1991 is the turning point in which not only was the export orientation ratio of Alberta red meat industry in excess of its Canadian counterpart, but it had also been growing consistently faster. Due to price effects and consumer preference changes in both Canada and the United State, demand for red meat has declined and been replaced by white poultry meat. Under this situation, the position of advantage possessed by the Alberta red meat industry in both the domestic and international markets becomes more important and promising when assessing the competitiveness of the industry.

The Alberta food and beverage industries' sales ratio trends upward steadily but modestly in the twenty-year period of 1961-1980 at an annual growth rate of 1.7%. It then goes flat, and a small plunge in the middle of 1980s was observed as a consequence of a larger decline in the Alberta red meat sector in that period. Although the market share has recovered in the last few years, it is still not better than it was in 1981. Unless the increasing trend seen in 1993 continues, the industries will not be able to improve their competitiveness in the future.

Total Factor Productivity of the Food and Beverage Industries in Alberta and Canada

In many studies of competitiveness, value added per employee is referred to, as we did in the previous section, as "labour productivity". Using the index number approach, a more accurate definition for labour productivity would be the quantity index of output as a ratio of the quantity index of the labour input. Labour productivity has often been referred to as productivity since it is easy to access relevant data and to measure. Traditionally, too, labour was considered a major input of production. Since measurement of labour productivity does not take changes in other input variables into consideration, it may give a misleading indication of the economic situation when used as a proxy for total productivity. In order to realize the efficiency and competitiveness of Albertan and Canadian food and beverage industries, it is necessary for us to adopt the concept of total factor productivity.

Total factor productivity is the aggregated output quantity index as a ratio of the aggregated input quantity index. In this part of study, its measurement is also conducted using the index number approach. More specifically, the Tornqvist-Theil index, a discrete approximation to the Divisia index number approach, is used. For the Canadian food and beverage industry, total output is defined by gross output, and the current dollar values of gross output are available from the Statistics Canada publication "Gross Domestic Product by Industries". For Alberta, since the GDP figures from "Provincial Gross Domestic Product by Industry" are represented by net output and are only available since 1970, we use the total shipments of the industries as a proxy for gross output, which implies the assumption that inventory is constant for the whole period. Inputs are disaggregated into four factors: labour, capital, fuel and electricity, and materials. For both Alberta and Canada, current dollar expenditures on wages and salaries, fuel and electricity, and raw materials, as well as the number of persons employed are available from “Manufacturing Industries of Canada, National and Provincial Areas”, Statistics Canada Cat. No. 31-203. The cost of wages and salaries, deflated by the number of employees, gives us information on the price of labour inputs. This is the only input price index available for the Alberta food and beverage industries; all others will be approximated by the Canadian prices. The prices of fuel and electricity and materials are derived from “The Input-Output Structure of the Canadian Economy”, and applied to both Canadian and Albertan food and beverage industries. The current and constant dollar values of net capital stock and depreciation for Canadian food and beverage industries are published in “Fixed Capital Flows and Stock, Historical”, Cat. 13-568, which are used to derived the price index of capital. The value of capital services is calculated as the sum of depreciation and opportunity cost, with depreciation calculated according to Cahill and Hazledine (1989), as being 10.69% of net capital stock. Net capital stock is not available for Alberta and has been proxied by the expenditures on machinery, buildings and construction. Assuming that the price indexes, length of service life and rates of depreciation of capital in these industries are the same for Canada and Alberta, the Canadian figures are then used to estimate the net capital stock in Alberta by the perpetual inventory method, the details of which can be found in Veeman, Fantino and Peng (1995). Once Albertan and Canadian food and beverage industry values and price indexes are collected for the period 1961-1993, they are used to derive the implicit quantity indexes for output and inputs. Due to the limitations of price and capital data, a study of total factor productivity in the red meat sector cannot be conducted here.

Indexes of total factor productivity (TFP), partial labour productivity (PLP), and quantities indexes of output (Y) and inputs (X) for the Albertan and Canadian food and beverage industries are displayed in Figures 15 and 16. Although output and inputs grew faster in Alberta than in Canada, Alberta’s TFP index is in a disadvantaged position. The growth rate of TFP measures the residual growth of output not accounted for by the growth of total inputs. As listed in Table 10, from 1961-1974, TFP grew marginally, at annual rates of 0.33% for Alberta, and 0.35% for Canada. But since then productivity has gone steadily downward, decreasing at annual rates of 1.52% in Alberta and 1.15% in Canada. For the period 1974-1993, our study results are consistent with Salem (1987), who found that while TFP in the Canadian food and beverage sector was growing rapidly in 1960s and early 1970s, it has seen very little improvement since that time[6].

Our estimates indicate that in both Alberta and Canada, food and beverage industries featured declining trends and deterioration in terms of total factor productivity, with Canada in a relatively better position in the last twenty years. There are many factors which may cause this situation. Some of the possible causes discussed by West (1987) include: lagging research and development, economies of size, excessive cost of inputs, and sluggish market demand.

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[6] Salem’s annual average growth rate of TFP is 0.18% for 1962-66, 0.51% for 1967-71, 0.36% for 1972-1976, and 0.19% for 1977-1982. The overall rate of growth for the 1962-1982 period is 0.36% in his study. Cahill and Hazledine (1989) estimated that the productivity growth rate for Canadian food and beverage industries is 0.1% for the period 1961-1982.

Figure 15

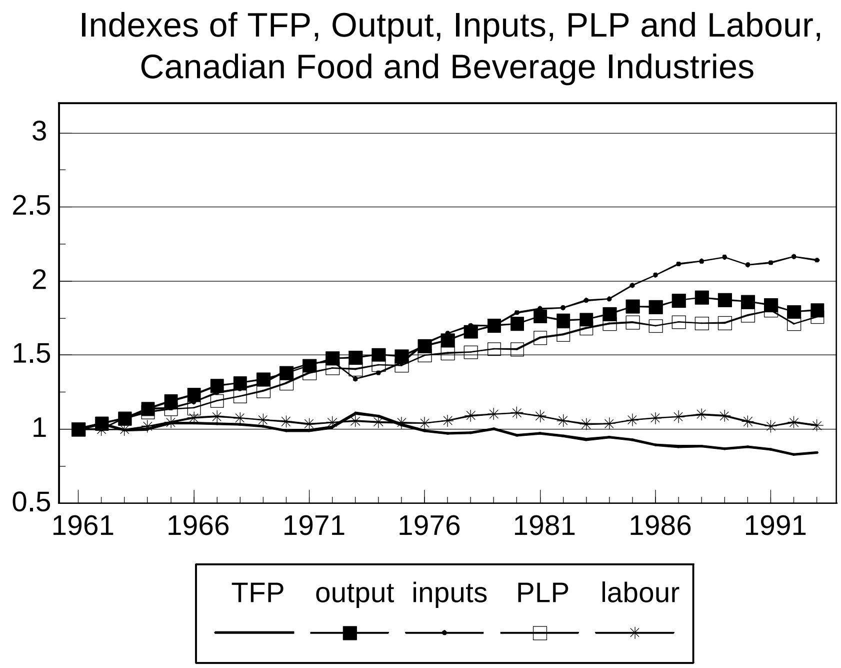


Figure 16

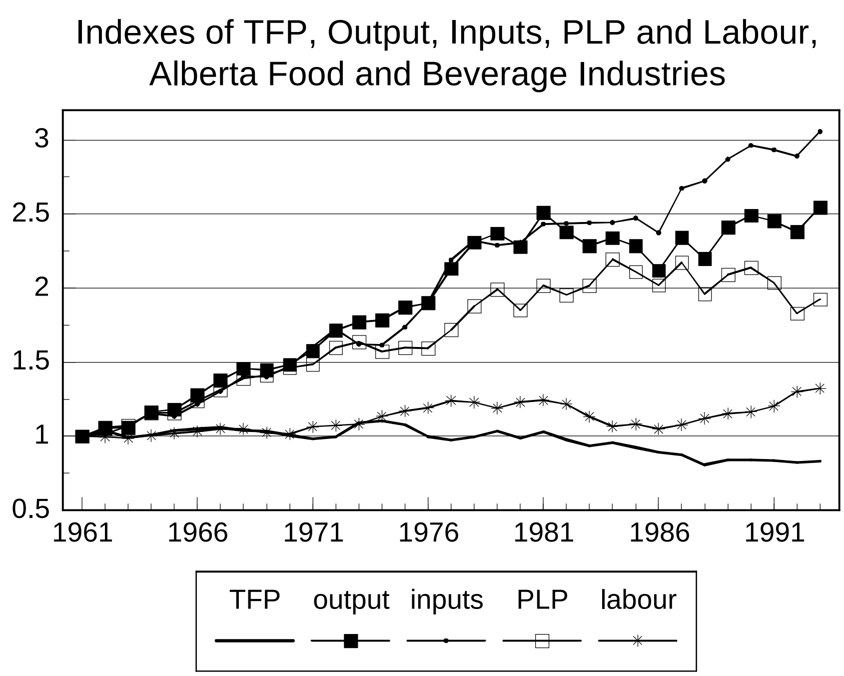


Table 10. Annual Growth Rates of TFP and Labour Productivity for Alberta and Canadian Food and Beverage Industries, Percent Per Year

Index	1961-1993		1961-1974		1974-1993	
	Alberta	Canada	Alberta	Canada	Alberta	Canada
Output quantity (Y)	2.90	1.89	4.79	3.29	1.19	1.07
Input quantity (X)	3.66	2.55	4.45	2.93	2.75	2.25
Labour quantity (L)	0.62	0.10	0.81	0.38	0.05	-0.08
PLP=Y/L	2.26	1.79	3.95	2.89	1.14	1.15
TFP=Y/X	-0.74	-0.64	0.33	0.35	-1.52	-1.15

Productivity and technical change are closely related to investment in research and development (R&D). However, R&D in the food processing sector is an area of weakness in Canada. According to West (1987), in the late 1970s and early 1980s in the Canadian food and beverage industry, R&D expenditure was estimated to be 0.1% of the industry's sales, compared to 1.5% for the country's overall economy. Both Canadian ratios lag behind US R&D expenditures, which were 0.4% of sales in food and beverages and 2.5% of sales in the economy as a whole. Similarly, approximately 95% of public funding in agri-food industries is targeted at the production level and only a small amount is invested in the value-added processing sector (Toma & Bouma, 1996). A survey research by West and Vaughan (1995) reveals that another problem to increase R&D investment in Canada results from firms consisting of foreign direct investment, which account for about 34% of assets and 31% of sales in the Canadian food and beverage industry. Although they both spend relatively more of their revenue on R&D than Canadian owned firms do, and contribute to Canadian industries through spillover effects, most of the R&D spending is centralized in the parent companies. West (1987) also pointed out that the rate of capital formation on new machinery and equipment is a useful indicator of technical change since much R&D is done by Canadian or foreign firms which supply equipment and ingredients, etc. to the food and beverage sector.

Government spending on agri-food R&D is an important source of funding for research aimed toward more basic and less firm specific projects. One government program related to the Alberta food industry, the "Canada/Alberta Nutritive Processing Assistance Agreement", has been advocated by an Agriculture Canada study (1986). This program has provided capital grants for the establishment, expansion and modernization of facilities since 1976, and was thought to be a contributor to the growth of the Alberta food and beverage manufacturing sector vis-a-vis the rest of Canada. Recently, Alberta Agriculture, Food and Rural Development (AAFRD) announced the launch of the Value-Added Initiative for industry research, development and commercialization, and the establishment of a non-profit corporation to coordinate research agreements with companies, universities, commodity associations and other groups. The aim of this project is to facilitate the development of value-added agri-food and fibre products and advanced processing technologies. AAFRD will enter into a $35 million fund agreement with the value added corporation in order to support the province's research and economic development initiative with industry. It will also promote the industrial funding and the partnership roles of government and industry in R&D. The initiative will be a boost for R&D productivity and the competitiveness of the Alberta agri-food industries.

By surveying the methods and results of some studies on productivity in the Canadian food and beverage industry, Hazledine (1991) concluded that economies or diseconomies of scale have not been a significant factor over the long run, so that TFP growth and technical change have been approximately equivalent. The bias of technical progress has been toward labour saving technology and materials use which results in a larger share of materials expenditure in total cost. This finding is supported by our study in which materials take about 80% of the Canadian cost, and in Alberta the results are even stronger since the material share is more than 80%. Labour has accounted for about 17% of the total cost for Canada and 12% for Alberta, with energy and capital service taking a relatively smaller proportion. All shares remained fairly stable over the time period.

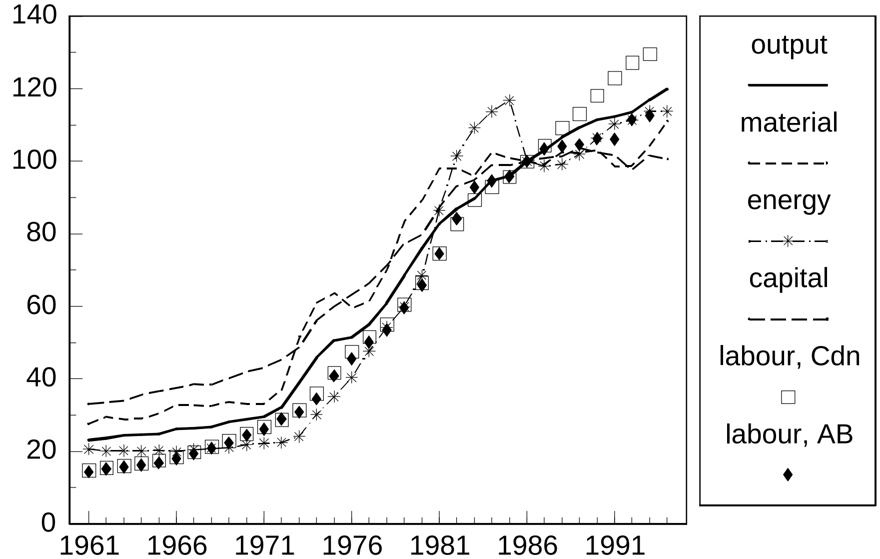
Price is an important factor affecting the competitiveness and productivity of an industry. Unfortunately, with the exception of labour, information about the prices of output and other individual inputs is not available for Alberta food and beverage industries. Therefore discussion will be based on Figure 17, assuming that the price trends for Alberta follow those of the Canadian industry. The prices for output and factor inputs have increased simultaneously during the period from 1961 to 1994. While overall, the prices of capital and material increased the least, they climbed almost as quickly as the others inputs from 1973 to 1985, attributing to the oil crisis and energy price shock in this period. Labour prices in Alberta and Canada are amongst the fastest growing prices, resulting in the substitution of capital, and possibly other inputs, for labour. We have seen an increasing gap between the prices of labour in Alberta, relative to Canada, in the last few years, implying that wage rate in Alberta food and beverage industries has increased less rapidly than the Canadian average.

Over the whole period, the labour quantity index, or the number of employees in the Alberta food and beverage industry, has grown at an annual compound rate of 0.65%, larger than the 0.1% growth rate for Canada. In fact, a declining trend has characterized Canada in the last two decades as shown in Table 10. Over the period, the quantity indexes of aggregated inputs grew more than the labour input, and labour has been replaced by other inputs. This results in partial labour productivity growing faster than the total factor productivity in both Alberta and Canada.

Competitiveness and productivity are also inevitably driven by consumer demand for commodities and market conditions both domestically and globally. Each sector faces a different situation and challenge. In general, poultry, fruits and vegetables, and wheat based products have benefited from an increasing trend of consumption. On the other hand, driven by health consciousness and low priced substitutes, red meat and high fat dairy products have seen demand fall. The Alberta food and beverage industry and its core, the red meat sector, have both suffered

Figure 17

Output and Inputs Price Indexes, 1986=100,
Alberta and Canadain Food and Beverage Industries



from the shifts in consumers' preferences and perceptions.

Summary and Conclusions

This project addresses several issues related to efficiency, productivity, and competitiveness in Alberta's agriculture and food sector, both its primary agricultural sector and its secondary processing industry related to food and beverages. A major underlying theme of this work is that the competitiveness and economic sustainability of Alberta's agriculture and food sector are considerably driven by long run trends in total factor productivity (or, alternatively, increases in technical efficiency) in these sub-sectors. Increases in productivity, in turn, are heavily influenced by the investments, both public and private, made by society in research and development. Long run viability in agriculture, and food, then , is critically determined by "science (policy) for agriculture".

Two emerging trends in Alberta's agriculture and food sector are initially documented: the increasing role of specialty crop production and the rising importance of value added production. By the mid-1990s, specialty crop production, on less than 2 percent of Alberta's total cultivated area, was capturing well over 15 percent of Alberta's total cash receipts. Familiarly, in the 1990s, exports of consumer oriented agricultural products with a considerable amount of value added have grown more rapidly than the exports of bulk agricultural commodities.

Productivity trends and competitiveness issues were examined for Alberta's primary agricultural production sector. Index numbers for agricultural output, aggregate input, and (total factor) productivity were constructed, using Tornqvist-Theil indexing procedures, for both Alberta and the Prairies for the period 1948 to 1994. Alberta's annual output growth rate of 2.43 percent and its productivity growth rate in agriculture of 1.9 percent over this time period closely mirror output and productivity performance for the entire Prairies. Since 1978, however, both output growth and productivity performance in Alberta have been somewhat slower than in the prairie region as a whole.

The foregoing aggregate productivity trends in primary agriculture mask considerably different trends for the crops sector in Alberta versus the livestock sector. Both crop output growth and crop productivity growth have been consistently stronger than output and productivity growth in the livestock sector. Productivity, for example, has grown annually at 2.75 percent in the crop sector but only at 0.81 percent in the livestock industry in Alberta. Alberta's lagging agricultural productivity performance since 1980, albeit with some modest recovery in the 1990s, is largely attributable to negative productivity growth in the livestock sector. Surprisingly, however, despite lower (and even negative) productivity growth, the livestock sector has increased its returns-to-cost ratio much more rapidly, because it faces much less intense cost-price squeeze pressure than the crop sector. Historical productivity performance in the crop and livestock sectors in Alberta roughly parallels experience in nearby American states.

A simple econometric model was constructed to explore the relationship between total factor productivity (TFP) in primary agriculture and proxies for expenditures on research and development (R&D). Lagged R&D expenditures are found to be a statistically significant influence on productivity, lending empirical credence to the widely held belief that expenditures on R&D are vital to productivity growth in agriculture.

The Alberta food and beverage industry is one of the largest manufacturing industries in the province, and it has been greatly influenced by the implementation of Canada-U.S. Free Trade Agreement, and the North American Free Trade Agreement, as well as rapidly changing global business environments and economic conditions. It not only is driven by consumer demand and changing trends in consumer preferences due to improved public awareness of health and nutrition, but also by the enhancement of living standards for Alberta residents. Therefore, the performance of the industry is critical to Alberta's economy.

In this report, the competitiveness and productivity of the industry is assessed by first over viewing the performance of each of seven subsectors: red meat, dairy, brewery, bakery, soft drink, feed and flour. We then apply more a detailed analysis to the Alberta food and beverage industry, and the slaughtering and meat processing subsector. The study is conducted in a comparative form with Canadian industries used as counterparts. In this framework we defined and assessed competitiveness, and examined profitability and market shares as fundamental indicators, with their measurement based on information about the number of establishments, the number of employees, wages and salaries, the value of shipments, value added, imports, exports, and so forth.

In the thirty-two year period of 1961-1993, the Alberta food and beverage industry has experienced fundamental structural changes toward scale economies featured by higher levels of concentration and larger facilities. The number of plants has been reduced by 40%. On the other hand, the industry's total value added rose 2.6 times. As a result, the average value added per establishment has been growing at an annual compound rate of 4.67%, so that the 1993 level is 4 times the level in 1961. Despite this gain, the average scale of production is larger at the national level, and the difference between the two tends to be wider in the last ten years of the study. Labour productivity measured by value added per employee has steadily drifted up at a 2.04% annual rate and doubled in level, implying a substantial improvement in the industry's ability to combine a skilled workforce, capital equipment and technology to produce output. It performed as well as its Canadian counterpart before 1989, but has lagged behind since then. Value added per wages and salaries shows that for every dollar paid to the workers, about 2 to 2.5 dollars are added to output. This figure is lower in Alberta than in Canada, indicating a higher cost of labour used to produce the same amount of value added in this province. Value added per dollar of sales measures the proportion of total shipments achieved by processing purchased raw materials, and is substantially higher in Canada than in Alberta. This is mainly the result of the higher cost of material inputs, especially the cost of feed in the beef sector, one of the most important components of the Alberta food and beverage industry.

The market shares represented by the ratio of the Alberta food and beverage industry sales to the Canadian sales total was 6% in 1961, and trended upward slowly but steadily at an annual growth rate of 1.7% to reach the 1981 level of 11%, which has not been maintained or improved upon since that time. The competitiveness of the food and beverage industry indicates that the overall Canadian sector performed better in terms of profitability and market share.

Total factor productivity, measured by the index number approach, has been used to assess the performance of the food and beverage industry in both Alberta and Canada in this report. Its application to these industries has often been limited because of the lack of data, for example, the price and value of capital service. We would be unable to measure TFP for the red meat industry for the same reason. The growth rate of TFP measures the residual growth of output not accounted for by the growth of the aggregated inputs. Although both output and inputs grow faster in Alberta than in Canada, Alberta's TFP growth in the processing sector has been sluggish, if not negative. In the period of 1961-1974, TFP climbed marginally at annual rates of 0.33% for Alberta and 0.35% for Canada. But in the period of 1974-1993, with annual decreasing rates of 1.52% and 1.15% respectively, the food and beverage industries in both Alberta and Canada suffered from a loss of productivity, with Canada in a relatively better position. Factors which affect the growth of TFP include: lagging research and development, excessive cost of inputs, and sluggish market demand.

In comparison to the overall situation, Alberta's slaughtering and meat processing industry has been much more promising. This assessment indicates that overall it not only takes the strongest position among all Alberta food and beverage industries, but it also is more competitive than its Canadian counterpart. The red meat industry in Alberta, especially the beef packing subsector, has benefited from structural change in the industry which has led to greater concentrations of firms and the exploitation of economies of scale. The slaughtering and meat processing sector has also experienced considerable enhancement in labour productivity during the last decade. One of the drawbacks of the industry is the expensive cost of material inputs, which seems more serious in Alberta than for the Canadian average. The market share of Alberta red meat industry measured by its sales as a ratio of the whole nation's sales has increased significantly from 18% in 1961 to 29% in 1993. In spite of the extensive pressure of declining demand for red meat due to price effects and consumers' preference changes in both Canada and U.S., the industry has been more competitive in the international market, especially in the 1990s.

Finally, it is important to note the beneficial impacts that productivity improvement in primary agriculture has on the processing sector, and vice versa (Gopinath, Roe, and Shane 1996). Gains in productivity (or technical efficiency) in primary production may be transferred to the processing sector in the form of cheaper inputs, an important consideration in Alberta where more than 80 percent of input costs are expended on materials. Conversely, efficiency gains in the processing sector result in an increased derived demand for the products of primary agriculture. Policies which encourage productivity growth in either sector can increase the competitiveness of both sectors. Further, policies which stimulate increased expenditure on research and development lie at the heart of productivity enhancement in both primary agriculture and the food processing sector.

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