THE UNIVERSITY OF MANITOBA

AN INTEGRATED SUPPLY AND DEMAND ANALYSIS OF CANADIAN RAPESEED AND VEGETABLE-OIL PRODUCTS

by

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ABSTRACT

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by

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In recent years, events abroad and in Canada's agricultural economy have resulted in the rapid expansion of all segments of the Canadian rapeseed industry; in particular in production, exports, processing and utilization. Because the growth has been so rapid and diverse, many of those involved have been unable to make the necessary adjustments to cope with the new environment. Segments of the industry are so tightly related that an attack on a particular problem would cause a chain reaction among related issues. It therefore seems inescapable that any study of the industry must take a broad view.

Rapeseed has grown from an insignificant, to the third most valuable cash crop within a relatively short time period. However, this growth has been fairly erratic. Assuming that continuous expansion of the industry or, at least its maintenance as one of Canada's major field crops is a desirable national objective, it is essential that all aspects of the industry be understood, why for example does change occur in the industry? What is the future outlook for the industry? Answering these and related questions is the main purpose of this study.

In view of the nature of the many discrete market outlets competing for the available supply, and the mutual influence and interdependence among the various segments of the industry, an interdependent system approach was judged to be the most appropriate, especially in the absence of weekly or monthly data to test the incremental sensitivity of the causal relationships.

Initially, a fifteen-equation system was developed in which the complete structural relationships were sub-divided into four blocks: namely, the rapeseed supply block, the rapeseed exports block, the domestic utilization of rapeseed-oil block, and the consumption of vegetable-oil products block. The behavioral equations within each block were estimated at the disaggregate level. Results were obtained using ordinary least squares, two-stage least squares, seemingly uncorrelated regression and three-stage squares approaches in order to enable interested researchers to trace the causal relationships and to determine the factors leading to the present situation.

Later, it was realized that the "created" data, related to the prices of rapeseed oil, raised questions about the level of confidence that could be attached thereto. It was also realized that the aggregate model possessed a better predictive capability than the disaggregate model. Therefore, the model was condensed into an eight-equation system in which eight variables; namely acreage, supply, exports, crushings, farm prices of rapeseed, production of rapeseed-oil, and the prices and levels of consumption of vegetable-oil products were selected as the jointly-determined variables of the system.

The aggregate model comprised 8 structural relations, 8 jointly-determined variables and 19 predetermined variables, so that eight reduced-form equations could be derived with each endogenous variable being expressed in terms of all predetermined variables. The reduced-form coefficients were then solved from estimated structural, behavioral coefficients, and from the inter-relationships established through the specification of identity, market-clearing, and price-linkage equations.

In evaluating the reduced-form equations, performance of the model was judged to be satisfactory, provided that it was understood that large estimation errors could occur in circumstances where there was "irregular" behavior. The predictive capability of the model was also found reliable, given that accurate forecasts of the exogenous variables were available. Using the reduced-form equations certain simulation experiments could be undertaken to study the likely impact of policy proposals, or to forecast the behavior of endogenous variables under varying assumptions with respect to economic conditions and government programs.

Five sets of forecasts for the 8 key variables were made for the period covering 1976 through 1980 under various assumptions as to prevailing economic conditions. For example, rapeseed acreage in 1980 could vary but would more likely be at a level around 4.5 million acres; implying that acreage would gradually increase from the depressed 1976 level (about 2 million acres), but might not quite break the record 5.3 million acres grown in 1971.

Finally, it should be pointed out that though integrative, in terms of the industry itself, the model was not definitive. The question of inter-dependence soon makes one realize that the rapeseed industry is but part of the total agricultural industry, in turn, only a part of the

Canadian economy which is highly dependent on world markets. Further studies, particularly in input-output analysis could extend understanding of the internal functioning of the industry and thereby enable more rational policy formulation.

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CHAPTER 1

INTRODUCTION

A. A Preview of the Problem

Just as knowledge of the phenomenon of lights requires an appreciation of colour and wavelengths, knowledge of the rapeseed industry requires an appreciation of a whole sub-set of economic phenomena that are every bit as complex and fascinating as a rainbow. Generally, an empirical scientific inquiry must be carried out though such steps as identifying problem, collecting and analyzing data, as well as postulating and testing hypotheses in order to explore, explain and predict occurences in the subject matter under consideration.[1] The step of problem identification appears to be a good place to begin.

Change in the Canadian rapeseed industry has been so pervasive and erratic that many of those involved have been unable to cope with the rapidly changing environment. The problems have arisen when things did not happen as expected. While certain factors have been beyond our domestic control, the major problem appears to have been a lack of appreciation of the consequences of changes in one area on the other segments of the industry. Without an integrated view to broaden understanding of the inter-relationships at work, decision-makers would likely continue to respond to the wrong signals. As a result, policies could be designed, and actions taken, that would have less than the desired effects and

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[1] C.G. Hempel, Philosophy of Natural Science (Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1966); and T.W. Organ, The Art of Critical Thinking (Boston, Massachusetts: Houghton Mifflin Co., 1965).

perhaps lead to the decline of the industry.

The fact is that over a period of less than a quarter century, rapeseed has grown from being an obscure crop to the third most valuable cash crop in Canada. Although growth has followed an erratic pattern for a number of reasons, one of the more important has been that in some situations rapeseed has been considered to be little more than an inferior substitute for wheat. Wheat still dominates agriculture in Canada, and production of this crop has been particularly sensitive to weather conditions and uneven food production in the rest of the world. Rapeseed has therefore been subject to comparable but inverse fluctuations in acreage seeded and overall output.

Moreover, there have been supplementary forces at work. For example, in terms of physical characteristics rapeseed is, to a great extent a substitute for other kinds of oilseeds. Also, the share enjoyed by Canadian rapeseed of the international market has been relatively small. Thus, rapeseed has faced strong competition in both foreign and domestic markets, with political, economic and other changes abroad and at home substantially affecting the quantities absorbed. These factors have exacerbated the basic instability of the industry, which has in turn failed to make the adjustments necessary to cope with the prevailing conditions.

Most of the problems faced are multi-faceted, complex and inter-connected with other problems. A given problem is usually so entwined with its own internal components and other external factors, that an attack on a particular problem is certain to set-off a chain reaction among related issues. In this regard, the growing importance of the rapeseed industry, in both domestic and international terms, necessitates a rigorous integrated analysis in order to provide a broader understanding of the mechanics by which change in one area influences change in other areas which collectively comprise the industry.

Interest in and attention to the Canadian rapeseed industry, as will be discussed at length in the next chapter, has not been lacking. However, owing to the fast-changing nature of the industry and the fact that some previous studies were completed under a condition of limited data it would seem that, at the very least, further studies to confirm or revise previous research findings should be undertaken. These could provide timely knowledge, and hopefully a better understanding of the existing rapeseed industry.

While there have been a few economic studies with respect to rapeseed production and marketing, most of the research has dealt with only one or a few of the rapeseed markets; with only one or a few of the products derived from rapeseed; or with only one or a few countries involved in the production, trade and utilization of rapeseed and its products. An integrated study comprising all segments of the industry has not as yet been completed.[2] In order to more fully describe, analyze and explain how and why the industry has grown, a systematic framework for empirical measurement and analysis of the specific relationships between the variables relevant to the economic phenomena within the industry is

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[2]Two studies have attempted the building of a multi-equation model with respect to the rapeseed industry but the results were not published. These were: W.J. Craddock, "Canadian Rapeseed Price Prediction - A Preliminary Report", Unpublished paper (Winnipeg: Department of Agricultural Economics, University of Manitoba, 1973); and I.H. Uhm, "An Econometric Analysis of the Canadian Rapeseed and Its Join Products - Oil and Meal", Unpublished paper (Ottawa: Economics Branch, Agriculture Canada, 1973).

essential. This is particularly crucial since predictions of the expected variables should be made with a thorough understanding of how a particular market functions and how the multi-markets interrelate. The integrated model would also provide an analytical basis for predicting the likely consequences resulting from changes in government policies or socio-economic conditions. More fundamentally, studies in relation to the rapeseed industry are needed if continuous expansion of the industry or, at least, its maintenance as one of Canada's major field crops is considered a desirable national objective. This study is one which attempts to shed light on the Canadian rapeseed industry by re-tracing its history, identifying its components and linking them in an integrated model that describes its uniqueness.

Rapeseed Production

Rapeseed was introduced from Europe into Canada during World War II when it was used primarily as an engine lubricant by the Allied navies. The oil was refined for edible purposes in Canada for the first time in 1956. Thus the history of the development of the Canadian edible oil rapeseed industry covers only about 20 years. Nonetheless rapeseed has already proven to be a valuable alternative crop for wheat and grain producers.[3]

The combined effects of the growing diversification of Canadian agricultural enterprises and the expanding demand for vegetable oils, both in domestic and foreign markets, have resulted in a spectacular expansion of Canadian rapeseed production. In the late 1960's, world food

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[3]R.K. Downey et al, Rapeseed, Canada's Cinderella Crop, (3rd ed.), Publication 33 (Winnipeg or Vancouver: Rapeseed Association of Canada, April 1974).

production had been increasing rapidly enough that it had created a sense of security about global food production capabilities. As a matter of fact, a surplus in wheat and other commodities had become a burden to the major exporting countries as prices were too low to provide farmers with an adequate return, and unsold stocks were creating storage problems. To ease this burden, the United States, Canada and the European Economic Community all decided to cut agricultural production in certain sectors.[4] In Canada, the Lower Inventory For Tomorrow (LIFT) program was introduced. As a result, the area planted to wheat declined from 25 million acres in 1969 to 12.5 million acres in 1970; but rapeseed acreage increased from 2 to 4 million acres, and production increased 760 thousand tonnes to 1.6 million tonnes during the same period.[5]

Since then, rapeseed has established itself as Canada's third most valuable cash crop, following wheat and barley; and as the fourth largest field crop, surpassed only by wheat, barley, and oats in terms of acreage.[6]

The development of the rapeseed industry in Canada has been widely noted in the world. However, Prairie farmers have varied the acreage sown to this crop because rapeseed prices, and thus cash incomes, have been quite unstable; and as well, rapeseed requires that modifications be made

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[4]L.A. Fischer, Canadian Agriculture and the World Food Production, (Montreal, Quebec: C.D. Howe Research Institute, 1976)

[5]One tonne of rapeseed is equivalent to 44.092 bushels; see A.G. Wilson et al., Canadian Grains Industry Statistical Handbook 77, (Winnipeg, Manitoba: Canada Grains Council, 1977), p. 278

[6]A detailed discussion will be given in Chapter 2.

in farming practices in order to obtain maximum yields.[7]

Some hedging by producers, as well as by crushers and exporters, through operations in the futures market has been successful but farmers still need protection against violent price swings.[8] They also need protection when surplus problems occur due to transportation facilities being inadequate to handle all the seed or in situations where the market is overloaded and unable to absorb the total production.[9]

During the past two decades, all segments of the industry, from the producers to the end-users of rapeseed in all its forms, have learned to cope with the high level of uncertainty in the industry. However, as one knowledgeable analyst put it, "we continue to be plagued with the same problem, the same uncertainties - Will the producers stay with the crop? What will the acreage be? How much can we produce?"[10]

In order to provide a short-term outlook on supply, price and demand for major agricultural commodities with a view to guiding farmers, agribusiness groups, and farm policy-makers in their decisions, Agriculture Canada has sponsored the Canadian Agricultural Outlook

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[7]R.K. Baydock, "Factors Affecting Resources Management Decisions: A case study of the Manitoba Rapeseed Primary Producer", Unpublished Master's Thesis (Winnipeg, Manitoba: Natural Resource Institute, University of Manitoba, 1977)

[8]R.L.M. Dawson, "Marketing Canadian Rapeseed", Proceedings of the International Rapeseed Conference, (St. Adele, Quebec, September 1970), p. 61

[9]Joseph Ma, "Rapeseed Reaches Temporary Harvest Limit", Regina Leader Post, March 3, 1974

[10]J.J. Banfield, Report of the President, Rapeseed Association of Canada (Seventh Annual Meeting, March 1974), p. 3.

Conference annually.[11] Presumably Outlook reports enable producers to decide what is the best crop to grow, and how much to grow, in order to make the highest possible return from farming. However, a review of Outlook reports presented during the past 10 conferences shows that the regular intermediate and long-term outlooks were of little benefit to commercial growers, either when making general investment plans or when modifying long-term plans in the light of short-term predictions. During recent years, for example, no forecasts of the supply or prices of rapeseed were provided. With respect to forecasts of rapeseed exports and crushings, little attempt was made to explain what gave rise to the forecast errors in preceeding years or even what the basis was of the forecasts presented at conferences. As a result, there has been considerable dissatisfaction with the analytical content of the outlook reports. A former Executive Director of the Rapeseed Association of Canada summed it up this way:

> "The outlook paper, in its final paragraph on rapeseed concludes that "some increase in rapaeseed acreage will be necessary if Canada is to maintain her share of world markets". There is nothing wrong with the statement _per se_, but what impact is it likely to have on producers? Are they going to be persuaded by these words to plant more acres to rapeseed in 1973? Will they even be convinced that if they do not plan an increase in rapeseed acreage they should at least hold it at the 1972 level?"[12]

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[11]G.R. Purnell, "Foreword", _Proceedings of the 1970 Canadian Agricultural Outlook Conference_ (Ottawa: Economics Branch, Agriculture Canada, Oct. 1970), p. i.

[12]James McAnsh, "Oilseeds - Implications and Alternatives", _Proceedings of the 1972 Canadian Agricultural Outlook Conference_, (Ottawa: Economics Branch, Agriculture Canada, Nov. 1972), p. 52.

A former Commissioner of the Canadian Grain Commission added:

> "...outlook will require a lot more answers to "whys". There's practically no answers now. Just exports will rise here and drop there, crushings will drop here and rise there. Why do you think they dropped, and why will they rise. I distrust seeing other people's judgement without seeing the observantions they are basing their judgements on. Most farmers feel that way."[13]

Given the objective of more stable national production and also they need to develop appropriate agricultural policies, researches and decision-makers should know more precisely why rapeseed production fluctuates. The main task of this study is to shed light on this matter.

Exports

Exports of rapeseed from Canada commenced in 1956, but initially was given very little attention as greater emphasis was placed on the acceptance and utilization of the oil and meal within the confines of the domestic market.[14] During the 1957-64 period, exports were remarkably stable averaging annually around 279 million pounds. However, a big increase occurred when rapeseed exports reached more than 500 million pounds in 1965 compared to less than 200 million pounds in the previous year. Since that time, exports have been gaining in relative importance in the industry and the volume of exports has expanded steadily, reaching by 1973, less than 10 years later, a high of 2,600 million pounds.[15] The dramatic growth in exports reflects the fact that good quality and

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[13]F. Hetland, "Oilseeds - Implications and Alternatives", Proceedings of the 1971 Canadian Agricultural Outlook Conference (Ottawa: Economics Branches, Agriculture Canada, Nov. 1971), p. 67

[14]J.J. Banfield, "The Canadian Oilseed Crusher's View", Proceedings of International Rapeseed Conference, (St. Adele, Quebec, 1970), p. 63; Trade missions visited Europe, Asia and Latin America to assess the market potential and evaluate Canada's prospects for sharing in the international oilseed markets in the early 1970's.

[15]A detailed discussion will be given in Chapter 2.

competitive prices have made it possible to penetrate the world of oilseed, fat and oil market complex. Nonetheless, problems peculiar to the industry have been experienced.

The core of the problem regarding exports has been that, although the share of the international market attained by Canadian rapeseed has been relatively small, the quantity of seed exported has increased so rapidly that adjustments have been necessary. Circumstances have been such that Canada has been a "price taker" rather than a "price maker".[16] The reason is that soybeans dominate the world oilseed market, and also oils from the tropics are becoming more significant. The result is that while the price of rapeseed has been influenced mainly by the prices of soybean oil and meal. It is also influenced by the prices of palm oil, palm kernal and coconut oil.[17] In addition, Canada's exports have also been affected by the trade policies of the major rapeseed importing countries. For example, the Japanese government decided to liberalize imports of rapeseed at the end of 1971.[18] While this favoured Canadian exports, termination of the Japanese quota system itself is beyond the control of Canada.

As regards the transportation of rapeseed, the Canadian Wheat Board undertakes to schedule the movement of all grains from farms to country elevators, and further, to domestic crushers and exporting ports.[19]

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[16]Canada's share of the world oilseed market is less than 2 per cent, and there is a high degree of interchangeability between products.

[17]J.W. Duncker, "World Price Behaviour of Edible Oils and Fats", Canadian Farm Economics, 12:14-22, No. 3, June 1977.

[18]Y. Sakaguchi, "Japanese Rapeseed Imports", Proceedings (1970), op. cit., p. 51.

[19]A personal communication with M.G. Martin of the Canadian Wheat Board.

It has been acknowledged that the agricultural community in Western Canada has to modify the system of handling, storing and transporting grains in order to accomodate foreign market opportunities and to meet sales commitments.[20] However, the problems of "1) the restriction of rapeseed transportation from the area of production to the port of loading, 2) the limited storage space at Vancouver, and 3) the insufficient facilities for cleaning and drying at Vancouver" still need to be overcome.[21]

A successful export program is facilitated by easy and economical movement of the crop. In view of the importance, therefore, of determining the marketing system best suited to expanding Canadian exports of rapeseed, the Minister responsible for the Canadian Wheat Board commissioned the Rapeseed Marketing Committee to investigate alternative systems for marketing rapeseed and outline the advantages of each.[22] Following the study, an open marketing system with a futures market was adopted.[23] The open market system is based on the concept of price derived from the free play of supply and demand. In practice, "free enterprise" is constrained by government regulations and other direct and indirect public involvement. The trading mechanism of the futures market permits buyers and sellers to reduce the risk by providing a hedging mechanism against inventory purchases or commitments.[24] Discussion of

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[20]The Hon. Otto Lang, "Rapeseed and Rapeseed Products in Canada's Economy", Processings (1970), op. cit., p. 151

[21]Sakaguchi, op. cit.

[22]J. McAnsh et al., Rapeseed Marketing - A Description and Evaluation of Alternative Systems, (Ottawa: Information Canada, 1971)

[23]The Hon. Otto Lang, op. cit.

[24]J. McAnsh et al., op. cit., p. 32

the advantages and disadvantages of alternative marketing systems is beyond the scope of this study. However, what is certain is that the controversy with respect to the open market system versus the compulsory board system still prevails. The Senate Agriculture Committee recently recommended that "a bill that would give rapeseed farmers the option of selling their commodity through a marketing agency, be turned down by the full chamber."[25]

Overall, Canadian rapeseed production has greatly increased in volume and quality has improved. There is a bright future for expanding exports. The question which should be asked is - where do we go from here? The answer given by the Minister responsible for the Canadian Wheat Board was that:

> "It will be necessary to accelerate our market development effort. A two-pronged approach should be taken. The salesmen will have to explore and exploit all opportunities, without which even this ready market will not materialize. Technical and scientific service will have to go hand in hand with the salesman, in order to ensure the maintenance of high quality and customer satisfaction."[26]

As far as this study is concerned, the information needed to be provided is the quantitative measurement of the responsiveness of exports with respect to changes in the prices for rapeseed and its close substitutes. The desirable national goal has been "assurance that the maximum volume of Canadian rapeseed will be sold at the greatest return to producers and generation of the maximum possible income from exports".[27]

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[25]The Canadian Press, "Senate Committee Sinks Bill on Rapeseed Sales", The Ottawa Citizen, July 14, 1977, p. 8. That bill was introduced in the Commons in January 1977 by the Minister responsible for the Canadian Wheat Board.

[26]The Hon. Otto Lang, op. cit., p. 155

[27]J. McAnsh et al., op. cit., p. 30

Although rapeseed prices tend to follow the general price level determined in international oilseed markets, the attractiveness of Canadian rapeseed from the standpoint of quality, oil content, supply stability and responsible international business dealings should make it possible to develop preferential market for Canadian rapeseed vis à vis its substitutes. To the extent that this is realized, Canada might be able to set the rapeseed price at a level according to Canada's best interest. In this regard, up-to-date information on direct and cross-price elasticities of exports will be essential, and obviously need to be measured.

Domestic Utilization of Rapeseed

Rapeseed cannot be consumed directly. Oilseed crushing plants and crude edible-oil refining companies act as indispensable links between oilseed producers and consumers. Crushing plants extract the crude oil from the oilseed, while refining companies process the crude oil into final products such as margarine, shortening and salad and cooking oils. Domestic demand for rapeseed has been increased as a result of development of the above industries, as well as by consumption of rapeseed oil and meal.

Crushings: The Canadian oilseed crushing industry processes rapeseed, soybeans and sunflowerseed as well as non-edible flaxseed. Rapeseed crushings increased more than thirty-fold over the last two decades, increasing from about 26 million pounds in 1959 to about 800 million pounds in 1976. Canadian crushing capacity at the end of 1976 was estimated to be 1,950 million pounds of rapeseed and 1,860 million pounds of soybeans annually.[28] This capability was calculated on the basis

[28]Peter R. Perkins, An Economic Review of Western Canada's Rapeseed Processing Industry, (Edmonton: Department of Agriculture, Government of Alberta, Nov. 1976), p. 25

of a 300 working-day year and about 90 per cent utilization rate. This indicates current capacity is adequate to meet the demand for rapeseed oil.

In recent years, the Canadian International Development Agency (CIDA) repeatedly exported large quantities of rapeseed oil as a gift from Canada. As the Agency purchasers have usually been made on short notice with insufficient time for processing, collection and delivery, CIDA is accustomed to paying very large premiums over the domestic price in order to stimulate crushings. This has resulted in "an over-expanded and unhealthy situation" in the Western rapeseed crushing industry.[29]

Prior to 1973, rapeseed oil was not exported from Canada. However, huge rapeseed stocks in the 1972-73 crop year (about 1 million tonnes) led to the exporting of rapeseed oil under bilateral food aid programs sponsored by the Canadian International Development Agency over the 1973-75 period. While this timely coordination between the commitment to foreign food aid programs and domestic demand-supply conditions was a solution for one problem, it unfortunately created another problem of over-expanding crushing capacity.

Another major problem facing the crushing industry is the freight rate disadvantage attached to shipping rapeseed oil and meal. Rapeseed, which is grown and, for the most part, crushed in Western Canada, must compete with soybeans which are crushed in Eastern Canada. The disadvantages of freight rates weakens the competitiveness of Western

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[29]A personal communication with L.R.L. Symmes, General Manager, Edible Oils & Dairy Division, Canada Packers Ltd. (Toronto, August 16, 1977).

crushers because rapeseed moves at statutory rates where oil and meal do not.[30]

In general, oils and meal are priced on their relative oil content and quality. During the past five years the price of rapeseed oil and meal have been, on average, about 90 and 70 per cent respectively of the prices of U.S. soybean oil and meal.[31] In other words, rapeseed products are priced competitively with soybean products in Eastern Canada. These in turn are priced relative to the dominant competitor, U.S. soybeans. The price for the latter is established by the Chicago Board of Trade. The price received by rapeseed crushers in Western Canada are those Eastern prices less freight and the handling costs of moving the products from Western Canada to Eastern Canada.

On the other hand, the price received by rapeseed producers in Western Canada, or the price paid by domestic crushers, as well as elevator companies, is derived from the price established at the Winnipeg Commodity Exchange deducting all the costs associated with buying, handling and transporting. The price for rapeseed in Winnipeg, where rapeseed futures are traded, is always closely aligned with that of soybeans and its products as reflected in the futures market at Chicago.[32]

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[30]A personal communication with John T. Tryon, Director of Marketing, Canadian International Grains Institute (Winnipeg, August 15, 1977).

[31]P.R. Perkins. op. cit., p. 78. However, it should be noted that the varieties of rapeseed, yielding low erucic acid oil as well as low glucosinolate and low fibre content meal, could improve the competitive position of rapeseed products.

[32]A personal communication with A.M. Runciman, President, United Grain Growers Ltd. (Winnipeg, August 17, 1977).

Since both the price of rapeseed and the price of rapeseed oil and meal are closely derived from the prices of soybean oil and meal on the Chicago Futures market, the Western rapeseed crushing industry is limited by the difference between freight costs on moving raw seed and the products of that seed. Raw materials are transported at subsidized rates under a clause of the Railway Act (which are commonly known as the statutory rates), whereas processed oil and meal products must pay compensatory rates. So long as the freight on products is higher than the freight on seed, Western crushers have to pay relatively higher prices for seed and therefore make relatively lower profits on their products. Since prices for the latter are, as noted above, pre-determined in relation to U.S. prices, the cost of transporting rapeseed products and the seed, at products equivalent, equals the amount by which the crushings margin, as well as the price competitive ability, of the Western crusher is reduced.[33] Transportation arrangements for rapeseed products have been a persistant problem for the crushing industry. The matter is still being pursued by Western crushers towards achieving parity in freight rates between rapeseed products and the seed.[34]

It might be noted that while the disparity in freight rates between moving primary and processed products makes processing less profitable for Western crushers than would otherwise be the case this can be viewed as a direct subsidy to producer, which may be fortunate or unfortunate, depending on one's point of view.

Manufacturing: During World War II, rapeseed oil was widely used as a lubricant by the Allied navies. After the war, the market for

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[33]P.R. Perkins, op. cit., p. 88-92

[34]A personal communication with K.D. Sarsons, Chief Executive Officer, CSP Foods (Saskatoon, August 18, 1977).

lubricants began to decline as diesel engines replaced steam. Subsequently, experimental work on edible use for the oil was undertaken. However, in 1956, a ban on the use of rapeseed oil in edible products was imposed because of the question of nutritional value. Following a comprehensive investigation in 1957, the Department of National Health and Welfare announced it had no objective to the use of rapeseed oil, in moderate amounts, in foods.[35] This announcement opened the door to edible use.

The quality of Canadian rapeseed has shown steady improvement through the development of low erucic acid varieties. In addition, improvements in crushing and manufacturing techniques, achieved by the cooperation of scientists in government laboratories, universities and industries, have gradually eliminated the unfavourable nutritional aspects so an expansion of edible uses has continued. The climate in the area of production in most years is favourable to the production of sound mature rapeseed which is the major factor in the successful production of a high quality edible rapeseed oil.[36] The flavour and flavour stability of properly processed, protected and stabilized rapeseed oil is completely satisfactory for an oil used in today's food industry.[37]

Nearly all rapeseed oil is used for edible purposes and consumed in the form of one of the vegetable oil products. Salad oils are made only from vegetable oils, but margarine and shortening are made from vegetable

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[35]A.D. McLeod (ed.), The History of Rapeseed in Western Canada, (Regina, Sask.: Saskatchewan Wheat Pool, 1974), Chapter 2.

[36]B.M. Craig, "Comparative Characteristics of Rapeseed Oils", Proceedings (1970), op. cit., p. 169.

[37]Ragnar Ohlson, "Rapeseed Oil in Margarine and Other Products", Ibid, p. 185.

oils, as well as, animal fats and marine oils. There has been a tendency to substitute vegetable oils for fats and oils for health reasons. In addition, consumers prefer vegetable oils to animal fats because vegetable oils have had a competitive price advantage over animal fats and oils.[38]

Among the crude vegetable oils, rapeseed and soybean are the dominant oils with palm oil becoming increasingly important. Domestic utilization of rapeseed oil peaked in 1973 when it accounted for 41 per cent of the total vegetable oil usage, but declined to 33 per cent in the following two years. The proportion of rapeseed oil used as a percentage of all ingredients in vegetable oil products has varied from year to year among different types. Data for explaining these variations has been inadequate. In addition, technical as well as economic information on utilization of rapeseed oil versus other oils is confidential and not released by the manufacturing industry.[39]

It has been believed that "prospects for continued expansion of edible use appear certain, providing the new low acid oils remove any question of unfavourable nutritional factors."[40] It has also been expected that the paradoxial situation of exporting the cheaper rapeseed and importing the more expensive vegetable oils will be altered in the

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[38]This tendency has occurred in the United States, too. See S.A. Gazelle and P.D. Velde, "Margarine Consumption and Prices", Fats and Oils Situation, (Washington, D.C., Economic Research Service, U.S. Department of Agriculture, June, 1974.

[39]A personal communication with J.N. Rossall, Manager, the Procter & Gamble Company of Canada (Toronto, August 24, 1977).

[40]A.D. McLeod (ed.) *op. cit.*, p. 15

coming years.[41] However, these assumptions can only be confirmed or rejected after a more comprehensive quantitative analysis. This task remains to be done.

Consumption: Rapeseed oil and meal are jointly produced from crushing rapeseed. Since rapeseed has a high oil content, the value of rapeseed oil comprises about 70 per cent of the total value of rapeseed products while rapeseed meal accounts for the remaining 30 per cent. The profitability of rapeseed crushings depends largely on rapeseed oil pricing.[42] However, it is certain that the expansion of rapeseed crushing has been a result of an increase in the consumption of both oil and meal.

Rapeseed meal is a relative newcomer in feed formulations. In Canada, the livestock and poultry industry depends for its protein and energy largely on the cereal grains: wheat, barley and oats. During the last two decades, rapeseed meal has been used in supplementing the cereals. In recent years, however, rapeseed meal has receiving a great deal of attention.[43] According to Statistics Canada data, over the past twenty years the Canadian livestock and poultry industry has expanded by 35 per cent in terms of numbers of livestock and poultry on farms while the production of feed grains and hay has remained relatively constant.

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[41]P.R. Perkins, op. cit., p. 59.
In the most recent years, Canada exported about two-thirds of its rapeseed production and, at the same time, imported other crude vegetable oils (including domestic crushings of soybeans which are supplied by foreign sources) accounting for about 60 per cent of domestic utilization of vegetable oils.

[42]J.W. Duncker, op. cit., p. 14.

[43]J.M. Bell et al. "Panel Discussion on Rapeseed Meal Utilization", Proceedings (1970) op. cit., p. 339.

The history of the domestic use of rapeseed meal is brief. Until the early 1950's the Associate Committee in Animal Nutrition stated that "...we have felt it is unwise to recommend the use of rapeseed oil cake meal in feed rations" because it contained glucosinolates that caused enlargement of the thyroid in various experimental animals as well as some feed and performance problems.[44] Owing to the improvement in nutritive qualities, the Committee modified its feeding recommendation in the middle 1950's so that "it is not advisable to incorporate more than 10 per cent rapeseed meal into the total rations of livestock or poultry".[45] This recommendation was not changed until the late 1960's.

Revolutionary developments have occurred in the quality of rapeseed oil and meal because of the research effort expended in breeding, and in improvement of processing methods. The glucosinolate level and fibre content of Canadian rapeseed have been significantly reduced while the protein content of the meal has increased. "Tower" rapeseed meal is now comparable to or even better than soybean meal. Canada, as well as foreign countries, particularly Japan, has increased the use of rapeseed meal in all livestock and poultry rations.[46] The acceptance of rapeseed meal in terms of nutritive quality is certain.[47] But little has been done in the way of economics analysis with respect to using rapeseed as feed stuff.

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[44]A.D. McLeod (ed.), op. cit., p. 16

[45]Ibid

[46]A booklet published by the CSP Foods Ltd. in 1977.

[47]T.F. Sharby et al., Research on Rapeseed Seed, Dil, Meal and Meal Fractions, Publication No. 40, (Winnipeg or Vancouver: Rapeseed Association of Canada, Feb., 1976).

The demand for rapeseed oils is affected not only by the volume of rapeseed oils used in the production of vegetable oil products, but also by the consumption of these products including margarine, shortening and salad oils. The increase in the total consumption of vegetable oil products in Canada in the last two decades has partially induced the growth of the Canadian rapeseed industry. In order to reach an understanding of the development of the Canadian fats and oils market and its impact on the rapeseed industry, a traditional demand analysis for vegetable oil products is required. Determination of price elasticities, income elasticities of demand for these products and the substitution elasticities of vegetable oils for animal fats, as well as the identification of factors affecting consumption, are essential in projecting the demand for vegetable oil products. This will enable the domestic demand for rapeseed oil and rapeseed to be derived. Knowledge of the consumption of vegetable oil products is useful when explaining why the rapeseed industry has expanded in the past and when predicting the future growth of the industry.

While the major problems associations with each segment of the rapeseed industry have been reviewed above, only those areas which can be quantitatively analysed, based on presently available data, will be followed-up in this study. The hope is that other researchers might be able to address these problems when data becomes available, and also think of ingenious ways to incorporate the qualitative, non-measurable factors in future studies.

B. Objectives and Scope of the Study

Objectives of the Study

The main purpose of this study, as indicated in the above discussion is to bring together the various elements that comprise the rapeseed industry and develop a model to explain and enable prediction of changes on an integrated basis for the benefit of decision-makers. An attempt will be made, through descriptive analysis, to identify the problems need to be resolved so that rapeseed will continue to be Canada's major crops; and as a result of quantitative analysis to project likely scenarios for the Canadian rapeseed industry under various government policies and economic conditions. Specifically, this study has the following objectives:

1. To review the operation of the rapeseed industry in Canada, with the aid of a number of related studies, especially those with respect to the rapid expansion of production, trade, domestic utilization, and consumption of vegetable-oil products. This is aimed at acquiring a better understanding of the reasons why the industry evolved the way that it has.

2. To measure the supply response with respect to changes in the prices of rapeseed and competing field crops in Canada as well as to changes in government policies.

3. To detect some of major factors affecting the degree of penetration of Canadian rapeseed into oilseed markets. This aspect will focus on the measurement of direct and cross price elasticities of demand for Canadian rapeseed in Japan, the European Economic Community and "other nations", as well as in the total export market.

4. To measure consumers' responsiveness, in terms of their consumption of margarine, shortening, and salad oils, as well as total vegetable-oil products, to changes in the prices of related commodities and personal disposable income.

5. To develop an econometric model to determine the conditional equilibrium supply and demand for rapeseed and for vegetable-oil products and to integrate these sub-markets into a whole by means of identity, market-clearing, and price-linkage equations.

6. To interpret the empirical results; to simulate alternative situations making various assumptions with respect to policies and changes in economics conditions; and to outline the implications of results for policy makers.

7. To assess and evaluate statistical data and techniques related to this study.

Scope of the Study

As previously outlined, this study will investigate problems related to supply and demand of rapeseed in Canada. In general, the supply of rapeseed is determined by the inventory of rapeseed at the beginning of a period under consideration and domestic production. The latter, in turn, reflects the acreage seeded to rapeseed and the yield obtained per acre. Variations in rapeseed acreage are mainly the result of economic variables while rapeseed yield is mainly affected by seed variety, farming practices and the weather. The size of the inventory is affected by many factors. Economic factors alone provide little explanation for the variations in inventory. This study will identify and quantitatively measure the complex elements contributing to variations in rapeseed acreage but the analyses of yield and inventory variations will not be included in this study, although it must be acknowledged that variations in yield and inventory do take place and that these aspects cannot be totally ignored.

Demand for Canadian rapeseed is derived from exports and domestic utilization. As the international rapeseed markets can be distinctly divided into three sub-markets, namely Japan, the European Economic Community, and "other nations", the demand characteristics for Canadian rapeseed in each market, as well as at the aggregate level, will be investigated.

Domestic crushings are determined by domestic utilization of oil and meal. Since the value of meal is relatively less than that of the oil, the volume of the crush is mainly derived from the demand for rapeseed oil. Therefore, the demand analysis for rapeseed meal and the study of the connection between the development of the rapeseed industry and the livestock and poultry industry will not be pursued, although it is realized that they are complement areas for research. In this study a quantitative analysis of the utilization of rapeseed oil in the production of margarine, shortening and salad oils and the consumption of these products will be undertaken.

Owing to technological constraints, institutional rigidities and persistence of habits, rapeseed supply or response or changes in purchasing behaviour do not occur instantaneously with modifications in socio-economic environment.[48] In general, producers or consumers cannot immediately adjust the quantities of rapeseed supplied or demanded to a given disturbance in prevailing market conditions. The well-known Koyck-Nerlove type of distributed lag model approach can be used to detect the existence of the lagged effect on supply or demand, and to measure the length of time required to reach a full adjustment. This study will test

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[48]L.M. Koyck, Distributed Lags and Investment Analysis, (Amsterdam, the Netherlands: North-Holland Publishing Co.), 1954

the hypothesis of the existence of a conditioned behaviour by producers with respect to rapeseed production, and by consumers with respect to consumption of vegetable oil products. If the hypotheses relating to the lagged effects are confirmed, the short-run and long-run elasticities of supply and demand with respect to price and other variables will be further measured.

With respect to the analytical period, 1960 will be chosen as the beginning of the analytical period because rapeseed oil was not extracted for edible purposes until the late 1950's, and also, because some information required in this study for the period prior to 1960 is not available. The data for 1976 is not yet available. Therefore, the period of 1960 to 1974 inclusive will be selected for formulating models while the data for 1975 will be used for evaluating the forecasting validity of the models. Furthermore, the potential demand and supply situation surrounding the industry will be simulated up to 1980 under alterntive assumptions with regard to government policy and economic conditions in Canada, as well as in countries importing Canadian rapeseed. The key variables within the industry, i.e. the specified endogenous variables of the model, include acreage, supply, exports, crushings, farm prices of rapeseed, the production of rapeseed oil as well as the prices and the level of consumption of vegetable oil products.

C. Organization of the Study

Briefly, the study is organized as follows: Chapter 1 contains an outline of the basic problems facing the Canadian rapeseed industry and a statement of the objectives and scope of the study; Chapter 2 details the operation of the industry as well as reviews previous studies related to the industry; Chapter 3 provides the economic and statistical framework underlying the study; Chapter 4 explains the construction of the econometric model and also states the method of estimation that is used; Chapter 5 estimates parameters, interprets results, presents simulation experiments and suggest policy implications; the final Chapter summarizes conclusions, identifies limitations of the current study, and suggests areas for further study.

CHAPTER 2

A REVIEW OF THE CANADIAN RAPESEED INDUSTRY

In the span of about three decades rapeseed has progressed from being virtually unknown to the status of Canada's fourth most extensively-sown crop.[1] In this chapter, with the aid of a number of related studies, the advice offered by rapeseed industry executives and that of government, university and foreign embassy experts, a review of the progress of the industry in Canada, especially with respect to the rapid expansion of production, trade and domestic utilization will be undertaken. It is aimed at identifying the problems, and thus the areas to be investigated in this study in order to obtain a better understanding as to why the industry evolved the way that it has.

A. Supply and Disposition of Rapeseed in Canada

An overview of an industry can be made by investigating the supply and disposition of its products. The supply of Canadian rapeseed during a crop year (August 1st to July 31st) is determined by domestic production and the stocks at the beginning of the crop year. The supply is largely disposed of through exporters and Canadian crushing plants. An inventory is carried over into the next year. Part of the supply is absorbed as seed.

Detailed information regarding the supply and disposition of rapeseed in Canada has been available since the 1965-66 crop year. As

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[1]It is common to hear rapeseed referred to as Canada's "cinderella" crop, much as soybeans are referred to as the "miracle" crop in the U.S.; see R.K. Downey et al., Rapeseed, Canada's "Cinderella" Crop (3rd ed.), (Winnipeg or Vancouver: Rapeseed Association of Canada, April 1974).

Table 2.1 shows, domestic production averaged 48.4 million bushels during the past 11 crop years (1965/66 - 1975/76), with carryovers (including stocks on farm and in commercial position) averaging 12.2 million bushels. Of the average supply of rapeseed, 28.6 million bushels (47 per cent) were exported, 9.6 million bushels (16 per cent) were crushed domestically, 15.9 million bushels (26 per cent) were stored at the end of the crop year, and the remaining 6.5 million bushels (11 per cent) used as seed and animal feed, or else were lost in handling. These data reveal that exports and domestic crushing have been the major factors affecting the development of the Canadian rapeseed industry. Therefore these aspects will be of prime importance in the subsequent sections which review the operation of the industry.

B. Rapeseed Production in Canada

Rapeseed production is a function of the acreage under cultivation and the yield per acre. The latter has remained relatively stable during the past two decades, so that variation in rapeseed production has been due almost exclusively to variation in the acreage under cultivation.

Rapeseed Acreage

In 1956, only 352 thousand acres were devoted to rapeseed production. In 1965, about ten years later, following sustained expansion of exports and domestic crushings, rapeseed acreage had increased to approximately 1.4 million acres. Predominately due to the wheat stocks crisis in the late 1960's, rapeseed acreage expanded from 1 to 4 million

Table 2.1

Supply and Disposition of Rapeseed in Canada

Crop Years 1965/66 to 1975/76

Crop Year	Stocks on August 1	Production	Total Supply or Disposition	Exports	Crushings	Seed Dockage	Stocks on July 31
			million bushels				
1965/66	1.3	22.6	23.9	13.6	3.7	3.3	3.3
1966/67	3.3	25.8	29.1	13.8	5.0	4.3	6.0
1967/68	6.0	24.7	30.7	12.3	5.2	3.5	9.7
1968/69	9.7	19.4	29.1	14.3	6.9	2.6	5.3
1969/70	5.3	33.4	38.7	22.2	7.8	5.0	3.7
1970/71	3.7	72.2	75.9	46.8	8.6	9.5	11.0
1971/72	11.0	95.0	106.4	42.6	12.0	8.3	43.1
1972/73	43.1	57.3	100.4	54.0	15.6	10.1	20.7
1973/74	20.7	53.2	73.9	39.2	14.7	7.6	12.7
1974/75	12.4	51.3	63.7	26.1	12.2	7.8	17.6
1975/76	17.6	77.1	94.7	30.1	14.0	8.3	42.3
Average	12.2	48.4	60.6	28.6	9.6	6.5	15.9

Source: Rapeseed Association of Canada, Rapeseed Digest, Vol. 11-6 (June 1977).

Table 2.2

Acreages, Production and Values of Rapeseed in Canada
Crop Years 1956/57 to 1974/75

Crop Year	Acreage Seeded	Yield	Production	Farm Price	Total Value
	thousand acres	bu/acre	thousand acres	dollars per bus.	thousand dollars
1956/57	352	17.0	5,996	1.75	10,494
1957/58	618	14.0	8,661	1.60	13,858
1958/59	626	12.4	7,762	1.25	9,703
1959/60	214	16.7	3,560	2.00	7,120
1960/61	763	14.6	11,120	1.65	18,348
1961/62	710	15.8	11,220	1.80	20,196
1962/63	371	15.8	5,860	2.05	12,013
1963/64	478	17.5	8,360	2.50	20,900
1964/65	791	16.7	13,230	2.54	33,604
1965/66	1,435	15.9	22,800	2.33	53,124
1966/67	1,525	16.9	25,800	2.47	63,760
1967/68	1,620	15.2	24,700	1.92	47,506
1968/69	1,052	18.4	19,400	1.83	35,472
1969/70	2,012	16.6	33,400	2.29	76,494
1970/71	4,050	17.8	72,200	2.33	168,179
1971/72	5,306	17.9	95,000	2.16	205,530
1972/73	3,270	17.5	57,300	3.16	181,086
1973/74	3,150	16.9	53,200	5.72	304,304
1974/75	3,160	16.2	51,300	7.06	362,178
1975/76	4,020	17.9	72,100		

Source: Statistics Canada, Quarterly Bulletin of Agricultural Statistics, Cat. No. 21-003, Quarterly.

acres during the 1968-1970 period and to a record 5.3 million acres in 1971. As a result, rapeseed has now firmly established itself as Canada's fourth largest field crop, surpassed only by wheat, barley and oats in terms of acreage (Table 2.3). As a matter of fact, during the 1970-1975 period, the average rapeseed acreage was equivalent to about one-fifth of the wheat acreage. It has thus been evident for some time that rapeseed has emerged as a viable alternative to wheat and coarse grains on the Prairies.

The increase in rapeseed acreage, or the shift in cultivation patterns towards rapeseed production, reflects the fact that the financial returns from rapeseed are sufficient to render it competitive with other crops for land. In general, farmers are willing to grow a crop only if the revenue obtained from producing that crop is equal to, or higher than its opportunity cost.[2] The 1964-73 average value per acre of rapeseed was $45.9 which was higher than that for wheat ($44.8), barley ($40.0) and oats ($36.9) (see Table 2.4). Unfortunately, information on crop production costs has not been available, so that a comparison of the average per-acre net farm return for the major field crops has not been possible. However, in view of the fact that the prices of the various inputs in a particular region are usually the same for all crops, the unit production costs will differ only if rates of input utilization are different. The variation in unit production costs among crops is thought to be relatively lower than the variability in yield and in price. Accordingly, it seems reasonable to conclude that rapeseed has been a

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[2]The opportunity cost is defined as the highest potential revenue which could be obtained from growing alternative crops.

Table 2.3

Acreages of Major Field Crops in Canada
Crop Years 1965/66 to 1974/75

Crop Year	Wheat	Barley	Oats	Rapeseed
		million acres		
1965/66	28.3	6.1	8.4	1.4
1966/67	29.7	7.5	7.9	1.5
1967/68	30.1	8.1	7.4	1.6
1968/69	29.4	8.8	7.6	1.1
1969/70	25.0	9.4	7.3	2.0
1970/71	12.5[a]	9.9	6.9	4.1
1971/72	19.4	14.0	6.8	5.3
1972/73	21.3	12.5	6.1	3.3
1973/74	23.7	12.0	6.7	3.2
1974/75	22.1	11.8	6.1	3.2
1975/76	23.4	11.0	6.0	4.0

Source: see Table 2.2

[a] The program of Lower Inventory For Tomorrow (LIFT) was introduced as an emergency measure to alleviate the wheat surplus problem in crop year 1970/71.

Table 2.4

Gross Returns per Acre for Major Field Crops in Canada
Crop Years 1964/65 to 1973/74

Crop Year	Wheat	Barley	Oats	Rapeseed
		dollars per acre		
1964/65	32.2	30.7	30.0	45.8
1965/66	38.5	36.7	34.9	37.8
1966/67	49.1	42.4	35.0	41.7
1967/68	32.1	26.6	29.5	29.2
1968/69	29.6	29.8	28.8	33.7
1969/70	34.2	26.6	28.7	38.0
1970/71	38.3	31.0	30.8	41.5
1971/72	36.9	29.7	30.3	38.7
1972/73	46.5	51.8	43.8	55.3
1973/74	110.9	98.3	77.1	96.7
Average	44.8	40.4	36.9	45.8

Source: Computer from data published in Statistics Canada, Quarterly Bulletin of Agricultural Statistics, Cat. No. 21-003, Quarterly.

profitable crop in Canada.[3]

The answer to the question, "what land resources are available for the production of rapeseed", depends on how well the crop competes with alternative crops in economic terms, rather than on physical constraints. Census reports of Statistics Canada indicate that there has been an overall increase in the area of farmed from 117 million acres in 1921 to 158 million acres in 1971. In the Prairie provinces, the total area of class 1 C.L.I. (Canada Land Inventory) considered suitable, in terms of climate, soil and landscape properties, for the production of rapeseed is estimated to be about 50 million acres.[4] This means, assuming a four-year crop rotation to protect against pests and diseases, that 12.5 million acres of oilseeds could be grown annually on a sustained basis. Furthermore, allowing 1 million acres for the expansion of sunflower and mustard and possibly 3 million acres for flax, there would still remain 8.5 million acres annually for rapeseed. This potential area is considered greater than recent rapeseed acreage, indicating that decisions

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[3]In Manitoba, over the 1964-74 period, rapeseed yielded a significantly higher net return (i.e. gross return less costs of seed and fertilizer) than most of the other crops; see W.J. Craddock, "Economics of Oilseed Proudction", J.T. Harapiak (ed.), Oilseeds and Pulse Crops in Western Canada (Calgary, Alberta: Western Cooperative Fertilizers Ltd., 1975), p. 679-94. Another study, based on a survey of 125 farms in the Prairie provinces in 1972, concluded that rapeseed was and will continue to be a viable alternative to cereal production in the parkbelt and the Dark Brown soil zone; see J.M. Johnson, Rapeseed Production and Marketing, (Regina, Sask.: Economics Branch, Agriculture Canada, 1973).

[4]J.A. Shields and W.S. Ferguson, "Land Resources, Production Possibilities and Limitations for Crop Production in the Prairie Provinces", J.T. Harapick, (ed), op. cit..

at the time of seeding are governed to a high degree by economic factors other than land availability.[5]

Overall, there has been an upward trend in the amount of rapeseed acreage. However, the acreage sown has varied widely over time. For example, the acreage sown decreased by two-thirds, from 626,000 acres in 1958 to 213,500 acres in 1959, and then increased more than 3 times to 763,000 acres in 1960. Again, between 1968 and 1971, the acreage seeded increased five-fold, from 1 to 5.3 million acres, then over the next four years stabalized at a level around 3.3. million acres (Table 2.2). Fluctuations between any two successive years have been remarkable, averaging about 50 per cent over the past 20 years. Thus, the question that should be asked is - "what factors cause fluctuations in rapeseed acreage?" Recently, two studies exploring this question have been completed.[6]

Uhm formulated statistical models with respect to rapeseed acreage for each Prairie province, as well as for the Region as a whole.[7] He assumed that variations in rapeseed acreage were affected by the prices of wheat and rapeseed, exports of rapeseed, yields of rapeseed, stocks of

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[5]C.R. Phillips, "Canadian Oilseed Situation and Prospects", in International Association of Seed Crushers, Killarney Congress, (London, England, May 30-June 1, 1973), pp. 8-10

[6]I.H. Uhm, A Supply Response Model of Canadian Rapseeed and Soybeans No. 75/15, (Ottawa: Economics Branch, Agriculture Canada, 1975), and J.G. Nagy and W.H. Furtan, The Socio-Economic Costs and Returns from Rapeseed Breeding in Canada, Technical Bulletin, BL:77-1, (Saskatoon, Sask: Department of Agricultural Economics, University of Saskatchewan, May, 1977).

[7]Uhm, op. cit..

wheat, related government programs and the size of the previously tilled acreage. Apart from the statistical estimates themselves, the most significant contribution of the study was the actual introduction of a quantitative methods when analyzing the rapeseed supply situation in Canada. However, in order to re-test the postulated hypotheses and re-estimate the parameters, it would be desirable to include the most recent years in the analytical period, because, although a record of 5.3 million acres was cultivated in 1971, rapeseed acreage dropped to a level of 3.3 million acres during the subsequent 3 years. Obviously using the peak period as the last observation period would provide an upward bias to the estimates of parameters, particularly when, as in this case, the analytical period is relatively short.[8]

Nagy and Furtan conducted a cost-benefit analysis in relation to research that improved rapeseed yield and oil quality, and the distribution between consumers and rapeseed producers of the net social benefit of some $86 million that arose during the 1961-75 period.[9] In the process of measuring the consumer's and producer's surpluses, demand and supply curves for rapeseed were estimated. That study postulated that rapeseed production on the Prairies was determined by the prices of rapeseed and flaxseed, wheat stocks and a trend variable accounting for advances in technology, management practices and breeding.

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[8]In Uhm's study, the 1958-72 data were analyzed.

[9]Nagy and Furtan, op. cit., A similar analysis of the relative social costs and benefits of varietal breeding and research activities to improve the quality and increase the markets for rapeseed and its products was conducted by W. Darcovich, Rapeseed Potential in Western Canada - an Evaluation of a Research and Development Program, Economics Branch Publication 73/7, (Ottawa: Economics Branch, Agriculture Canada, 1973).

Empirical investigations of supply elasticities for individual crops have generally involved estimating the responsiveness of acreage to changing relative prices as an approximation of the price elasticity of supply. The economic literature is relatively silent on attempts to measure the price elasticity of supply (production) as contrasted to acreage.[10] As the production of a crop is determined both by yield and area, the price elasticity of supply is equal to the sum of the price elasticities of yield and acreage.[11] This is particularly true in a land-scarce region or country, because a shift in relative prices will induce a shift in cropland to the more profitable crop, and may as well, involve more fertilizer use or more intensive management in order to raise the yield.

In contrast, the Canadian agricultural industry has been characterized as labour-scarce. While relatively increasing prices for rapeseed will induce a shift from the production of other crops, they will also tend to encourage technical and biological innovations which will save labour and increase output per man in the long-run. In this situation, increased production will in the short-run be due almost solely to the increased land area devoted to rapeseed. However as a more marginal land is brought into production, yields will tend to decline, although the decline will likely be offset by greater use of fertilizer and improved management techniques. If yields remain constant, the elasticity of acreage will be a very close approximation of the elasticity of supply. The choice between the supply approach and the acreage

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[10]M.D. Whitaker, "A Model for Estimating Supply Versus Hectarage Elasticities for Individual Crops", Unpublished paper, (Logan, Utah: Department of Economics, Utah State University, 1975).

[11]Ibid., p. 6.

approach will heavily depend on the responsiveness of yields to changes in prices. This aspect will be discussed in some detail in the following section.

Rapeseed Yield

The average yield per seeded acre has been increasing moderately due to a combination of improved varieties and improved agronomic practices.[12] Favourable economic conditions have led to the rapid expansion of the rapeseed industry and encouraged investment in research seeking improvements in yield and in the quality of its oil and meal. However, as indicated in Table 2.5 and Figure 2.1, there was little correlation between yield and lagged rapeseed farm prices over the last two decades.[13] It must be acknowledged that variations in yield did take place, but that these were more affected by physical factors than by price fluctuations.[14] The year-to-year changes in yield, in terms of direction and magnitude, were not consistent with changes in prices.

The Argentine type (Brassica rapus) and the Polish type (Brassica campestris) are the two major rapeseed types produced in Canada. Although these two species have different agronomic characteristics, they are mixed and sold as one. The Argentine species have had a generally higher yield potential, but climate, soil type and timing of farm operations still determine the species best suited to a particular farm. Prior to 1970, the Argentine species only accounted for about one-quarter of the acreage under cultivation in Canada, but in recent years the area seeded to this

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[12] R.K. Downey et al., op. cit., p. 4.

[13] The rapeseed prices were adjusted by the price index of Canadian field farm products. Data sources are given in Table 2.5.

[14] R.K. Downey et al., op. cit., p. 16.

Table 2.5

Indexes for Yield and Farm Prices for Rapeseed in Canada, 1956 to 1975

Year	Rapeseed Yield[a]	Index of Yield	Lagged Rapeseed Price[a]	Deflated Rapeseed Price	Index of Rapeseed Price
	bus. per ac.	per cent	dol. per bus.	dol. per bus.	per cent
1956	17.0	100.0	1.75	0.972	100.0
1957	14.0	82.4	1.75	0.964	99.2
1958	12.4	72.9	1.60	0.946	97.3
1959	16.7	98.2	1.25	0.729	75.0
1960	14.6	85.9	2.00	1.136	116.9
1961	15.8	92.9	1.65	0.873	89.8
1962	15.8	92.9	1.80	0.939	96.6
1963	17.5	102.9	2.05	1.049	107.9
1964	16.7	98.2	2.50	1.267	130.3
1965	15.9	93.5	2.54	1.282	131.9
1966	16.9	99.4	2.33	1.108	114.0
1967	15.2	89.4	2.47	1.178	121.2
1968	18.4	108.2	1.92	0.948	97.5
1969	16.6	97.6	1.83	0.955	98.3
1970	17.8	104.7	2.29	1.249	128.5
1971	17.9	105.3	2.33	1.259	129.5
1972	17.5	102.9	2.16	1.179	121.3
1973	16.9	99.4	3.16	1.575	162.0
1974	16.2	95.3	5.72	1.722	177.2
1975	17.9	105.3	7.06	1.611	165.7

[a]Source: Table 2.2

[b]The prices of rapeseed were deflated by the price index of field farm products (1935-39=100).

Source: Statistics Canada, Index Numbers of Farm Prices of Agricultural Products, Cat. No. 62-003, monthly.

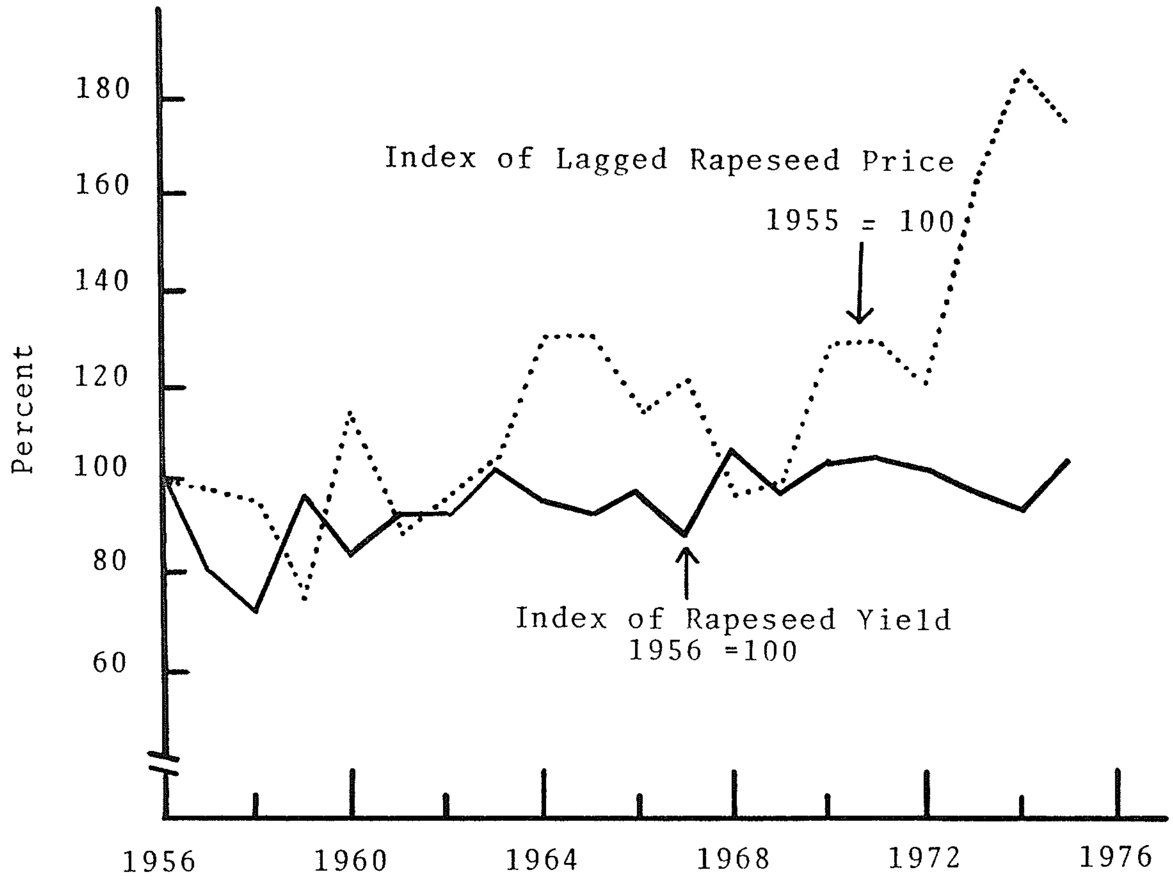

Figure 2.1

Indexes of Rapeseed Yield and Lagged Rapeseed Price

Source: Table 2.5

species has been increasing. In 1976, for example, total rapeseed acreage was about evenly divided between the two species.[15]

Although rapeseed breeding programs began in 1944, two years after the crop was introduced into Canada, research scientists did not undertake a full time breeding program until the early sixties. The task of the oilseed breeder and his co-workers has been to develop rapeseed varieties possessing certain desired characteristics, such as high-yield, early maturity, resistance to certain diseases, high oil and protein content, low erucic acid in the oil, and low glucosinolate and lower fibre content in the meal. During the period 1954 to 1974, about 14 new varieties were developed and licensed.[16] This suggests that, on average, a new variety was introduced every 1 to 2 years. In recent years, there has been a concentrated effort by rapeseed breeders to develop a "double-zero" variety (low erucic acid and low glucosinolate). Once a variety with such desirable qualities has been developed work will need to be done on improving yields.[17]

In addition to whatever variety is selected, the choice of land, as well as the length of the crop rotation, are important factors affecting yield. Rapeseed grows well on a wide range of soils although loamy soils are preferred. Rapeseed will not tolerate water-logged conditions and

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[15]Nagy and Furtan, op. cit., p. 20.

[16]A detailed discussion is given by B.R. Stefansson, "Rapeseed Breeding in Western Canada", in A.D. McLeod (ed.), The History of Rapeseed in Western Canada, (Regina, Sask.: Saskatchewan Wheat Pool, 1974); and R.K. Downey et al., "Breeding Rapeseed and Mustard Crops", in J.T. Harapick (ed.), op. cit..

[17]A personal communication with G.R. Sargent of Alberta Wheat Pool.

heavy soils. In the drier areas, higher moisture-holding clays and clay-loam soils have given good yields.[18] Yields vary significantly from year to year and province to province. Over the 1969-73 period, for example, yields on summer-fallow averaged over 18 bushels per acre, while average yields on stubble have been about 72 per cent of the yields obtained on summer-fallow. Yields in Manitoba were higher than those in Saskatchewan and Alberta. This may reflect more favourable moisture conditions in the production areas in the Red River Valley and Interlake region in Manitoba.[19] However, Manitoba had the highest proportion of rapeseed sown on cereal stubble land. These two factors offset the yield differences among the provinces (Table 2.6).

Yields are also affected by weather conditions, resource inputs and other factors such as seeding practices, use of fertilizer, weed control, control of diseases and insect pests, harvesting, drying, grading and storage.[20] Detailed discussion of these aspects is beyond the scope of this study. The requirements of intensive management in the production of rapeseed has prevented some non-growers from growing rapeseed because they have been concerned with certain technical problems associated with the crop.[21] In addition, what may actually have kept the yield from

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[18]R.K. Downey _et al._, (1974), _op. cit._, p. 15

[19]_Ibid_.

[20]Personal communications with B.R. Stefansson, Plant Science, University of Manitoba, Winnipeg; and L.M. Johnson, Economics Branch, Agriculture Canada, Regina.

[21]R.K. Baydack, "Factors Affecting Resources Management Decisions: A Case Study of the Manitoba Rapeseed Primary Producer", Unpublished Master's thesis, (Winnipeg, Manitoba, Natural Resource Institute, University of Manitoba, 1977).

Table 2.6

Rapeseed Yields by Province and Cropping Practice
1969 - 1973 Average

	Summerfallow		Cereal Stubble		Provincial
	Yield	Area	Yield	Area	Average
	bus. per ac.	per cent	bus. per ac.	per cent	bus. per ac.
Manitoba	21.0	52	16.4	48	18.8
Saskatchewan	18.3	89	12.3	11	17.6
Alberta	18.2	73	12.2	27	16.6
Prairie	18.4	78	13.4	22	17.3

Source: Computed from data presented in Rapeseed Association of Canada, Rapeseed, Canada's Cinderella Crop, (3rd ed.) (April 1974), p. 13.

increasing is the apparent lack of cultivation experience among new growers. As shown in Table 2.7, during the 1961-71 period, the almost three fold growth rate (289 per cent) of the number of growers has greatly exceeded growth (91 per cent) in the average acreage per farm. This suggests that increases in overall rapeseed acreage were mainly attributable to increases in the number of growers. These new growers may have experienced low yields due to a lack of production experience. The low yields obtained by this group would likely have offset efforts at yield improvement by experienced rapeseed producers and resulted in only a moderate increase in the overall average yield. In any case, the relatively inelasticity of the average yield per acre with respect to economic conditions would seem to make analysis of the phenomenon less essential, although it does not imply that this aspect can be totally ignored.

Geographical Distribution of Rapeseed Production

Rapeseed production is centered almost exclusively in the Prairie provinces with Saskatchewan leading in terms of acreage. While it does exist, rapeseed production in Ontario and British Columbia has been negligible. The main rapeseed production areas are concentrated in the Peace River region of Alberta, the north-central region of Saskatchewan, and the interlake and southern regions of Manitoba.[22] During the 1965-74 period, the distribution of acreage between Manitoba, Saskatchewan and Alberta has been in the order of 12, 48 and 40 per cent, respectively. The average per-acre yield was lowest in Alberta where 40 per cent of the rapeseed acreage was located but which accounted for only 38 per cent of

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[22]R.K. Downey *et al.* (1974), *op. cit.*, p. 14.

Table 2.7

Rapeseed Acreage and the Number of Farms Producing Rapeseed by Province, 1961, 1966 and 1971

Year	Province	Total Acreage	No. of Farms	Acreage per Farm
		thous. ac.	no.	acres
1961	Manitoba	29	699	44
	Saskatchewan	374	7,023	53
	Alberta	307	4,858	63
	Canada [a]	711	12,582	57
1966	Manitoba	170	2,661	64
	Saskatchewan	731	10,195	72
	Alberta	624	8,850	71
	Canada [a]	1,527	21,734	70
1971	Manitoba	581	7,325	79
	Saskatchewan	2,737	24,972	110
	Alberta	1,988	16,436	121
	Canada [a]	5,325	48,923	109
$\frac{1971}{1961}$	Canada	749%	389%	191%

[a]Canada includes prairie provinces and British Columbia

Source: Statistics Canada, Census of Agriculture: Areas and Census-Farms Reporting Field Crops, Cat. No. 96-521, 96-621 and 96-718.

Canada's production (see Table 2.8). In contrast, Manitoba had the highest yields (Table 2.9) and the greatest growth in rapeseed acreage in Canada (Table 2.8).

Because rapeseed has proven to be such a good alternative crop for grain producers, it would be worthwhile to identify and quantitatively measure the elements contributing to the variations in rapeseed acreage in Canada, and also to assess the impact of the major economic variables affecting yearly production and marketing. Obviously fluctuations in rapeseed prices and in turn cultivated acreage, are broadly attributable to changes in the supply of and demand for rapeseed. In order to minimize the cycle of excessive rapeseed production, falling prices and losses in revenues, followed by acreage cut-backs and shortages, policy makers ought to determine a desirable national production level. In facing this question, an examination of production and marketing factors which affect the total demand for Canadian rapeseed would obviously be critical. As noted earlier, exports and domestic crushers absorb most of the rapeseed produced. These outlets will now be examined.

C. Rapeseed Exports from Canada

Destination of Canadian Rapeseed Exports

Canadian rapeseed exports, during the past two decades, have shown a pronounced long-run increase in volume. The expansion of rapeseed exports is a reflection of the fact that Canada has established herself as a supplier of rapeseed to meet the ever increasing demand for vegetable oils in the world at large. Spatial equilibrium theory holds that, in general, a commodity will be exported from a surplus region to a deficit

Table 2.8

GEOGRAPHIC DISTRIBUTION OF RAPESEED ACREAGE AND PRODUCTION ON THE PRAIRIES, 1956 - 1976

Year	Acreages				Production			
	Man.	Sask.	Alta.	Can.	Man.	Sask.	Alta.	Can.
	.....thousand acres				..... million bushels			
1956	29	297	26	352	0.5	5.0	0.5	6.0
1957	28	520	70	618	0.3	7.3	1.0	8.7
1958	21	535	70	626	0.3	6.6	0.9	7.8
1959	12	165	37	214	0.2	2.8	0.6	3.6
1960	33	550	180	763	0.5	8.0	2.6	11.1
1961	29	374	307	710	0.4	5.6	5.3	11.2
1962	32	167	172	321	0.6	2.6	2.7	5.9
1963	45	210	223	478	0.8	4.0	3.6	8.4
1964	84	303	404	791	1.5	5.3	6.5	13.2
1965	145	555	735	1435	2.4	10.7	9.5	22.6
1966	170	731	624	1525	2.1	12.7	11.0	25.8
1967	145	600	875	1620	2.3	10.2	12.2	24.7
1968	91	511	450	1052	1.9	10.3	7.2	19.4
1969	196	1000	816	2012	3.5	18.2	11.7	33.4
1970	400	2200	1450	4050	7.2	39.5	25.5	72.2
1971	581	2737	1988	5306	12.0	51.0	32.0	95.0
1972	470	1500	1300	3270	8.5	24.8	24.0	57.3
1973	400	1450	1300	3150	7.7	24.0	21.5	53.2
1974	500	1560	1200	3260	8.5	24.0	19.5	52.9
1975	750	1800	1700	4320	12.5	33.0	30.5	77.1
1976	250	850	850	1985	4.5	19.4	16.5	41.0

Source: see Table 2.2

Table 2.9

RAPESEED YIELD PER ACRE ON THE PRAIRIES

1956 - 1976

Year	Manitoba	Saskatchewan	Alberta	Canada
	....	bushels per	acre	....
1956	16.6	17.0	18.5	17.0
1957	12.5	14.0	14.8	14.0
1958	12.0	12.3	13.0	12.4
1959	15.0	17.0	16.0	16.7
1960	14.4	14.6	14.7	14.6
1961	12.3	15.0	17.1	15.8
1962	18.0	15.7	15.5	15.8
1963	16.9	19.2	16.0	17.5
1964	17.5	17.5	16.0	16.7
1965	16.2	19.3	12.9	15.7
1966	12.4	17.4	17.6	16.9
1967	15.9	17.0	13.9	15.2
1968	20.9	20.2	16.0	18.4
1969	17.9	18.2	14.3	16.6
1970	18.0	18.0	17.6	17.8
1971	20.7	18.6	16.1	17.9
1972	18.1	16.5	18.5	17.5
1973	19.2	16.6	16.5	16.9
1974	17.0	16.0	16.2	16.2
1975	16.7	18.3	17.9	17.8
1976	18.0	22.8	19.4	20.7

Source: see Table 2.2.

region.[23] India, China and Canada have been the three largest rapeseed producing countries. However, domestic consumption in India and China, as well as in other rapeseed producing nations, usually exceeds their production. Thus less than one-quarter of the rapeseed produced in the world in 1973 entered export channels. Accordingly, Canada has been by far the largest rapeseed exporting country in the world. In 1973, rapeseed exported from Canada comprised about 71 per cent of international rapeseed exports.[24]

Commencing in 1956 Canada began exporting rapeseed. Exports increased from 60 million pounds in that year to 265 million pounds in 1957. For a time afterwards exports were remarkably stable, averaging around 279 million pounds over the period 1957 to 1964. Another large increase occurred when rapeseed exports reached 532 million pounds in 1965. Since that time the amount of rapeseed exports has steadily expanded. For example, exportes amounted to 1,402 million pounds in 1970 and with a record high of 2,631 million pounds reached in 1973. This dramatic growth pattern of Canadian rapeseed exports is illustrated in Table 2.10.

Japan and the European Economic Community (the EEC includes Belgium, Denmark, France, Germany (West), Ireland, Italy, Luxembourg, the Netherlands and the United Kingdom) have been the major purchasers of Canadian rapeseed. During the past two decades, about 86 per cent of the rapeseed exported from Canada was sold to Japan and the EEC while the remaining 14 per cent was purchased by other nations throughout the world. However, the number of nations importing Canadian rapeseed has gradually

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[23]P.A. Samuelson, "Spatial Price Equilibrium and Linear Programming", American Economic Review, 42(1952).

[24]Rapeseed exports in the world at large, in 1973, was 1,677 thousand tonnes (see FAO, UN, Yearbook of Trade).

Table 2.10

DESTINATION OF CANADIAN RAPESEED EXPORTS

Year	Japan	EEC	Other Nations		Total
	....	million pounds	....		
1956	12.3	45.0	2.9	(3)[a]	60.1
1957	0	259.4	5.3	(2)	264.7
1958	37.2	246.7	0.6	(3)	284.4
1959	81.0	144.6	0.1	(1)	225.7
1960	88.4	128.1	43.1	(2)	260.0
1961	40.4	182.4	48.2	(2)	271.0
1962	104.6	299.2	25.9	(2)	429.6
1963	229.5	48.1	32.9	(3)	310.5
1964	125.0	30.3	26.8	(4)	182.1
1965	229.1	207.6	95.7	(5)	532.4
1966	389.0	268.9	40.0	(4)	697.9
1967	469.1	211.9	61.0	(5)	742.1
1968	555.8	30.3	138.4	(5)	724.5
1969	540.3	72.9	63.6	(7)	676.8
1970	741.5	441.8	218.3	(9)	1401.5
1971	952.7	1243.9	341.1	(16)	2537.7
1972	1296.8	771.9	307.5	(13)	2376.1
1973	1567.5	579.2	484.9	(9)	2631.6
1974	1089.0	102.2	166.8	(8)	1358.0
1975	1277.3	66.0	147.5	(7)	1490.7
1976	1514.3	105.9	87.6	(6)	1707.8

[a]Numbers within parentheses are the number of the "other nations".

Source: Statistics Canada, Exports by Commodities, Cat. No. 65-004 Monthly.

increased (Table 2.10).

The determinants of international trade in rapeseed, that is the trade policies of individual countries, the diplomatic relationships among nations, and uncontrollable weather conditions, have changed frequently in different directions and to different degrees. For example, Japan implemented a reduction in its tariff on Canadian rapeseed, commencing on October 29, 1971.[25] This change resulted in an immediate increase in imports of Canadian rapeseed from 953 to 1,297 million pounds between 1971 and 1972. The disruption of diplomatic relationships between Canada and Taiwan (The Republic of China) (Canada's second best customer in 1968) temporarily halted the rapeseed trade between these two nations in 1970, although trade was resumed in 1973. Sharply curtailed production in the EEC, due mainly to bad weather, resulted in an increase in its imports of Canadian from 73 million pounds in 1969 to 442 million pounds in 1970.[26] In addition, no long-term rapeseed trade agreement has ever been made between Canada and any country. Consequently, the magnitude of Canada's rapeseed exports has varied from year to year, and from one country to another. These variations in trade reveal that overall expansion in rapeseed exports from Canada has been achieved through competition with other products in the international oilseed market. In order to establish the increased world trade in rapeseed that Canada can secure, while at the same time ensuring that the greatest possible net returns are obtained by rapeseed growers in Canada, measurements of the price elasticities of demand for Canadian rapeseed in the

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[25] Winnipeg Free Press, Sept. 15, 1971, p. 1.

[26] Statistics Canada, Exports by Commodities, Cat. No. 65-004 monthly.

importing countries are required. For the purpose of explaining variations in Canada's share of the international oilseed market, a knowledge of the demand and supply conditions in the United States, Japan and the EEC appears to be essential since U.S. soybeans compete with rapeseed, and Japan and the EEC are the major importers of Canadian rapeseed. Prospects for trade in oilseeds with the above-cited regions will be reviewed below.

Prospects for Oilseed Trade in the United States

The United States has been experiencing a high rate of increase in production of soybeans and a relatively slow growth in domestic consumption of vegetable oils. Therefore, it may be reasonable to assume that the volume of oilseeds available for export will increase substantially in the future.

Americans are eating more margarine, shortening, and cooking and salad oils than in earlier years, but less butter and lard. In the early 1950's, the U.S. market for fats was split equally between animal fats and edible vegetable oils. In recent years, vegetable oils have accounted for about four-fifths and animal fats only about one-fifth of consumption. On a per capita basis, annual vegetable oil consumption in 1975 was about 20 kilograms, double that in 1950-52. Soybean oil is extending its lead as the major edible oil and now accounts for nearly three-fifths of all fats and oil food products.[27] However, in view of the fact that consumption of fats and oils is approaching a maximum level, the rate of increase

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[27]G.W. Kromer, "U.S. Food Consumption Trends", in Fats and Oils Situation, FOS-272, (Washington, D.C.: Economics Research Service, U.S. Department of Agriculture, April, 1974), pp. 16-32.

in oil consumption in the U.S. is predicted to be below that in the world as a whole.[28]

Soybeans, cottonseeds, and peanuts are the three major oilseeds produced in the U.S. Cottonseed and peanut production are controlled by acreage allotments. In 1975, for example, production of these two kinds of oilseeds amount to about 3 million tons compared to 41 million tons of soybeans.[29] Peanuts and cottonseed are mainly domestically consumed, while more than one-third of the soybeans are exported. Soybean production is not controlled. On the contrary, it is encouraged by government support under the Food for Peace Program (PL480). The government makes loans to farmers and accepts soybeans as collateral. The amount of loans is equivalent to average soybean production valued at the government support price. A farmer has the option of redeeming the loan if the market price is higher than the support price, or, of delivering the soybeans at maturity in full satisfaction of the loan, regardless of market price.[30] This has

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[28]L.F. Herrmann et al., World Supply and Demand Prospects for Oilseeds and Oilseed Products in 1980, Foreign Ag. Econ. Report 71, ERS, USDA, (Washington, D.C.: U.S. Government Printing Office, March 1971), p. 52; Per capita consumption of margarine, shortening and salad oils in the U.S. for years 1972 through 1975 were in the order of 43.7, 44.3, 44.4 and 44.5 pounds, respectively, showing the U.S. has had a smaller growth in consumption of those products in recent years. Data obtained from FOS-287 (May 1977). This evidence tends to support Herrmann's prediction and thus the view that consumption may be approaching the saturation level.

[29]These statistics are obtained from Fats and Oils Situation, ERS., USDA.

[30]J.P. Houck and J.S. Mann, An Analysis of Domestic and Foreign Demand for U.S. Soybeans and Soybean Products, Technical Bulletin 256, (St. Paul, Minnesota: Agricultural Experiment Station, University of Minnesota, 1968), p. 6.

coincided with increased demand for soybeans by domestic crushers, as well as that of the importing nations, and resulted in a dramatic expansion of soybean production from 10 million tons in 1955 to 23 million tons in 1965, and, further to 41 million tons in 1975.

Over the past 15 years, about two-thirds of U.S. soybeans have been destined for the E.E.C. and Japan, which are also the major destinations for Canadian rapeseed (Table 2.11). Since soybeans and rapeseed are almost fully substitutable, it can be seen that the U.S. soybeans will continue to be the major competitor of Canadian rapeseed in the international oilseed markets over the next decade.

Prospects of Oilseed Trade in the Japanese Market

Japan's oilseed imports have risen rapidly during the last two decades as a result of its increasing consumption of vegetable oils and a decline in its own production of oilseeds. This trend is expected to continue in the next decade.

Overall consumption of vegetable oils in Japan has been influenced by increasing per capita usage and, to a lesser extend, by an increase in population. While its current per capita consumption amounts to only about one-quarter that of the Western developed countries, Japan has a high level of personal income and its demand for vegetable oils is

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[31]G.W. Kromer, "U.S. Soybean Economy in the 1980's", Fats and Oils Situation, (Washington, D.C.: Economics Research, U.S. Department of Agriculture, April, 1973), pp. 16-23.

Table 2.11

Destination of U.S. Soybean Exports, 1960-1975

Year	E.E.C.	Japan	Total	EEC plus Japan as % of Total
	---------	thousand tonnes	--------	per cent
1960	1,547	1,088	3,672	72
1961	2,026	1,018	4,075	75
1962	2,258	1,299	4,921	72
1963	2,365	1,230	5,105	71
1964	2,515	1,344	5,786	67
1965	3,079	1,690	6,834	70
1966	3,175	1,655	7,134	68
1967	3,061	2,011	7,270	70
1968	3,129	1,905	7,821	64
1969	4,680	2,764	11,798	63
1970	5,202	2,803	11,830	68
1971	4,875	2,928	11,367	69
1972	5,833	3,299	13,075	70
1973	6,964	2,693	14,703	66
1974	5,103	2,642	11,473	68
1975	7,183	3,220	15,138	69

Source: USDA, Economic Research Service, Fats and Oils Situation. FOS-245, FOS-253, and FOS-285, Oct., 1976.

Data are converted from thousand bushels into thousand metric tons by the conversion of 1 bushel = 60 pounds,
1 ton = 2200 pounds, and
1 ton = 36.667 bushels.

expected to increase substantially by 1981.[32] At the same time it should be noted that Japan has, traditionally, imported only a negligible amount of cottonseed oils.[33] Hence, its increasing demand for vegetable oils will likely be met from domestic production of vegetable oils which are mainly crushed from foreign oilseeds. Japan has been increasing imports of all kinds of oilseeds, including soybeans, rapeseed, cottonseed, peanuts, sesameseed, and sunflowerseed (Table 2.12). In 1973, about 97 per cent of the oilseeds crushed in Japan were imported from various countries over the world.[34]

Changes in Japanese food consumption patterns have had some impact on the increased imports of oilseeds. During the past two decades Japan shifted away from its traditional rice-based diet to consumption of more wheat and livestock products.[35] In densely populated Japan, oilseed meal has been used as a major feed for livestock.[36] The demand for oilseed mean, generated by the livestock industry, has expanded the oilseed crushing industry. The latter, in turn, has led to the substantial

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[32]L.F. Herrmann et al., op. cit..

[33]This evidence is provided by statistics published in the Yearbooks of Trade published by FAO of the United Nations.

[34]Estimated from data published in FAO, UN, Yearbook of Production.

[35]F.L. Herrmann et al., World Demand Prospects for Agricultural Exports of Less Developed Countries in 1980, Foreign Ag. Econ. Report 60, ERS, USDA, (Washington, D.C.: U.S. Government Printing Office, June 1970), p. 19.

[36]Some time ago, rapeseed meal was used primarily as fertilizer in Japan. In recent years, it has been mainly used as feed. A personal communication with Mr. Y. Inomata, an official of the Japanese Embassy (Ottawa, April 15, 1978).

Table 2.12

Imports of Oilseeds into Japan, 1960-1975

Year	Soybeans	Rapeseed	Cottonseed	Peanuts	Sesameseed	Sunflowerseed
	thousand tonnes					
1960	1,128	55	71	6	28	20
1961	1,158	24	100	3	22	17
1962	1,293	42	150	3	28	27
1963	1,544	94	168	10	33	12
1964	1,607	82	206	19	34	1
1965	1,847	108	217	25	33	4
1966	2,168	218	266	38	38	4
1967	2,170	222	216	30	40	96
1968	2,421	258	246	49	39	71
1969	2,591	284	244	44	34	90
1970	3,244	345	297	59	53	45
1971	3,212	416	248	52	41	37
1972	3,396	614	180	62	51	28
1973	3,635	693	159	76	56	5

Source: FAO,UN, Yearbook of Trade

shift in the import of oilseeds themselves, rather than oil, into Japan. It may be somewhat surprising to learn the Japan, the largest importer of Canadian rapeseed, exports soybean oil and ranked sixth among the world's leading exporters of rapeseed oil in the late 1960's and early 1970's.[37]

The reduction in domestic production of oilseeds in Japan has also contributed to increased imports. Soybeans, peanuts, and rapeseed are produced in Japan. However, total oilseed production, in terms of oil equivalent, has decreased by more than two-thirds, from 210 thousand tons in 1960 to 60 thousand tons in 1974 (Table 2.13). This occurred because population expansion and urbanization reduced the overall available area or arable land available for crops.[38]

Imports of soybeans and rapeseed accounted for about 78 and 15 per cent respectively of Japanese total oilseed imports in 1973, (Table 2.12). Apparently, as suggested earlier, the Canadian share in the Japanese oilseed market has been seriously affected by competition from U.S. soybeans.

Broeska constructed a demand analysis for Canadian oilseeds in the Japanese market.[39] He concluded that, during the analytical period of

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[37]Foreign Agriculture Circular, FOP 4-76 (Washington, D.C.: Foreign Agriculture Service, U.S. Department of Agriculture, April 1976) and various issues. Since 1973, however, the amount of exports of soybean and rapeseed oils from Japan has been declining.

[38]United Nations, Statistical Yearbook for Asia and the Far East (1970); and Statistics Department, the Bank of Japan, Economical Statistics Annual, 1975 (March 1976).

[39]R. Broeska, "A Demand Analysis of Canadian Oilseeds in the Japanese Market", Unpublished Master's Thesis (Winnipeg, Manitoba: Department of Agricultural Economics, University of Manitoba, 1970).

Table 2.13

Production of Oilseeds in Japan, 1960-1974

Year	Soybeans	Peanuts	Rapeseed	Sum in Oil Equivalent
	thousand tonnes			
1960	418(74)	126(40)	264(92)	206
1961	387(68)	142(45)	274(96)	209
1962	336(59)	143(46)	247(86)	191
1963	318(56)	144(46)	109(38)	140
1964	240(42)	131(42)	135(49)	133
1965	230(41)	137(44)	126(45)	130
1966	199(35)	139(44)	95(35)	114
1967	191(34)	136(44)	79(30)	108
1968	168(30)	122(37)	68(27)	94
1969	136(24)	126(40)	48(19)	83
1970	126(22)	125(40)	30(12)	74
1971	122(22)	111(36)	23(9)	67
1972	127(22)	115(37)	16(6)	65
1973	118(21)	97(31)	13(5)	57
1974	135(24)	101(32)	9(4)	60

Source:FAO, UN, Yearbook of Production

Numbers within parentheses are oil equivalent.

1963 through 1968, the volume of Canadian rapeseed which the Japanese imported was mainly determined by the Canadian price, the price of U.S. soybeans, the level of Japanese domestic oilseed production, and the cost of transportation between Vancouver and Japan. The major findings confirm that soybeans and rapeseed are quite sutstitutable; and that the quantity of rapeseed demanded by the Japanese was inversely related to the price of rapeseed, Japanese production of oilseeds and the cost of transportation.

As the largest single market for Canadian rapeseed, Japan has been of major interest to producers and exporters who are dependent on this outlet for their financial returns. Broeska's findings should be useful to producers when making decisions as to the volume of oilseeds which should be produced, as well as to indicate to exporters the factors governing Japanese imports. However, many other conditions, such as the elimination of Japanese tariffs on rapeseed, the reduction of Japanese domestic production of oilseeds to only about 3 to 4 per cent of its total oilseed crushings, as well as the improvement in the quality of Canadian rapeseed oil and meal, have significantly changed over the past decade compared with those during the 1963-68 period. Furthermore, Broeska's study did not recognize the fact that the quantity of rapeseed exported from Canada to Japan would simultaneously affect the quantity of rapeseed imported by other countries and crushed domestically. In other words, it would be inappropriate to treat Japan as the exclusive market for Canadian rapeseed.

Prospects of Oilseed Trade in the European Economic Community

The E.E.C. consists of nine countries. These are: Belgium, Denmark, France, West Germany, Ireland, Italy, Luxembourg, The Netherlands and the United Kingdom. On the basis of net imports of vegetable oils and oilseeds, the E.E.C. was the world's leading importer in the 1960's.[40] Consumption of vegetable oils in the member countries reached about 2 million tons in 1960. The trend towards self-sufficiency (the ration of domestic production to consumption) has gradually increased from approximately 6 per cent in 1960 to 25 per cent in 1973. Although the rate of increase in domestic production of oilseeds has substantially exceeded that of net imports, the E.E.C. has remained an oilseed deficit region (Table 2.14).

The production of oilseeds in the E.E.C. is mainly accounted for by the production of rapeseed in France and, to a lesser degree, in West Germany. The quantities of sunflowerseed and cottonseed production are relatively small compared to rapeseed. For instance, in 1973, production of rapeseed amounted to 661 and 222 thousand tons, respectively, in France and Germany while production of sunflowerseed amounted to about 117 thousand tons and cottonseed only one thounsand tons in the whole E.E.C.[41]

The E.E.C. has been a net importer of soybeans, peanuts, sunflowerseed, rapeseed, and cottonseed, with imports of soybeans and peanuts accounting for over 92 per cent of its total oilseed imports during 1970-73. Soybeans are mainly imported from the U.S. while peanuts come from East and West African countries.[42] Soybeans and peanuts dominate the E.E.C. market and are the major competitors of Canadian rapeseed.

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[40]L.F. Herrmann et al., (1971), op. cit..

[41]FAO, UN, Yearbook of Production

[42]FAO, UN, Yearbook of Trade

Table 2.14

Production, Trade and Apparent Consumption of Oilseed Oils in the European Economic Community, 1960-1973[a]

Year	Production[b]	Imports[c]	Exports[c]	Consumption[d]	Production as Proportion of Consumption
	thousand tonnes				per cent
1960	69	1,282	151	1,200	5.7
1961	86	1,061	127	1,020	8.4
1962	132	1,201	183	1,150	11.4
1963	114	1,349	217	1,246	9.1
1964	164	1,409	254	1,319	12.4
1965	193	1,482	257	1,418	13.6
1966	185	1,661	273	1,573	11.7
1967	246	1,813	306	1,753	14.0
1968	280	1,863	406	1,737	16.1
1969	300	2,089	501	1,888	15.8
1970	353	2,327	617	2,063	17.1
1971	420	2,305	703	2,022	20.7
1972	461	2,270	868	1,863	24.7
1973	501	2,460	977	1,984	25.2

[a]All figures are expressed in terms of oil equivalent. Oil extration rate are given below: Soybeans:17.7%; peanuts:32%; Sunflowerseed: 32%; Cottonseed:16%; and Rapeseed: 1960-63: 35%; 1964-65: 36%;1966: 37%; 1967: 38%; 1968: 39%; 1969-73: 40% (see USDA, Foreign Agriculture Circular, Fats and Oils, FFO 17-73, Oct., 1973, p. 13).

[b]Compiled from FAO, UN, Production Yearbook.

[c]Compiled from FAO, UN, Trade Yearbook.

[d]Apparet consumption is calculated as production plus imports less exports.

While the E.E.C. has been Canada's second-largest market for rapeseed, imports of this crop have accounted for only about 2 to 3 per cent of total E.E.C. imports. A relatively small change in E.E.C. oilseed imports could lead to a substantial change in the quantity of Canadian exports to the E.E.C. Hence, in the past, annual variations in imports of rapeseed into the E.E.C. from Canada have been noticeable. It should be noted here that eighteen African countries became associate members of the E.E.C. under the treaty of Rome in 1958, subsequently renewed in 1963 and 1969, and received tariff preferences for their exports into the E.E.C. market along with economic aid and technical assistance.[43] Changes in the foreign trade policies of those African countries could in combination with internaltion competition in prices, also have had some impact on the source of the E.E.C.'s imports of oilseeds.

Moreover, in January 1973, The U.K., Denmark and Ireland joined the E.E.C. Since then, the Commonwealth Preferential Tariffs, traditionally enjoyed by Canada when exporting commodities to the U.K., have been eliminated. According to E.E.C. policies respecting Common External Tariffs, there are no tariffs on oilseeds, but progressive tariffs are applied to vegetable oils, depending on the value-added to the product prior to importation. For example, the tariff on crude vegetable oils destined for industrial use is fixed at 5 per cent, in contrast to 15 per cent on refined edible vegetable oils.[44] The Canadian disadvantage

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[43]N.D. Aitken and R.S. Obutelewicz, "A Cross-Sectional Study of E.E.C. Trade with the Association of African Countries", The Review of Economics and Statistics, 58 (November 1976), pp. 425-33.

[44]O.A. Al-Zand, European Community Markets for Soft Oils - Implications for Canada, Economics Branch Publication 75/13 (Ottawa: Economics Branch, Agriculture Canada, August, 1975).

in the tariff area can be viewed as an equivalent loss of a competitive price advantage in relation to other countries. As late as 1973, Canada exported sizeable quantities of rapeseed oil to the E.E.C., but this became negligible by 1975.[45] The increase in E.E.C. tariffs on vegetable oils and their products have effectively restrained imports of Canadian rapeseed oils.

Al-Zand has estimated import demand functions for "soft oils" by the E.E.C. countries, using time series data for the period 1958 to 1972.[46] This study suggested that soybeans and soybean products remain the dominant products in the E.E.C. oilseed market. The demand for soybeans is closely associated with a demand for high protein meal for livestock feeding, whereas the demand for rapeseed is more closely associated with the edible oil market because rapeseed has a very high oil content. The evidence of positive income elasticities of demand for soft oil, coupled with rising incomes, suggests that the potential remains for an increasing import demand for vegetable oils and oilseeds, including rapeseed. The study also suggested that since the import demand for soft oils in most E.E.C. countries is price inelastic, Canadian exports of oilseed products cannot be enlarged significantly through price competition with other substitute products. On the other hand, non-price

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[45]Statistics Canada, Exports by Commodities, Cat. No. 65-004 monthly.

[46]O.A. Al-Zand, op. cit.
"Soft oils" include those vegetable oils derived from soybeans, groundnuts, rapeseed, sunflowerseed, cottonseed, sesame and olives. They are defined as "soft" since they take a liquid form under normal room temperature.

competition practices can be used effectively, to maintain or even enlarge the Canadian share of the E.E.C. market. These practices include quality control, advancement of credit, and improvement of handling and storage facilities throughout the trade channels.

In view of the E.E.C.'s protection of its domestic oilseed crushing industry by the imposition of a tariff on processed oilseed products, but not on raw products, demand for soft oil will be mostly in the form of raw oilseed. Furthermore, the demand characteristics for oilseed products may not be similar to those for oilseeds. Therefore, the findings reported in Al-Zand's study can only be indirectly applied to the making of policy decisions about the export of rapeseed from Canada to the E.E.C.

D. Domestic Utilization of Rapeseed

Crushings of Rapeseed in Canada

The oilseed crushing industry is one of the fastest growing industries in Canada. In order to assess the adequacy of existing capacity, a brief review of the industry would appear to be necessary. Prior to 1968 there were 12 establishments crushing oilseeds in Canada.[47] One small flaxseed mill in Toronto was abandoned in 1968 and another one in Montreal was closed in 1969, so that the number of establishments was reduced to 10 during the 1967-73 period. The number was further reduced to 8 as a result of another closing of a plant in Montreal and one in Winnipeg. Geographically, in 1975, 3 establishments were located in Ontario, one in Manitoba and two plants each in

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[47]A manufacturing establishment is a factory, mill or plant principally engaged in manufacturing crude vegetable oils and their by-products.

Saskatchewan and Alberta.[48] In spite of the shrinking number of establishments in the industry, crude vegetable oil production has increased from 243 million pounds in 1961 to 579 million pounds in 1973, representing an increase of 138 per cent. This rate of increase of oil production was greater than that for oilseed crushings (109 per cent) and also for the employment of production workers (73 per cent) (Table 2.15). These data show that both the oil-yield from oilseeds and the productivity per worker had increased. The increase in yield, as discussed in the previous chapter, was partly attributed to improvements in the varieties of oilseeds and in crushing processes. The increase in productivity could be partly attributed to the enlargement in the size of plants. For example, the number of workers per plant increased from 31 persons in 1961, to 64 in 1973, and further to 70 persons in 1974. Productivity per worker has tended to be higher with a large-scale plant (Table 2.15).

The Canadian oilseed crushing industry mainly processes soybeans and rapeseeds, and, to a lesser extent, sunflowerseed and non-edible flaxseed. While soybeans continue to occupy a dominant position in the industry, the proportion of soybean crushings to total edible oilseed crushings has declined from 96 per cent in 1959 to 65 per cent in 1974. On the other hand, rapeseed crushings showed a striking increase of more than 24 times, from about 26 million pounds in 1959 to 645 million pounds in 1974. As the oil-yield of rapeseed is more than double that of soybeans, rapeseed oil production has exceeded soybean oil production during the most recent years. During the 1971-74 period, rapeseed crushings constituted about one-third of all Canadian oilseed crushings whereas

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[48] Statistics Canada, Vegetable Oil Mills, 1974, Cat. No. 32-223, annual, (May 1977).

Table 2.15

Productivity Per Worker of the Canadian
Oilseed Crushing Industry, 1961-1975

Year	No. of Plant	No. of Worker	Oilseeds Crushed[a]	Veg. Oils Produced	Oil Production per Worker
			thous. bus.	thous. lbs.	thous. lbs.
1961	12	368	19,764	243,171	661
1962	12	379	21,381	256,029	676
1963	12	420	22,393	266,562	635
1964	12	408	26,225	300,064	736
1965	12	437	25,678	311,908	714
1966	12	445	27,195	335,320	754
1967	12	464	29,024	370,426	798
1968	11	472	27,926	359,313	761
1969	10	468	31,050	409,940	876
1970	10	524	36,245	472,362	901
1971	10	569	38,033	512,757	901
1972	10	603	41,247	572,158	949
1973	10	635	41,519	579,387	912
1974[b]	8	556	40,683	536,172	815
1975[b]	8	503	38,763	531,423	777

Sources: Statistics Canada, Vegetable Oil Mills, Cat. No. 32-223, and Oilseeds Review, Cat. No. 22-006.

[a]Oilseeds include flaxseed, rapeseed soybeans, and sunflowerseed.

[b]The amount of flaxseed and sunflowerseed crushings for 1974 and 1975 were not reported, and therefore excluded.

rapeseed oil production accounted for roughly one-half of total Canadian vegetable oil production.[49]

Production of rapeseed oil reached 319 million pounds in 1973, exceeding domestic utilization at its peak (239 million pounds in 1973) by 81 million pounds.[50] It is evident that the capacity of crushers is more than enough to meet the demand for oil by domestic refiners. Thus prospects for expanding the crushing industry will depend upon expanded domestic utilization of rapeseed oil by the food processing industry, as well as on gaining an increasing share of the international edible oil market. During the 1973-76 period, about 23 per cent of the rapeseed oil produced in Canada was shipped to Bangladesh and India under bilateral food aid programs, and exported to other nations as well.[51] Exports offered both challenges and opportunities for expanding the crushing industry in Canada. However, since the available data on exports

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[49]During the 1971-74 period, crushings of soybeans and rapeseed were 1,398 and 649 million pounds respectively, while production of soybean and rapeseed oils were 251 and 249 million pounds respectively. The above statistics were reported in Statistics Canada, <u>Oils and Fats</u>, Cat. No. 32-006.

[50]All rapeseed has been and will likely continue to be crushed in Western Canada. See Peter R. Perkins, <u>An Economic Review of Western Canada's Rapeseed Proceeding Industry</u>, (Edmonton: Government of Alberta, Nov. 1976), p. 22-26.

[51]Grain Marketing Office, Department of Industry, Trade and Commerce, <u>Fats and Oils in Canada, Annual Review 1975</u> (Ottawa, June 1976) p. 34.

of oils were quite limited, a useful quantitative analysis could not unfortunately, be pursued in this study.

The demand for rapeseed for crushing is determined by the demand for rapeseed oil, as well as the oil extraction rate.[52] The latter increased moderately from an average level of around 35 per cent during 1959-61 to 38 per cent during 1962-66, and further to 40 per cent in the late 1960's. The rate dropped back to about 38 per cent in the early 1970's because the newly bred "double-zero" varieties, while having the merit of very low erucic acid content in the oil, and low glucosinolates in the meal, had a lower oil content.[53] Efforts of plant breeders have held the rate at about 40 per cent during the most recent years. This rate seems likely to be maintained in the years immediately ahead (Table 2.16). Variations in oil extraction rates are relatively small, so that the utilization of rapeseed oils is the key factor affecting the amount of rapeseed crushings.

Utilization of Rapeseed Oil in Canada

At one time the use of rapeseed oil for edible purposes was prohibited by law in Canada. However, the steady growth in the volume of domestic rapeseed crushings is the best gauge of the acceptability of rapeseed oil by Canadian edible oil refiners. The rapid expansion of rapeseed oil utilization has been achieved, from a food technological point of view, by the great interchangeability between rapeseed oil in

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[52]The oil extraction rate is defined as the ratio of rapeseed oil produced to rapeseed crushed.

[53]R.K. Downey _et al._, _op. cit._, p. 8.

Table 2.16

Rapeseed Crushings, Oil Production, and Oil Extraction Rates in Canada, 1959-1976

Year	Crushings	Crude Oil Production	Oil Extraction Rates
	---- million	pounds -----	per cent
1959	26.3	9.5	36.0
1960	18.9	6.8	35.9
1961	59.1	20.8	35.3
1962	74.8	28.5	38.1
1963	79.6	30.7	38.6
1964	87.5	34.1	39.0
1965	131.8	51.8	39.3
1966	213.7	84.4	39.5
1967	251.2	100.9	40.2
1968	288.5	116.4	40.4
1969	373.1	149.3	40.0
1970	391.5	154.3	39.4
1971	440.2	173.8	39.5
1972	660.5	254.0	38.5
1973	851.1	318.7	37.5
1974	645.0	248.5	38.5
1975	688.1	275.6	40.1
1976	808.1	331.3	41.0

Source: Statistics Canada, Oils and Fats, Cat. No. 32-006 or Oilseeds Review, Cat. No. 22-006.

hydrogenated or non-hydrogenated form and other oils.[54] Domestic utilization of rapeseed oil for manufacturing margarine, shortening and salad oils doubled from 102 million pounds in 1967 to 201 million pounds in 1974 (Table 2.17).

Rapeseed oil has been used by refiners all across Canada. There were 34 crude vegetable oil refining firms in 1974, of which, only 25 had facilities for manufacturing margarine, while 22 produced shortening and 18 produced salad oils. Geographically, 20 firms were located east of Manitoba in Ontario, Quebec and the Atlantic Region, and 14 were located west of Manitoba in the Prairie provinces and British Columbia.[55] Analysis of location patterns within the industry, with respect to the distribution of consumer markets in the different regional economics, is an interesting research area, but one that is beyond the scope of this study.

Margarine and shortening are made from crude vegetable oils, animal fats and marine oils. There has been a tendency to substitute vegetable oils for animal fats and oils. The proportion of crude vegetable oils used in manufacturing shortening increased from 67 per cent by weight in 1967 to 72 per cent in 1974 (Table 2.19). The proportion of vegetable oils used in the production of margarine increased at an even greater rate, from 75 per cent to 94 per cent (Table 2.18). This tendency has developed because of ease of handling and measuring oils and the belief

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[54]Ragnar Ohlson, "Rapeseed Oil in Margarine and Other Products" Proceedings of International Rapeseed Conference (Ste. Adele, Quebec, Sept. 1970), p. 186.

[55]Statistics Canada, Oils and Fats, Cat. No. 32-006 monthly.

Table 2.17

VOLUME AND DISTRIBUTION OF EDIBLE OILS AND FATS
USED IN THE PRODUCTION OF VEGETABLE OIL PRODUCTS

Year[a]	Rapeseed Oil		Soybean Oil		Other Veg. Oils		Marine and Animal Oils		Production	
	.... million pounds									
1967	102	(19)[b]	154	(29)	150	(28)	127	(24)	533	(100)
1968	117	(21)	146	(26)	159	(29)	133	(24)	555	(100)
1969	136	(23)	154	(26)	169	(29)	132	(22)	591	(100)
1970	130	(22)	183	(31)	157	(27)	118	(20)	588	(100)
1971	160	(28)	143	(25)	148	(26)	125	(21)	576	(100)
1972	212	(33)	145	(22)	172	(27)	119	(18)	648	(100)
1973	238	(34)	173	(25)	176	(25)	108	(16)	695	(100)
1974	201	(28)	260	(36)	140	(20)	112	(16)	713	(100)
1975	208	(28)	232	(31)	199	(27)	104	(14)	743	(100)
1976	222	(28)	267	(34)	225	(28)	78	(10)	792	(100)

[a]Prior to 1967, data on utilization of rapeseed oil were not available.

[b]Numbers within parentheses are measurement by per cent.

Source: Statistics Canada, Oils and Fats, Cat. No. 32-006, monthly.

Table 2.18

VOLUME AND DISTRIBUTION OF EDIBLE OILS AND FATS USED IN THE PRODUCTION OF MARGARINE IN CANADA

Year[a]	Rapeseed Oil		Soybean Oil		Other Veg. Oils		Marine and Fish Oils		Production	
	.... million pounds									
1967	36	(25)[b]	54	(38)	16	(11)	36	(26)	142	(100)
1968	33	(23)	51	(35)	18	(12)	43	(29)	145	(100)
1969	42	(28)	53	(35)	16	(11)	41	(26)	152	(100)
1970	41	(29)	59	(42)	13	(9)	29	(20)	142	(100)
1971	47	(36)	41	(31)	15	(11)	29	(22)	132	(100)
1972	69	(46)	42	(28)	19	(13)	19	(13)	150	(100)
1973	76	(45)	59	(35)	18	(11)	15	(9)	168	(100)
1974	63	(34)	90	(48)	21	(11)	12	(7)	186	(100)
1975	74	(36)	86	(42)	31	(15)	15	(7)	206	(100)
1976	70	(32)	110	(50)	34	(15)	8	(3)	222	(100)

[a,b]Footnotes and source see Table 2.17.

Table 2.19

VOLUME AND DISTRIBUTION OF EDIBLE OILS AND FATS USED IN THE PRODUCTION OF SHORTENING IN CANADA

Year[a]	Rapeseed Oil		Soybean Oil		Other Veg. Oils		Marine and Fish Oils		Production	
	....				million pounds		....			
1967	39	(14)[b]	71	(25)	79	(28)	91	(33)	280	(100)
1968	46	(16)	70	(24)	81	(28)	90	(32)	287	(100)
1969	49	(15)	83	(26)	95	(30)	90	(29)	317	(100)
1970	43	(13)	99	(31)	91	(28)	91	(28)	324	(100)
1971	61	(19)	75	(24)	85	(27)	96	(30)	317	(100)
1972	74	(21)	72	(20)	107	(31)	99	(28)	352	(100)
1973	89	(24)	85	(23)	107	(28)	93	(25)	374	(100)
1974	65	(18)	120	(34)	72	(20)	101	(28)	358	(100)
1975	49	(14)	102	(28)	119	(33)	90	(25)	360	(100)
1976	47	(13)	110	(30)	136	(37)	70	(20)	363	(100)

[a,b] Footnotes and source see Table 2.17.

that unsaturated fats are better for health.[56] The trend has also developed because vegetable oils may have had a competitive price advantage over animal fats and oils.[57]

Among the crude vegetable oils themselves, rapeseed oil has been gradually substituted for other oils, including domestically produced soybean and sunflowerseed oils, and imports of coconut, corn, palm, cottonseed, and peanut oils. The total amount of all kinds of vegetable oils used in producing margarine, shortening, and salad oils reached 601 million pounds in 1974, representing an increase of 48 per cent over the 1967 level. The amount of rapeseed oil used in 1974 was double that of 1967. These two different rates of growth indicate how much faster the usage of rapeseed oils has increased relative to that of other oils (Table 2.17).

The proportion of rapeseed oil used as a percentage of all ingredients in the different types of vegetable oil products has been generally increasing although at different rates for different products. For example, during the 1967-74 period, in the production of margarine, the proportion increased from 23 to 34 per cent (Table 2.18). In the production of shortening, it increased moderately from 15 to 18 per cent (Table 2.19) while there was a substantial increase, with respect to salad oils, from 24 to 43 per cent (Table 2.20).

Overall, the proportion of rapeseed oils used in the manufacture of different oil-products depends, in part, on differences in the quality

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[56]Statistics Canada, <u>Oils and Fats</u>, Cat. No. 32-006 monthly.

[57]In general, the production cost of livestock is higher than that of crops. Consequently, the price of animal fats is expected to be higher.

Table 2.20

VOLUME AND DISTRIBUTION OF EDIBLE OILS USED
IN THE PRODUCTION OF SALAD OILS IN CANADA

Year[a]	Rapeseed Oil		Soybean Oil		Other Veg. Oil		Production	
	.... million pounds							
1967	27	(24)[b]	29	(26)	55	(50)	111	(100)
1968	38	(31)	25	(20)	60	(49)	123	(100)
1969	45	(37)	19	(16)	57	(47)	121	(100)
1970	45	(37)	25	(20)	52	(43)	122	(100)
1971	52	(41)	28	(22)	47	(37)	127	(100)
1972	69	(47)	31	(21)	47	(32)	147	(100)
1973	73	(48)	29	(19)	50	(33)	152	(100)
1974	72	(43)	50	(29)	47	(28)	169	(100)
1975	86	(49)	43	(24)	48	(27)	177	(100)
1976	104	(50)	47	(23)	57	(27)	208	(100)

[a,b]Footnotes and source see Table 2.17.

of each ingredient, but also on technological and economical factors that have nothing to do with the quality of the crude oils themselves.[58] It would be desirable to detect the responsiveness of the usage of rapeseed oil to changes in its own price and that of competitive substitutes, as well as in technological improvement. However, no research report in this regard has been found.

Consumption of Fats and Oils in Canada

Per capita consumption of fats and oils, as a whole, has not increased remarkably, but there has been a notable change in the proportions of vegetable oils and animal fats in the mix over the past two decades. As shown in Table 2.21, per capita consumption of animal fats in the form of butter and lard has declined 50 per cent, from 26 pounds in 1958 to 13 pounds in 1975. On the other hand, consumption of vegetable oil products, in the form of margarine, shortening, and salad oils, has increased more than 75 per cent from 21 to 37 pounds during the same period. It has been evident for some time that vegetable oil products were being substituted for animal fats. Since Canada only imports negligible amounts of margarine and shortening from the United States, nearly all vegetable oil products consumed in Canada are produced domestically.[59] Thus the increased demand for vegetable oil products, induced both by increases in population and per capita consumption, has increased the demand for rapeseed oil and, further, strengthed the

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[58]Ragnar Ohlson, op. cit., p. 189.

[59]Canada imported about 8,000 tonnes of margarine and shortening annually from the U.S. during 1971-75. See Grain Marketing Office, Department of Industry, Trade and Commerce, op. cit., p. 77.

Table 2.21

Annual Per Capita Consumption of Fats and Oils in Canada, 1958-1975

Year	Margarine	Shortening	Salad oil	Sub-total	Butter	Lard	Sub-total	Total
	pounds							
1958	8.5	9.6	3.2	21.3	19.1	7.0	26.1	47.4
1959	8.7	9.2	3.7	21.6	18.1	10.3	28.4	50.0
1960	9.4	9.4	4.1	22.9	17.0	7.2	24.2	47.1
1961	10.1	9.1	4.2	23.4	16.5	8.4	24.9	48.3
1962	9.9	9.9	5.0	24.8	19.1	8.0	27.1	51.9
1963	9.2	9.9	5.0	24.1	19.1	7.5	26.6	50.7
1964	8.9	10.3	4.8	24.0	19.0	7.7	26.7	50.7
1965	8.7	9.9	4.7	23.3	18.6	7.4	26.0	49.3
1966	8.9	12.8	6.4	28.1	17.8	6.9	24.7	52.8
1967	9.1	13.8	5.4	28.3	16.9	7.8	24.7	53.0
1968	9.4	14.1	6.0	29.5	16.5	7.8	24.3	53.8
1969	9.7	15.3	5.8	30.8	15.7	7.6	23.3	54.1
1970	9.4	15.3	5.8	30.5	15.8	7.8	23.6	54.1
1971	9.24	15.06	5.92	30.22	15.66	8.2	23.86	54.08
1972	9.69	16.60	6.74	33.03	14.94	7.6	22.54	55.57
1973	9.83	17.49	6.95	34.27	13.64	6.7	20.34	54.61
1974	10.72	17.04	7.63	35.39	13.29	7.5	20.79	56.18
1975	11.58	17.39	7.81	36.78	11.92	5.8	12.50	49.28

Source: Statistics Canada, Apparent Per Capita Domestic Disappearance of Food in Canada, Cat. No. 32-226 (Ottawa, Ontario: Information Canada, Annual).

rapeseed industry.

Until the early 1950's, the sale of margarine in Canada was prohibited by law.[60] Traditionally, butter has been the preferred table spread in Canada. However, over the past 25 years, margarine has been widely accepted as a substitute partly because the price of margarine has been lower than that of butter. The butter-margarine price ratio has remained constant around 2.1 to 1 in favour of margarine during the past 15 years.[61] In addition, many consumers appear to have switched from butter to margarine because of the "cholesterol" scare.[62] The year-to-year changes in annual consumption of margarine averaged 4.0 per cent during 1958-75. The comparable figures for shortening and salad oils were 4.3 and 6.0 per cent, respectively. Margarine had the smallest variation in consumption (Table 2.21). It appears that changes in consumers' "habitual behaviour", in relation to margarine consumption may have been significant, but that their responsiveness to changes in "economic" factors may have had a smaller impact on margarine consumption. However, this hypothesis can only be confirmed or rejected through statistical tests.

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[60]A. D. McLeod (ed.), The History of Rapeseed in Western Canada. (Regina, Sask.: Saskatchewan Wheat Pool, 1974), p. 30.

[61]Statistics Canada, Prices and Price Indexes, Cat. No. 62-002, monthly.

[62]S.A. Gazelle and P.D. Velde, "Margarine Consumption and Prices", Fats and Oils Situation, FOS-273, (Washington, D.C.: Economics Research Services, U.S. Department of Agriculture, June, 1974), pp. 20-24.

Shortening and lard are commonly used for frying and cooking purposes. Lard, which has a higher melting point, produces food having a drier or "less oily" appearance. However, steadily declining lard-yields per hog and thus lard production, as well as the "cholesterol" scare, have been major factors behind the reduction in lard consumption.[63] In 1975, per capita consumption of shortening increased to 17 pounds, but lard consumption declined to 6 pounds (Table 2.21).

The type of shortening oil used by industrial fryers, or by the housewife, is usually specifically dictated by them. They may demand a single-oil component or a blend of oils. Specifications, in general, are governed by such things as the melting point, oxidative stability, the keepability of the fried product, as well as by economic factors. Actual performance in the trade over the past decade has demonstrated an increasing acceptance of rapeseed oil as a frying medium.[64] So far as this study is concerned, one thing needs to be investigated; that is, how consumers respond to changes in economic factors.

The level of the per capita consumption of salad oils in Canada has been smaller than that for margarine or shortening. However, the growth rate for the consumption of salad oils has been the greatest among vegetable oil products (Table 2.21). It has been generally accepted that fresh vegetables and salad oils are complementary goods. It has also been determined that the income elasticity of demand for fresh vegetables in Canada is positive.[65] Therefore, increased personal incomes would

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[63] Ibid., p. 21.

[64] B. Costigliola, op. cit., p. 204.

[65] Z.A. Hassan and W.F. Lu, Food Consumption Patterns in Canada, Economics Branch Publication 74/8 (Ottawa: Agriculture Canada, 1974).

increase the consumption of both goods. The expanded supply of domestically-produced rapeseed oil has led to the latter becoming the chief ingredient in the production of salad oils (Table 2.20). At the same time the increasing consumption of salad oils has also contributed to the increased demand for rapeseed oil which was met by a sharp expansion in the domestic oilseed crushing industry over the past decade.

Al-Zand and Hassen recently completed a demand analysis for fats and oils in Canada based on the 1950-72 data.[66] That study expressed the per capita demand for butter, lard, shortening and margarine as functions of their own price, the price of close substitutes, the per capita income of consumers, and a trend variable designed to capture the effects of time-related changes in tastes and preferences. The demand parameters were estimated by ordinary least squares, by Zellner's seemingly unrelated regressions and by full information maximum likelihood.[67] Some interesting findings were given by that study as: The level of total per capita demand for all fats and oils was expected to remain stable at the existing level; consequently, the process of substitution between fats and oils would continue to play a key role in determining the level of demand for individual oils; the effect of a product's price and the price of its substitute appears to be highly

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[66]O.A. Al-Zand and Z.A. Hassan, "The Demand for Fats and Oils in Canada", Canadian Journal of Agricultural Economics, 25-2 (July 1977), pp. 14-25.

[67]For detailed discussions on these estimation methods, see A. Zellner and H. Theil, "Three-Stage Least Squares: Simultaneous Estimation of Simultaneous Equations", Econometrica, 30 (Jan. 1962), pp. 54-78.

significant in both magnitude and direction; adequate recognition must be taken of the fact that vegetable oil prices in Canada are mainly determined by the prices of those products in the U.S. and international markets; ready domestic availability and favoured prices of domestically-produced rapeseed oil tend to exert a negative influence on the consumption of animal fats and butter.

In Al-Zand and Hassan's study, "prices and incomes used in the estimating procedures were treated as exogenous variables".[68] Although no explanation was given, this current study tends to agree to this treatment. Without doubt, improvement in national economic conditions, and hence in disposable income, cannot be achieved by the efforts of an individual sector alone. The mechanism for determining prices, particularly the level it establishes for the price of soybean oil, is to a great extent the benchmark for the price of all edible oils.[69] In so far as Canadian refiners and manufacturers of oilseed products are concerned, they order crude oils six months in advance, in order to ensure that material for vegetable oil products is available at reasonably low prices. While the prices of vegetable oil products are thus basically determined by the cost of materials and wages and salaries they are also strongly influenced by the potential reactions of competitive companies. In view of the fact that there are only eight major refiners and manufacturers of fats and oils in Canada, relative to the great mass of consumers, it could also be that the prices of fats and

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[68] Ibid., pp. 21-24.

[69] A personal communication with A.M. Runciman, President of the United Grain Growers Ltd.

oils are more supply then demand determined.[70] Assuming that the price at a given point in time is not affected by the quantity of fats and oils consumed, it would seem that from the estimation procedure point of view the price variables can be treated as exogenous in the demand functions for fats and oils.[71]

E. Schematic Representation of the Canadian Rapeseed Industry

The preceding sections, with the aid of time-series data, described the development of major segments of the industry. This section provides a time span indication of the evolving industry using 1967 and 1975 cross-sectional data. Figure 2.2 is designed to illustrate both the relative importance of each segment within the industry and their different growth rates over the past eight years. The 1975 data presented in the diagram show the most recent situation with respect to the factors determining the supply of rapeseed and the market channels available for its disposition. The 1967 data, shown in parentheses in the diagram, were chosen as the earlier reference point because some data were not available prior to that year.

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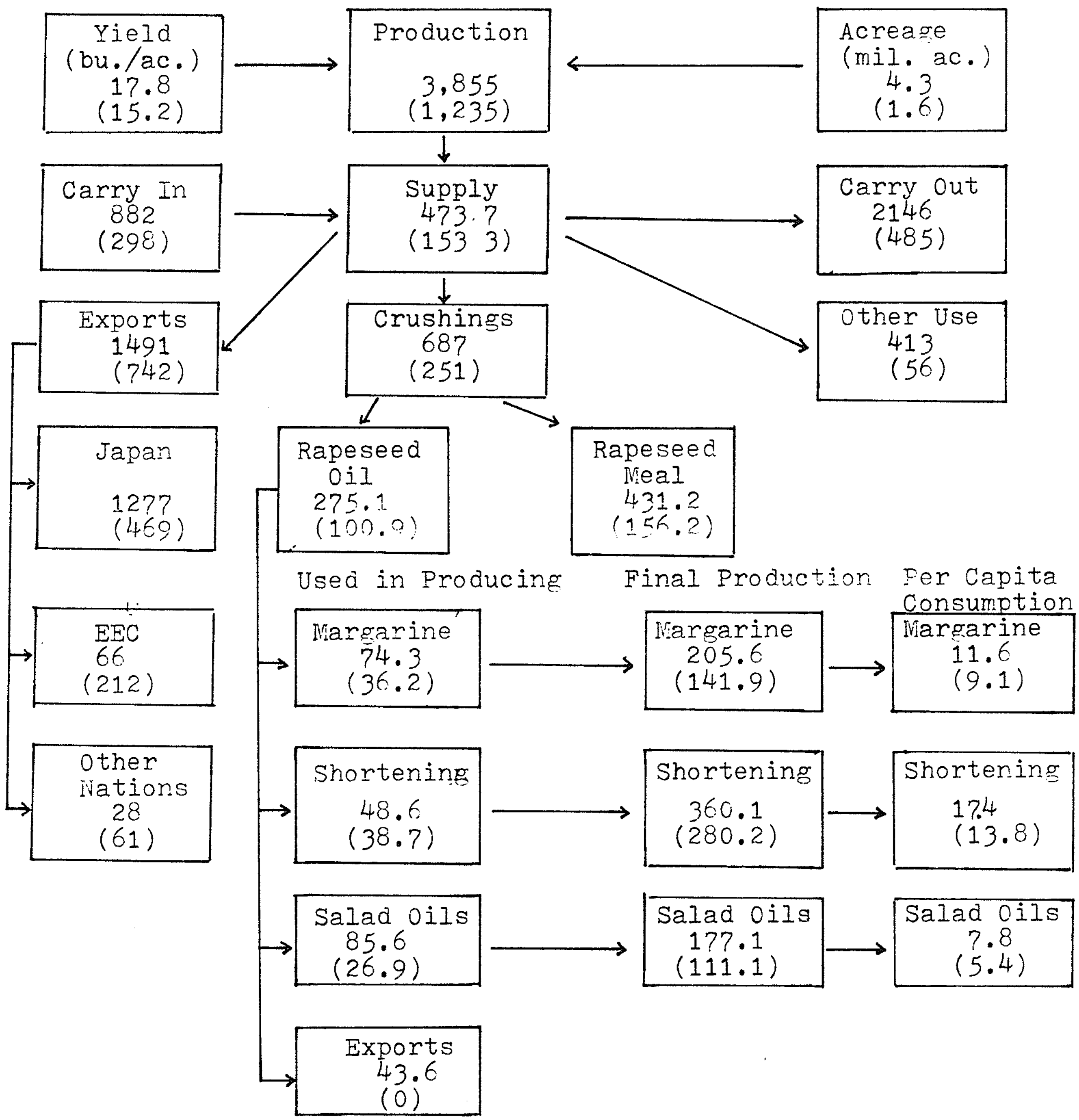
[70]A company may have several establishments. There are 34 establishments in Canada producing fats and oils.

[71]The best linear unbiased estimators cannot be obtained if all regressors specified in an equation are predetermined.



Arrows indicate direction of influence or market channels.
Units: millions of pounds except otherwise indicated.

Figure 2.2: Rapeseed Supply And Disposition in Canada for 1975 and (1967)

CHAPTER 3

Economic and Statistical Framework

Given the objective of the study there are a number of analytical approaches that might be relevant, with the most appropriate being dependent on the nature of the industry. In order to determine the best approach in an objective manner, this chapter will outline a number of possible alternatives, discuss the nature of the rapeseed industry in terms of factors affecting the determination of its price-quantity equilibrium and then conclude which alternative is to be adopted in the circumstances. From there the chapter will proceed to develop the proposed econometric methodology, especially the choice of estimation methods and the criteria to be used in evaluating the results.

A. An Integrated Supply and Demand Analysis

"Without knowledge of the basic supply and demand situations no one can possibly understand the major policy issues in agriculture."[1] This statement is especially applicable to the Canadian rapeseed industry. Much of the economic research stimulated by the rapid growth of the rapeseed industry has been directed thus far at quantifying the relationships within the industry. However, as reviewed in the previous chapter, the studies have generally concentrated on either the demand side or the supply side of the market. No known research

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[1] P.A. Samuelson and P. Temin, <u>Economics</u> (10th ed.), (New York: McGraw-Hill Book Co., 1976), p. 408.

reports have yet been published integrating all the parts in a single demand-supply model; this will be undertaken in this study. It is expected that a more useful model will be formulated in this way. A simultaneous equation system approach will be used, for reasons specified later, but it might be prudent to acknowledge the existence of possible alternatives which will first be briefly discussed in terms of their advantages and limitations.

Cobweb Theorem

In the late 1930's Ezekiel formulated the cobweb theorem to explain price-quantity sequences for agricultural commodities.[2] This theorem was formulated on the basis of the phenomenon of lagged supply adjustment: Since production takes time, the adjustment of producers' outputs to the prevailing price cannot be instantaneous, and can only become perceptible in the market after the relevant period of time required for producing that commodity.[3] As shown in Figure 3.1 the quantity demanded in any period depends upon the price in that period, but the quantity supplied depends on the price in the previous period. The price of the product in period t fluctuates until it brings about equality of demand and supply when the given supply appears on the market. For example, for some reason, supply of a crop initially drops to Q_1 which is below the equilibrium amount Q^* as shown in Figure 3.1. When consumers' demand equals the initial supply the corresponding initial price is P_1. This price induces producers

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[2] Mordecai Ezekiel, "The Cobweb Theorem", Quarterly Journal of Economics (Feb. 1938), pp. 255-80.

[3] J.M. Henderson and R.E. Quant, Microeconomic Theory: A Mathematical Approach (2nd ed.), (New York: McGraw-Hill Book Co. 1971), p. 142.

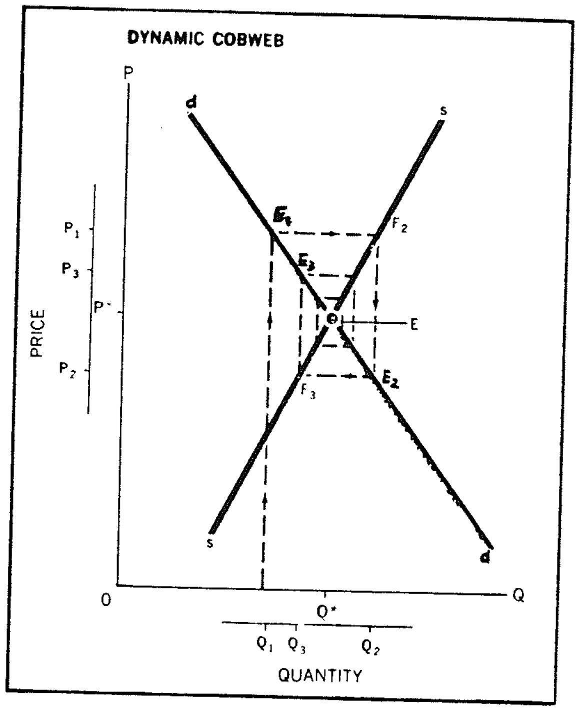

Figure 3.1

Illustration of Cobweb Theorem

Source: P.A. Samuelson and P. Temin, Economics (10th ed.), (New York: McGraw-Hill Book Co., 1976), p. 406.

to supply Q_2 in the next period. If the quantity demanded then is to equal the quantity supplied in that period, the price must fall to P_2. However, this price-level cuts production to Q_3 in the following period and so on. This process continues indefinitely, producing a cobweb pattern, the magnitude of their fluctuations depend upon the elasticity of the demand and supply curves. The fluctuations in prices are like the ocean's surface under the play of the winds.

The mechanism operating in the above Figure shows that the prices tend to converge towards the equilibrium level, indicated by the intersection of the demand and supply curves, where no further changes would occur. This is a case of "convergent fluctuation" where supply is less elastic than demand. Conversely, when the elasticity of supply is greater than the elasticity of demand, price-supply oscillations might continue to grow more and more unstable, until price fell to absolute zero or production was completely abandoned. This is the case of "divergent fluctuation". "Continuous fluctuation", without an equilibrium being approached, would occur where demand and supply had the same elasticity.[4]

The cobweb theorem can be used to conceptualize price-quantity sequences, or to explain the extent of price variability associated with agricultural commodities. The uncertainty of farm prices has been one of agriculture's major economic problems: During the current planning process, because of the historic unpredictability of market prices, last year's prices are of little use as a guide to the producer. He might guess the most probable set of prices for planning

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[4]G.S. Shepherd, Agricultural Price Analysis, (5th ed.), (Ames, Iowa: Iowa State University Press, 1964), pp. 35-39.

purposes. This set of prices, probably a discounted set of the previous year's prices, may not reflect the changing wants of society and, thus, distort the optimum allocation of resources. In particular, risks rising out of price uncertainty, have an important impact on income expectations and may also prevent farmers from investing in costly new production techniques and result in a slowing of the spread of introduction of technological advances in farming.[5] The cause of this kind of undesirable price fluctuation could be partially isolated using Cobweb oscillations as one of the analytical tools. Subsequently, suggestions could be advanced as to how the degree of price-supply variability could be reduced by appropriate agricultural policies and programs.

Although the Cobweb theorem is conceptually logical enough and remains a useful tool in visualizing the factors contributing to long-run price movements, it is worth noting that there are some problems in its practical application. For example, it is not difficult to understand how changes in weather, or in short-run socio-economic conditions previously enumerated, could cause marked deviations in actual production and marketing from that which farmers may have attempted to achieve. In addition, demand and supply schedules may not remain unchanged over a period of time sufficiently long for evidence of the Cobweb phenomenon to work itself out in practice. Therefore, it is rarely applied in actual price analysis.[6]

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[5]W.W. Cochrane, op. cit., pp. 78-80.
Alternatively, some price changes might facilitate or induce changes in resource combinations in accordance with the dictates of a changing world.

[6]F.L. Thomsen and R.J. Foote, Agricultural Prices (2nd ed.), (New York: McGraw-Hill Book Co. 1952), pp. 86-7; W.W. Cochrane also had the same view (see Cochrane, op. cit., p. 66 and p. 73).

Recursive Systems

The theoretical formulation of a demand-supply model for a commodity was first given by Cournot in 1838.[7] He assumed that consumers' demand for a commodity during a given time period was a function of the commodity's market-price and also that producers' supply of the commodity was a function of that price. It was accepted that, in general, there existed an inverse relationship between the quantity demanded and price while there was a positive relationship between the latter and the quantity supplied. Therefore, price was determined by the intersection of demand and supply curves. Two important observations about Cournot's model were that the supply and demand relationships were exact without disturbance, and the model was static.[8]

For a long time Cournot's law of demand and supply remained of purely theoretical interest. In 1919 empirical research aimed at determining demand and supply curves from statistical data was started by Moore.[9] He investigated the influence of cotton prices on the production of and demand for this commodity in the U.S. His work was expanded by Schultz, who concentrated his research on estimating demand

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[7]A.A. Cournot, Researches into the Mathematical Principals of the Theory of Wealth (Paris: Huchette, 1938; Translated by N. Bacon, New York: The MacMillan Co., 1897).

[8]G. Stojkovic, "Market Models for Agricultural Products", H.O.A. Wold (ed.), Econometric Model Building; Essays on the Casual Chain Approach (2nd ed.) (Amsterdam, The Netherlands: North-Holland Publishing Co., 1967), p. 387.

[9]H.L. Moore, "Empirical Laws of Demand and Supply and the Flexibility of Prices", Political Science Quarterly, 36, (Dec. 1919), pp. 566-67.

and supply curves for various agricultural products over the period between the two world wars.[10]

In the late 1930's Jan Tinbergen launched his pioneering and dynamic macroeconomic system which market a bold raising of sights in econometric analysis.[11] Since then, research into econometric model-building has followed two main approaches, viz. recursive and nonrecursive systems.[12] The latter was initiated by Haavelmo, and further developed by T.C. Koopmans and the Cowles Commission research groups.[13] The recursive or causal chain systems was developed by Wold and Jureen.[14] Both approaches were landmarks in progress from deterministic to stochastic systems in model building.[15]

A recursive system is really a special case of the simultaneous equations system. In such a system, the endogenous variables are determined one at a time, in sequence. The first endogenous variable, which is independent of other endogenous variables, is determined from the first equation. Its solution, then appears in the second equation

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[10] H. Schultz, The Theory and Measurement of Demand, (Chicago, Illinois: University of Chicago Press, 1938).

[11] J. Tinbergen, An Econometric Approach to Business Cycle Problems (Paris: The Hermann Co., 1937).

[12] R.H. Strotz and H.O.A. Wold, "Recursive vs. Nonrecursive Systems: An Attempt at Synthesis", Econometrica, 28-2, (April 1960), pp. 417-27.

[13] T.A. Haavelmo, "The Statistical Implications of a System of Simultaneous Equations", Econometrica, 11-1, (Jan. 1943), pp. 1-12.

[14] H.O.A. Wold and L. Jureen, Demand Analysis (New York: John Wiley and Sons, Inc., 1953).

[15] H.O.A. Wold (ed.), Econometric Model Building: Essays on the Causal Chain Approach (2nd ed.), (Amsterdam, The Netherlands: North-Holland Publishing Co., 1967) p. iii.

to determine the value of the second endogenous variable, and so on. Since each of the equations in the system can, by a sequence of substitutions, be transformed into a single endogenous variable, the ordinary least squares technique can be applied to obtain the best linear unbiased estimates of the structural cooefficients. The most attractive feature of a recursive system, relative to a non-recursive system, centers on its simplicity with respect to estimation of the economic relationships specified in the model.

This concept can be illustrated by a diagram of causal ordering. In Figure 3.2, variables X(01), X(02), and X(03) represent three sets of predetermined variables which are assigned to Causal Order 0 since their values are not determined or caused by interaction within the model. They are predetermined or, in other words, ready for use in explaining the movements of the endogenous variables. For example, the endogenous variable X(1) is a function only of exogenous variable X(01). Considering the model as a whole, X(1) is the first endogenous variable which can be determined by the exogenous variables. Thus, the step of explaining X(1) is assigned to Causal Order 1. The second endogenous variable, X(2) is defined as a function of X(1) and X(02). As the value of X(1) has been fully determined in the first step, this step is called Causal Order 2. Similarly, X(3) is a function of X(2) and X(03). The value of X(3) cannot be determined logically at any earlier stage than Causal Order 3 because the value of X(2) is a prerequisite for the estimation of X(3).[16]

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[16]K.A. Fox, Intermediate Economic Statistics, (New York: John Wiley and Sons, Inc., 1968), p. 410.

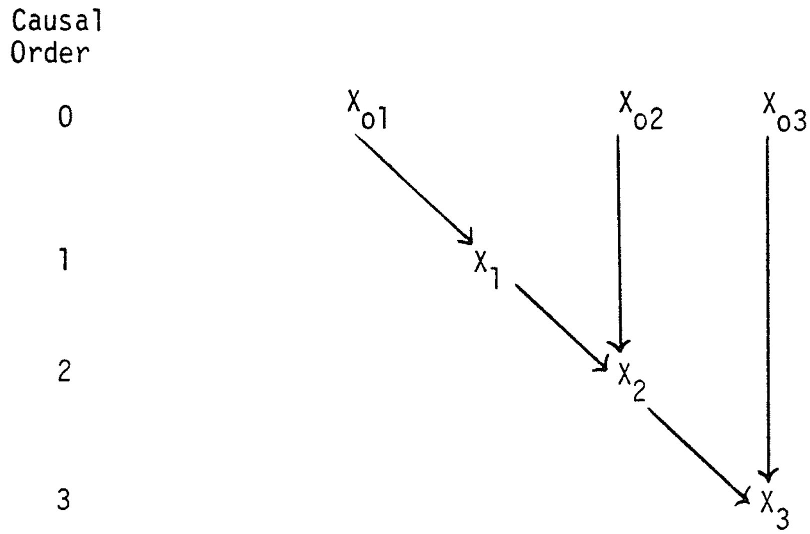

Figure 3.2

Illustration of Causal Ordering

Source: K.A. Fox, <u>Intermediate Economic Statistics</u>, (New York: John Wiley & Sons, Inc., 1968), p. 410.

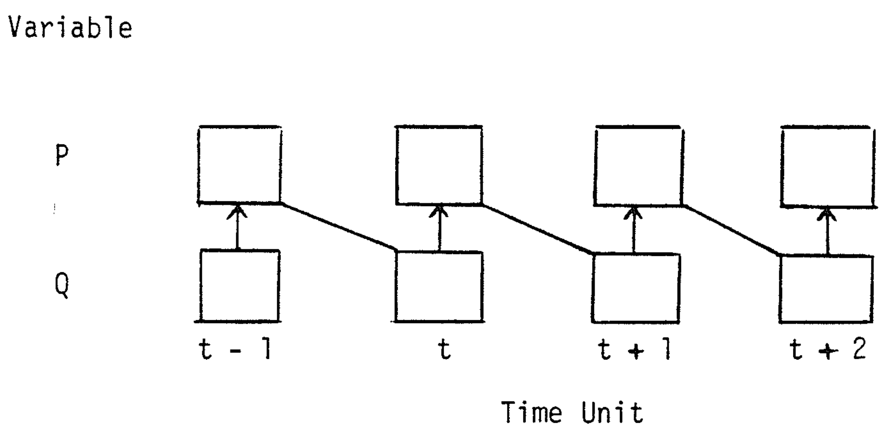

Figure 3.3

A Simplified Recursive System

Source: K.A. Fox, <u>Ibid</u>., p. 406

On Causal Order 1 in the recursive system, as one equation contains only a single endogenous variable, unbiased estimates of the coefficients can be obtained by ordinary least squares regression analysis if the Markoff conditions hold.[17] The unbiased and consistent estimates of the coefficients in Causal Order 2 can also be obtained by the least squares method if the estimated values of X(1) obtained in Causal Order 1 replace the actual values of X(1) before making the computations. This is because the estimated X(1) series becomes a predetermined variable which is uncorrelated with the residuals in the estimating equation in Causal Order 2. Similarly, in the succeeding steps, each of the equations in the system can be transformed into a single endogenous variable by a sequence of substitutions.

The most simplified recursive model representing the price-quantity relationships can be expressed as follows:[18]

3.1 Supply equation : $Q_t=aP_{t-1}+U_t$

3.2 Demand equation : $P_t=bQ_t{}^*+V_t$

3.3 Market clearing : $Q_t{}^*=Q_t$

where Q_t is the quantity supplied at time; $Q^*{}_t$ is the quantity demanded, P_{t-1} is the lagged price which is predetermined; P_t is the current price of the commodity which is a dependent variable; a and b are parameters to be estimated, and U_t and V_t are

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[17]A detailed discussion will be given in the next section.

[18]This example is given by A.S. Goldberger, Econometric Theory, (New York: John Wiley & Sons, Inc., 1964), p. 354.

residuals. Operation of the model can be visualized with the help of the following diagram (Figure 3.3).[19] The supply equation is represented by the arrows slanting downward from P_{t-1} to Q_t and P_t to Q_{t+1}. The demand equation is represented by vertical arrows leading from Q_t to P_t and Q_{t+1} to P_{t+1}. The Q_t^* is eliminated through the linkage of the "identity equation" (equation 3.3), showing that the cause-effect relationship flows from the price to the quantity and, then, from the quantity to the price, and so on through time in an irreversible dynamic process. This is a special case of a recursive system and is also a manifestation of the cobweb theorem.[20]

Strotz and Wold argued that at any given moment of time, if variable X is a cause of variable Y, then variable Y cannot be a cause of variable X unless at a different point of time. The causal sequence being a linear chain without feedback involves a small time lag. This is the most important reason for the opinion that the dynamic economic relationships underlying the operation of the economy are really recursive in nature.[21] However, some practical problems appear to limit the application of the recursive system.

It is true that it is difficult to find examples of markets where equilibrium prices and quantities are simultaneously determined. More realistically, sellers may set prices, buyers react, stocks may be accumulated or depleted, sellers react to those movements, and so on.

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[19] This diagram is given by K.A. Fox, op. cit., p. 406.

[20] Willard W. Cochrane, Farm Prices: Myth and Reality, (3rd ed.), (Minneapolis, Minnesota: University of Minnesota Press, 1964), p. 181.

[21] R. Strotz and H. Wold, op. cit.

The causal sequence involves some sort of adjustment process. The crucial factor is that the length of time required for completing the adjustment process is unknown and it could vary under different circumstances. If data do not coincide with the adjustment period, they would be invalid when they are used to measure the true cause-effect relationships. In this case, it would no longer make economic sense to use the recursive system approach. The common way of dealing with this problem of causal direction is to construct annual or quarterly non-recursive models which ignore the lags within their respective periods of observation.[22] The heavy emphasis on interdependent models by the leading econometricians in the 1940's and 1950's was partly based on the implicit assumption that the most important time series were, and would continue to be available on an annual basis.[23] As Johnston noted in similar circumstances, the "enforced aggregation over time periods can trun a truly recursive model into a full simultaneous one with all the resultant estimation problems.[24] Due to the lack of weekly or even monthly data for measuring the real causal relationships, a recursive system approach could not be applied at the present time. Consequently, an alternative approach had to be sought.

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[22]T.C. Liu, "A Monthly Recursive Econometric Model of United States: A Test of Feasibility", The Review of Economics and Statistics, (Feb., 1969): Reprinted in The Collected Economic Papers of Professor Ta-Chung Liu, (Taipei, Taiwan: The Institute of Economics, Academia Sinica, 1976), pp. 285-97.

[23]K.A. Fox, op. cit., p. 390.

[24]J. Johnston, Econometric Methods (2nd ed.), (New York: McGraw-Hill Book Co., 1972), p. 380.

Simultaneous-Equation Systems

Economic models normally involve a set of relationships designed to explain the behaviour of selected variables. For example, a simple model of the market for a given commodity may involve supply and demand functions which are able to explain the equilibrium price and quantity exchanged in the market. Additionally, a sophisticated model may explain the determination of various income components by means of appropriately specified relationships. Such a system of equations explicitly takes account of the interdependent nature of the broad economic relationships present in a model. Values of endogenous variables are jointly determined by interaction of the relationships in a model commonly known as the simultaneous-equation system. Since there are no cause (stimulus) - effect (response) relationships among the endogenous variables, this system is also referred to as the non-recursive system.[25]

In view of the fact that the essence of economic theory is to postulate the interdependence of economic phenomena so that determination of the values of variables can be undertaken by simultaneous interaction of the relationships, the staff members of the Cowles Commission for research in econometrics concluded that an entire system of equations had to be considered as a unit in order to understand and to quantify economic relationships. Hence the single equation approach is now completely outmoded.[26] While the system approach is

[25] H. Wold, "Forecasting by the Chain Principle", in H. Wold (ed.) (1967), op. cit., pp. 6-36.

[26] R.J. Foote, Analytical Tools for Studying Demand and Price Structures, Agricultural Handbook 146, U.S. Department of Agriculture, (Washington, D.C.: U.S. Government Printing Office, 1958), pp. 53.

commonly applied in macro-economic studies. For example, the Klein-Goldberger model and the Brookings model of the U.S. economy, the CANDIDE model and the TRACE model of the Canadian economy, and the Osaka model of the Japanese economy are well-known.[27]

In the area of oilseed studies, Houck and Mann have applied the system approach to deal with the U.S. domestic and foreign demand for soybeans.[28] And an attempt has been made by Craddock to develop a comparable system for the Canadian rapeseed economy.[29] As far as this study is concerned, as will be reviewed in the next Section, each segment of the industry has been facing a nearly perfect competitive market. The equilibrium of price and quantity within each segment and between segments of the industry are simultaneously determined. This characteristic is, of course, the basic justification for the use of a simultaneous approach. In addition, there are certain characteristics of interdependence between the segments of the industry which support the application of an interdependent system approach.

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[27]L.R. Klein and A.S. Goldberger, An Econometric Model of the United States, 1929-1952, (Amsterdam, The Netherlands: The North-Holland, Inc., 1955);

J. Duesenberry, et al., (ed.), The Brookings Quarterly Econometric Model of the United States (Chicago, Illinois: Rand McNally & Co., 1965);

J.A. Sawyer, Trace Mk IIR: An Annual Econometric Model of The Canadian Economy, Report Series 5, Institute for Policy Analysis, (Toronto, Ontario: University of Toronto, 1974);

S. Ichimura et al., "A Quarterly Econometric Model of Japan", Osaka Economic Papers, March 1964.

[28]J.P. Houck and J.S. Mann, An Analysis of Domestic and Foreign Demand for U.S. Soybean and Soybean Products, Technical Bulletin 256, Agricultural Experimental Station, University of Minnesota, 1968.

[29]W.J. Craddock, "Canadian Rapeseed Price Prediction - A Preliminary Report", Unpublished paper, (Winnipeg, Manitoba: Department of Agricultural Economics, University of Manitoba, 1973).

These characteristics are briefly described below.[30]

Joint Products: Oil and meal are jointly produced by crushing rapeseed. Hence supplies of oil and meal are tightly linked to each other, and to the quantity of rapeseed crushed. On the other hand, although the economic factors which influence growth in demand for oil and meal are different, the prices of oil and meal jointly determine the value of rapeseed products. The latter, in turn, influence the amount of rapeseed crushed.

Multiple Markets: Many distinct market outlets compete for the available seed, meal and oil. These outlets grow at different rates individually, but any change in demand in one market simultaneously affects the supply available to other outlets because the overall supply is given.

Interdependence of Rapeseed and Its Products with Larger Economic Sectors: Rapeseed is one of the oilseeds in the world-wide network of competing edible oil-producing products. Its oil is one of the many edible vegetable oils in the fats and oils category, and its meal is one of several high-protein feed products for the livestock-feed sector. Therefore, the whole rapeseed industry is an integral part of the broader economic complex where competition and substitution between commodities are substantial, and there is a high degree of interdependence between any one component of the complex and the others.

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[30]These ideas were advanced by J.P. Houck and J.S. Mann, Domestic and Foreign Demand for U.S. Soybeans and Soybean Products, Technical Bulletin 256 (Agricultural Experimental Station, University of Minnesota, 1968), p. 8.

Simultaneity of Equalibrating Price-Quantity Determinations Among Segments: In the rapeseed industry, the nature of the mutual influence and interdependence of the segments, with respect to the demand for rapeseed and its products, should not be ignored. Any change in the factors affecting the demand in one segment of the industry is reflected throughout the entire industry within a year. Naturally annual product prices and market flows are simultaneously determined.

Given the above discussion, and the reality of the simultaneous determination of prices and quantities, it appears to be appropriate to use an interdependent system in this study to investigate the supply and demand characteristics for Canadian rapeseed and rapeseed oil.

B. The Market Structure of the Canadian Rapeseed Industry

The primary objective of this section is, with the aid of existing economic theory, to explicitly identify the factors which influence price-output behaviour related to the Canadian rapeseed industry. Factors affecting the structure of an industry are judged to be important when they force individuals and firms within the industry to adjust and readjust their merchandising and production plans. The more important factors, according to Boyne, are the numbers of sellers and buyers, and the substitutability and complementarity of products and inputs.[31] The economic behaviour of producers, exporters,

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[31]D.H. Boyne "Market Structure Variables and the Analysis of Firm Behaviour", in V.L. Sorenson (ed.), Agricultural Market Analysis, (East Lansing, Michigan: The Board of Trustees of Michigan State University, 1968) pp. 81-98; Additional factors, including cost structure, vertical integration an "conglomerateness" are also important, see F.M. Scherer, Industrial Market Structure and Economic Performance, (3rd ed.), (Chicago, Illinois: Rand McNally & Co., 1971), p. 5. The detailed discussions, however, are beyond the scope of this study.

crushers, refiners, and manufacturers will thus be analyzed in terms of those factors.

Producers

Prairie farmers produce rapeseed which may be purchased by elevator companies for crushing or by exporters for shipment in its natural state. Under normal circumstances, the growers are numerous and selling equivalent products from the purchaser's point of view, implying that there are no advantages or disadvantages associated with selling to a particular purchaser. Both producers and purchasers are free to enter or withdraw from the market, and generally process perfect information about the prevailing prices.

The assumption of perfect competition may not be fully realized in the real market at the farm level, but it is generally accepted that the market is perfectly competitive.[32] As the number of farmers and purchasers are sufficiently large, an individual seller or buyer has only an imperceptible influence on the market price and on the actions of others. A producer can maximize his profits by producing up to the point where price equals his marginal cost. Evidently, since the the product is homogeneous and everybody possesses perfect market information, a purchaser will not buy at a price higher than that prevailing in the market. Resources tend to be attracted to industries whose products are in the greatest demand. The market price of a product, under conditions of perfect competition, is determined by the joint actions of buyers and sellers in equalizing the aggregate market demand for and supply of the product. The equilibrium price-quantity

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[32]The condition of perfect competition exists where the product is homogeneous, both buyers and sellers are numerous, possess perfect market information, and are free to enter or exit the market in the long run. See J.M. Henderson and R.E. Quandt, op. cit., p. 104.

is attained when the equality of demand and supply guarantees that buyers' desires (utility maximization) and sellers' desires (profit maximization) coincide.[33]

Exporters

Rapeseed, to a great extent, is interchangeable with various oilseeds and oil-bearing products; therefore, the overall availability of oilseeds in international markets affects the degree of competition. Theoretically speaking, Canadian rapeseed could be exported to any country in the world. No one importer can exercise the "power of buyer" to depress our rapeseed prices below the international price level.[34] On the other hand, only a few countries export oilseeds to Japan and the E.E.C. which are Canada's major markets. The market structure of these foreign markets can, from the Canadian point of view, be classified as "oligopolistic" - a special case of "imperfect competition".[35]

In the real world, the majority of markets tend to fit into the realm of "imperfect competition": They are neither perfectly competitive nor perfectly monopolistic.[36] In the economic literature, discussion of the pricing mechanism under "competition among the few" has been extensive.[37] Under conditions of oligopoly, there

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[33]Ibid., p. 149.

[34]F.M. Scherer, op. cit., Chapter 9, "Market Power on the Buyers' side.

[35]Ibid., p. 239.

[36]P.A. Samuelson and P. Temin, op. cit., p. 483.

[37]For example, seven out of thirty-six articles selected in W. Breit and H.M. Hochman (ed.), Reading in Microeconomics (2nd ed.), (Hinsdale, Illinois: Dryden Press, 1971) are related to "imperfect competition" market structures.

are only a few firms in an industry, the activity of a single firm evokes and influences reactions from others. The demand curve faced by a single firm is to some extent, indeterminate, unless the firm can predict with accuracy what the reactions of its rivals will be to market initiatives on its part.[38]

In the Japanese market, Broeska claimed that Canadian rapeseed exporters faced a "kinked" demand curve.[39] This concept assumes that an acceptable market price has been established and that if one firm lowers its price, other firms will follow suit in order to maintain their market share. If, however, one firm raises its price, other firms will be reluctant to follow and they will increase their market shares. Either raising or lowering price, therefore, will be of no benefit to any firm since none can maintain their market shares at a higher price nor increase their market shares at a lower price. The result, therefore, is the "kinked price", which is associated with a discontinuous marginal revenue curve, being acceptable to all firms. Below this price, rival firms are very responsive to price decreases because it puts intolerable pressure on their profit margins; above this price they are not responsive to price increases because it results in losing their market shares.[40] However, the fact that the Japanese oilseed market has been facing price fluctuations from year to year, does not seem to agree with the characteristics of

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[38]R.H. Leftwich, The Price System and Resource Allocation (3rd ed.), (New York: Holt, Rinehart and Winston, 1966), p. 240.

[39]R. Broeska, "A Demand Analysis of Canadian Oilseeds in the Japanese Market", unpublished Master's Thesis, (Winnipeg, Manitoba: Department of Agricultural Economics, University of Manitoba, 1970), p. 74.

[40]R.H. Leftwich, op. cit., p. 226.

relative price rigidity, which the theory explains.

There is reason to believe that the pricing mechanism of "price leadership by a dominant firm" might be an appropriate explanation of price fluctuations in the international market faced by Canada's exporters.

As discussed earlier in Chapter 2, U.S. soybeans have dominated world oilseed markets, including that of Japan and the E.E.C. The share which Canada assumes of the world market is relatively small. Canadian exporters may behave as though they were operating highly in a competitive context, but they only can sell what they do, as long as they sell at the price set by the dominant exporter. The dominant exporter determines his price by assuming that his rivals will continue to act as price takers, but the latter's reactions must be seriously considered. Since no known "collusion" exists between U.S. and Canadian exporters it might not be inappropriate to describe the structure of the export market as "imperfect collusion" under conditions of imperfect competition.[41] This statement could be valid in the light of the evidence that U.S. soybean and rapeseed prices have been highly correlated.[42]

Rapeseed and soybeans can be differentiated on the basis of physical characteristics, although they are close substitutes. In addition, non-price competitive factors, such as sales promotion

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[41]This terminology was used by R.H. Leftwich, op. cit., Chapter 11, "Pricing and Output Under Oligopoly".

[42]The correlation coefficient of international prices of rapeseed and soybeans over the 1958-73 period was 0.93. See O.A. Al-Zand, European Community Markets for Soft Oils: Implication for Canada, No. 75/13, (Ottawa: Economics Branch, Agriculture Canada, 1975), p. 51.

through trade missions, and the reliability of continuous supply, can assume particular importance. Therefore, Canada's exporters may experience a less than perfectly elastic demand curve.

Crushers

There are a few firms which crush the rapeseed, and a few refiners and manufacturers of oil products who utilize the rapeseed oil produced by the crushers. Intuitively, the structure of the market faced by the crushers could be characterized as "bilateral oligopoly". However, evidence can be gauged from the fact that, in 1975, for example, crude rapeseed oil accounted only for about 28 per cent of the ingredients used in the production of vegetable oil products.[43] The position of rapeseed crushers in the fats and oils manufacturing industry is similar to the position of rapeseed exporters in the international oilseed market. They can only be considered as a "small firm" in an imperfectly competitive market. Soybean oils, either those produced by eastern crushers in Canada, or imported from the U.S., have dominated the market associated with Canadian fats and oils. As discussed earlier in Chapter 2, the price of rapeseed oil is mainly determined by the price of soybean oil, which is, in turn, established on the Chicago Board of Trade. This practical pricing mechanism can be best explained by the theory that under unorganized non-collusive oligopolistic markets, the dominant firm sets the price for the industry and allows the small firms to sell all they desire to sell at that price.[44] Therefore, Prairie crushers might face very elastic demand curves for their products.

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[43]As indicated in Table 2.17 in Chapter 2, about 743 million pounds of margarine, shortening and salad oils were produced in 1975, utilizing only about 209 million pounds of rapeseed oil.

[44]R.H. Leftwich, op. cit., p. 223.

From the point of view of the effect of substitute products on a firm's behaviour and market results, the elasticity of demand for its products will be greater, the greater the substitutability of a competing product; and the larger the number of substitute products, the more elastic the demand for its product.[45] As discussed earlier in Chapter 2, many imported crude vegetable oils, edible animal fats and marine oils are substitutable for rapeseed oil; and the degree of substitutability is high. This supports the argument that crushers face very elastic demand curves. However, some qualification of this statement might be required.

The subject of vertical integration has been one of the most interesting research areas in the marketing of Canadian agricultural and food products.[46] The linkage of two or more stages of production and marketing processes can reduce transaction costs, and increase managerial control and market power because of a number of factors, such as less intensive contracting, less duplication, a higher degree of standarization, fewer production lines, faster intra-system flows, better intra-system communication, lower system risk, faster adoption of technology and higher productivity.[47] However, vertical integration can harm non-integrated firms which find themselves

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[45]D.H. Boyne, op. cit., p. 95.

[46]D.G. Devine and M.H. Hawkins, "Vertical Integration and Competition in the Canadian Food Industry", in R.M.A. Loyns and R.L. Louks (ed.), Competition and Public Policy on Competition in the Canadian Food Industry, Proceedings of Agricultural and Food Marketing Forum, (Winnipeg, Manitoba: Department of Agricultural Economics, University of Manitoba, 1977), pp. 76-100.

[47]M. Etgar, "Effects of Administration Control on Efficiency of Vertical Marketing Systems", Journal of Market Review, 13 (Feb., 1976), pp. 12-24.

denied certain sources of supply or markets, or locked into a price squeeze by their integrated rivals. When firms integrate, fear of predatory tactics induces others to follow suit, if they can; it makes survival more difficult for those too small to adopt this alternative. This results in an increase in the size of an optimal production unit, and intensifies pressure through market concentration.[48]

In the author's opinion no vertical integration exists in the rapeseed industry. However, it is common practice for the manufacturers of vegetable oil products to order their crude vegetable oils for processing six months in advance of need in order to improve price stability and ensure long-term supply continuity.[49] If this advanced purchasing practice has resulted in intensified competitive power for the "contracted" firms over the "non-contracted" firms the market structure, and subsequently market performance, would be more complex than that discussed previously. Due to data deficiencies relevant to the investigation of vertical integration within the rapeseed industry, the assumption that crushers are facing very elastic demand curves is made in this study.

Manufacturers

There were 34 establishments in Canada in 1975 that produced margarine, shortening and salad oils. Since some establishments belong to the same company there are really only eight major manufacturers of oil products. On the buyer's side, there are numerous consumers. This is a typical oligopolistic market. The mechanism of price and, thus,

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[48]F.M. Scherer, op. cit., pp. 87-88.

[49]A personal communication with M. Faille of Canada Packers Ltd. (Montreal Division, Sept. 20, 1977).

profit determination of an oligopolist depends upon the actions and reactions of his rivals. Different theories are based upon different assumptions regarding market behaviour. There seems to be no one set of assumptions which has a very general applicability.[50] However, one thing is certain: if a firm in an oligopolistic market supplies a substantial portion of the market, then he faces a downward sloping demand curve, the elasticity of which is determined by the competitive position of his product.

Canada imports only a negligible amount of margarine and shortening and nearly all the vegetable oil products consumed are produced domestically. No disaggregated data on sales of vegetable oil products by company are available and thus no measurement of the degree of concentration of sellers within the industry can be made. "Concentration" is measured by the per cent of the total output of the industry which is produced by the X largest firms, where X is some small number such as four or eight.[51] According to Bain, a "critical level" of concentration occurs when 70 per cent or more of the market is controlled by the eight largest firms. Industries with more concentration than this, average substantially higher profits than those with less concentration.[52] In Canada, as noted above, there are only eight major manufacturing companies (it should be noted that one company may have several establishments). There seems little doubt that the degree of

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[50] M. Shubik, Strategy and Market Structure, (New York: John Wiley & Sons, Inc., 1959), p. 16.

[51] J.S. Bain, Industrial Organization, (New York: John Wiley & Sons, Inc., 1959).

[52] J.S. Bain, "Relation of Profit Rate to Industry Concentration", Quarterly Journal of Economics, (Aug. 1951), pp. 293-324.

concentration must be very high. This may imply that considering the market for an individual product, each company has supplied significant portions of the market and that each has its own influence on the determination of the market price. To some extent, each is a "price maker". However, considering the market for vegetable-oil products as a whole, regardless of the nature of the market structure, the equilibrium price and quantity are determined at the intersection of the aggregate demand-supply curves. Since both the quantity demanded and the average price of vegetable-oil products are co-determined, it would be, from an econometric point of view, appropriate to treat both variables as endogenous variables in an aggregate simultaneous-equation model.

In summary, the number of rapeseed growers is numerous, so that each producer has little influence on the price of the product. The share of Canada's rapeseed in international oilseed markets is relatively small so that Canada has little influence on the price prevailing in the world market. The number of crushers is small, but the number of competing commodities of rapeseed oil is large and the degree of substitutability between those commodities is great. Therefore, crushers' influence on the selling price of rapeseed oil is limited to non-price competition and product differentiation such as quality of oil, consumer preference, security of supply and health considerations. In contrast, manufacturers of vegetable oil products have significant influence on the prices of their products because the number of producers is small and the competition from foreign countries is not significant. Thus farmers, exporters and crushers can be classified as "price takers" since prices are jointly determined by market demand

and supply of the corresponding products they produce. On the other hand, manufacturers of vegetable-oil products exert a significant influence in determining the market prices of margarine, shortening and salad oils after taking account of the potential reactions of a limited number of rivals. However, considering the overall market for vegetable-oil products, the basic economic principle of demand and supply determining the equilibrium price and quantity is still applicable. It may thus be concluded that a simultaneous system approach is an appropriate analytical tool, given the nature of the market structure of the industry.

C. Methodology

The essence of this study is measurement of the economic relationships and prediction of the future, given the variables associated with the industry under review. The methodology adopted follows the well-known sequence described below:[53]

Specification of the model: This involves the employment of economic theory and available information relating to the phenomena being studies, to express in mathematical form the causal relationships between the dependent and independent variables. A priori expectations about the sign and size of the parameters of the mathematical functions will also be given.

Estimation of the model: The process of obtaining numerical estimates of the coefficients of the model requires a sound knowledge of the various econometric methods, their underlying assumptions and

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[53]This section draws heavily from A. Koutsoyiannis, Theory of Econometrics, (London, England: The MacMillan Book Co., 1973), Chapter 2.

the economic implications of the parameter estimates. These coefficients of the model will be obtained by applying appropriate econometric techniques to the data reflecting the variables included in the model.

Evaluation of estimates: This involves the application of economic, statistical and econometric criteria, in order to evaluate the estimates made in terms of the irreliability. The evaluation consists of judging whether the estimates of the parameters are theoretically consistent and statistically significant.

Evaluation of the forecasting power of the model: The objective of econometric researach is the establishment of reliable estimates of the coefficients of the specified economic relationships, which can then be used to predict values of the endogenous variables. Since forecasting is one of the prime aims of econometric research, it seems self-evident that any model designed for forecasting should have its predictive power assessed. This stage investigates the stability of the estimates and such things as their sensitivity to changes in the size of the sample.

D. A Distributed Lag Model

A detailed specification of an integrated supply-demand model will be presented in Chapter 4. It is expected that, within the model, the supply equations will contain lagged endogenous variables. Since dynamism, as represented by lagged variables, is judged to be of importance, it may be useful to outline their application to econometric models.

The Role of Expectations

Measurement of the supply function for an agricultural commodity over a specific span of time is complicated by the difficulty of measuring expectations. Farmers are conscious of many important factors affecting their price expectations. However, in formulating expectations, they may not consciously go through the complex process of attempting to forecast these variables and assess their relative importance in establishing prices. The selection of an appropriate expectation model involves, nonetheless, implicit assumptions about the knowledge and understanding of economic relationships by producers. An expectation model could assume that current prices would continue over the coming production period, i.e., an application of the Cobweb Theorem. However, in the real world, a more tenable position is that expectations reflect present and past prices. Logically, the most recent prices should be given the greatest weight since motivational information retained by the human mind is usually a declining function of time.[55]

The analytical technique of "distributed lags", which explicitly takes into consideration the continuance of time in the process of model building, is commonly used to measure adjustments in production and consumption. The distributed lag models applied in various

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[54]This section is a modified version of the more extensive discussion present in R.M.A. Loynes and W.F. Lu, Characteristics of Demand for Eggs in Canada: An Analysis of Cross-Section and Time-Series Data, Research Bulletin 72-3, (Winnipeg, Manitoba: Department of Agricultural Economics, University of Manitoba, 1972).

[55]J.N. Ferris, "Equilibrium and Overall Adjustment" in V.L. Sorenson (ed.), op. cit., pp. 219-42.

economic studies have been mainly those developed by Koyck, Cagan and Nerlove in the late 1950's.[56]

<u>Distributed Lag Models</u>[57]

Tinbergen proposed a demand equation of the form:

$$3.4 \quad Q(t) = a+b(o)p(t)+b(1)p(t-1)+\ldots+U(t)$$

$$= a+\sum_{i=0}^{n} b(i)p(t-i)+U(t)$$

$$i = 0,1,2,\ldots, n \text{ periods}$$

where Q(t) = quantity of a commodity demanded at time period t,

P(t-i) = price of the commodity at time period (t-i), and

U(t) = residual errors

This equation implied that current consumption of a commodity was affected by its current and previous prices. Tinbergen suggested successively adding the lagged prices to equation 3.4 and estimating the regression coefficients by the least squares method until the signs of the coefficients become erratic and ceased to make sense.[58] In practice, correlation between the lagged values of independent variables tend to be very high so that this expansion of the extrapolative mechanism is not likely to be useful.

Koyck assumed that the series of coefficients in equation 3.4

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[56]A. Griliches, "Distributed Lags: A Survey", <u>Econometrica</u>, 35, (1967), pp. 16-49; Also in T.M. Dowling and F.R. Glake (ed.), <u>Readings in Econometric Theory</u> (Boulder, Colorado: Colorado University Press, 1970).

[57]An excellent survey of five expectation models including extrapolative, adaptive, rational, implicit, and Bayesian, was completed by R.D. Green: "Expectation Formulations and Optimal Decisions in Cattle Feedlot Problems", unpublished Ph.D. dissertation, (Missouri: University of Missouri, May 1972). The present discussion is limited to those which will be applied in this study.

[58]J. Tinbergen, <u>Econometrics</u> (New York: The Blakison Co., 1951), p. 23.

were subject to a convergent geometric distribution, i.e., $b(1)=cb(o)$, $b(2)=cb(1)=c^2b(o),\ldots$, and that $0<c\leq 1$. Here the value of b would become smaller and smaller by a constant proportion as time passed. Apparently, a remote value of P exerted a smaller influence on Q than did a recent value of P. Under Koyck's assumption, the lags' coefficients decay geometrically from the very beginning, or after a short delay. In the former case, equation 3.4 can be rewritten as:

$$3.5 \quad Q(t)=a+b(o)\sum_{i=0}^{\infty} c^i p(t-i)+U(t), \qquad 0<c\leq 1$$

then by lagging one period for each variable in equation 3.5 multiplying each variable by c to yield:

$$3.6 \quad cQ(t-1)=ca+b(o)\sum_{i=1}^{\infty} c^i P(t-i)+cU(t-1), \qquad 0<c\leq 1;$$

and finally subtracting equation 3.6 from equation 3.5 to arrive at

$$3.7 \quad Q(t)=a(1-c)+b(o)P(t)+cQ(t-1)+[U(t)-cU(t-1)], \qquad 0<c\leq 1$$

In the above equation, only two, instead of an infinite number of coefficients, need be estimated.[59] This procedure is known as the Koyck transformation.

Cagan suggested further that the nominal amount of money Q(t) which individuals want to hold depends on the expected price of money P*(t), i.e.,

$$3.8 \quad Q(t)=a+bP^*(t)+U(t)$$

The expected price of money is assumed to be a function of all past prices and expectations are revised at any time in proportion to the error associated with previous expectations, i.e.,

$$3.9 \quad P^*(t)-P^*(t-1)=c[P(t)-P^*(t-1)], \qquad 0<c\leq 1$$

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[59]L.M. Koyck, Distributed Lags and Investment Analysis, (Amsterdam: North-Holland Publishing Co., 1954)

This proposition of Cagan is called an "adaptive expectation model."[60] The value of c in equation 3.9 is called a "coefficient of expectation" which is estimated by means of "trial and error" as proposed by Cagan.[61]

Additionally, Nerlove combined Cagan's adaptive expectation model with Koyck's reduction procedure to propose that the expected, or the long-run equilibrium quantity of a commodity consumed $Q^*(t)$ is a function of its price $P(t)$, based on the assumption that disposable income and other prices were constant, i.e.,

3.10 $Q^*(t)=a+bP(t)$

This presumed that there was an equilibrium quantity corresponding to the price level. Nerlove also adopted the assumption made by Koyck, i.e., successive lag coefficients decrease geometrically, and postulated a partial equilibrium model as:

3.11 $Q(t)-Q(t-1)=c[Q^*(t)-Q(t-1)]+U(t) \quad 0<c\leq 1$

where $Q(t)-Q(t-1)$ = the actual change in consumption between two periods,

c = the adjustment coefficient, and

$Q^*(t)-Q(t-1)$ = the change in consumption that would be necessary to attain the equilibrium level.

This model implied that the actual change in Q during a period was only a proportion of the change that would be necessary to attain equilibrium in that period.[62]

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[60]A. Griliches, op. cit., p. 16.

[61]P. Cagan, "The Monetary Dynamic of Hyper Inflations", in M. Friedman, (ed.), Studies in the Quantity Theory of Money, (Chicago, Illinois: University of Chicago Press, 1956), pp. 37-41.

[62]M. Nerlove, Distributed Lags and Demand Analysis, Agriculture Handbook No. 141, (Washington, D.C.: U.S. Department of Agriculture, 1954), pp. 16-20.

Substitution of equation 3.10 for Q*(t) in equation 3.11 yields:

3.12 $Q(t)=ac+bcP(t)+(1-c)Q(t-1)+cU(t)$ or

3.13 $Q(t)=a'+b'P(t)+c'Q(t-1)+U'(t)$

The coefficients in equations 3.12 and 3.13 correspond with each other; $a'=ac$, $b'=bc$, and $c'=1-c$. The adjustment coefficient can be computed by th relationship of $c=1 - c'$ where the magnitude of c' can be directly estimated from equation 3.13. The coefficients in equation 3.10 (called the long-run coefficients) can be obtained by dividing the corresponding coefficients in equation 3.13 (called the short-run coefficients) by the adjustment coefficient; e.g. $bc=b'$, therefore $b=b'/c$. Subsequently, the short-run and long-run elasticities can be derived from the corresponding short-run and long-run coefficients.[63]

Equation 3.13 shows the immediate responsiveness of adjusting the quantity of a commodity consumed, or supplied, to a unit change in price would be b' units of Q. Equation 3.10 indicates that the effect of a change in one unit of P on the total adjustment of Q in the long-run would be b units of Q. The relationship between b and b', as discussed above, is connected by $b=b'/c$, where $c=1-c'$. Since the value of c is always less than one, b must be greater than b'.[64] Development of an equation to determine the length of

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[63]M. Nerlove, "Lags in Economic Behaviour", <u>Econometrica</u>, 40, (1972), pp. 221-252; Also Nerlove, <u>Distributed Lags and Demand Analysis for Agricultural and Other Commodities</u>, Ag. Handbook 141, (Washington, D.C., U.S. Department of Agriculture, 1958).

[64]One economist has argued that b may not be greater than b' because in the long run some other substitutes may become available. His agrument would be true but the assumption of "other things being constant" does not always hold (see A. Subotnik, "Short and Long Run Elasticities in Consumer Demand Theory", <u>American Journal of Agriculture Economics</u>, Aug. 1974), p. 553.

the period required to complete the adjustment of prices will be attempted next.

A Method of Estimating the Speed of Adjustment

The time path to a new equilibrium, associated with a partial-adjustment type of distributed lag model, can be deduced graphically. In Figure 3.4, the level of q_0 represents the initial equilibrium quantity of a commodity consumed or supplied. Assume that due to a disturbance the new equilibrium quantity is expected to be Q^*. Then, the vertical distance of q_0Q^* represents the change in quantity (this change can be either positive or negative) that would be required to attain the new equilibrium. This adjustment cannot take place within one period, because of imperfect market information and psychological, technological and institutional rigidities.[65] Accepting the assumption adopted in equation 3.11 only a "c" proportion of q_0Q^*, or q_0q_1, will be adjusted in period t. Similarly, as regards the actual adjustment in period t+1, only a proportion of q_1Q^* or q_1q_2 can be achieved, other things being unchanged.

The aggregate adjustment in quantity over an infinite number of periods can be expressed as:

3.14 $\text{plim } AA = \sum_{i=0}^{\infty} c(1-c)^i = 1$

Where $i=0,1,\ldots,\infty$ periods

plim AA=the probability limit of the aggregate adjustment in quantity, and

c=the adjustment coefficient.

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[65]M. Nerlove, (1958), op. cit.

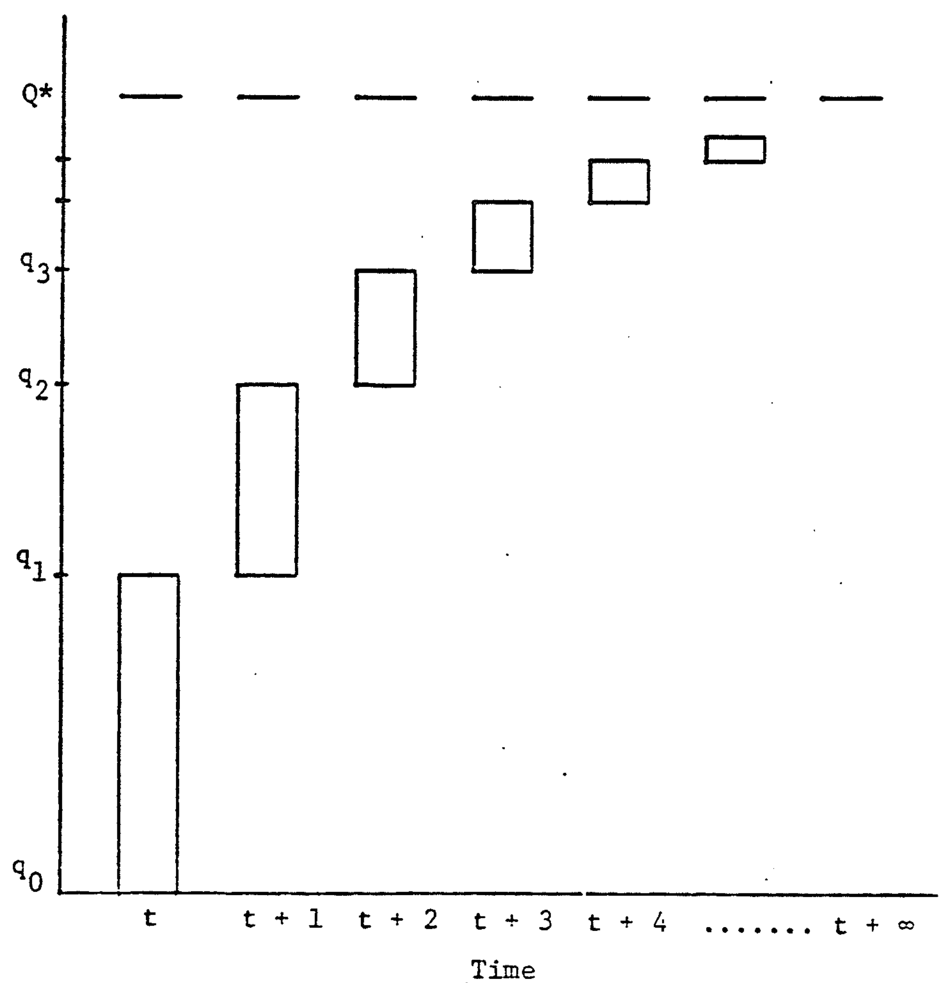

Figure 3.4

The Path of Adjustment Approaching Equilibrium Consumption
(Adjustment Coefficient = 0.4)

The aggregate adjustment over n periods is

$$3.15 \quad AA'=c+c(1-c)+c(1-c)^2+...+c(1-c)^{n-1}$$

Multiplying each item in equation 3.15 by (1-c), and subtracting the results from the original equation, produces:

$$3.16 \quad AA'-AA'\ (1-c)=c-c(1-c)^n, \text{ or}$$

$$3.17 \quad AA'=1 - (1-c)^n$$

Finally, a method of measuring the speed of adjustment can be done by

$$3.18 \quad n =\log(1-AA')/\log(1-c)$$

When the equilibrium quantity is determined, the value of the probability limit of AA equals one. in other words, equation 3.17 becomes $(1-c)^n=0$. This condition can only be true if the adjustment period approaches infinity, and adoption of the assumption that the value of c lies between 0 and 1. After a certain part of the adjustment has taken place, the magnitude of subsequent adjustments becomes minute. From a practical standpoint, this suggests that it may not be useful for a production planner to wait a very long time for a full adjustment. Alternatively, if only a 95 per cent adjustment of $[Q^*(t)-Q(t-1)]$ is expected, then AA' equals 0.95 and equation 3.17 becomes $(1-c)^n=0.05$. The value of n, the adjustment period, can be estimated from the relationship $n=\log 0.05/\log (1-c)$. This means that the length of the adjustment is determined by the magnitude of 1 less the adjustment coefficient, as well as the magnitude of the adjustment expected to be completed, relative to the potentially full adjustment.

The time period required to approach the adjusted level is presented in Table 3.1. The table shows, for example, that if the adjustment coefficient equals 0.8, and only 90 per cent of the full adjustment is expected, then 1.4 units of time would be required. On the other hand, with a low adjustment coefficient of 0.2 and a high

TABLE 3.1

Simulated Length of Adjustment Approaching "Equilibrium"

Adjustment Coefficient	Proportion of Expected Adjustment to Full Adjustment		
	0.90	0.95	0.99
	---------------------- units of time ----------------		
0.8	1.43	1.86	2.86
0.6	2.51	3.27	5.03
0.4	4.41	5.87	9.02
0.2	13.21	17.19	26.42

(99 per cent) adjustment expectation, 26.4 periods are needed to achieve "equilibrium". A possible application of this technique would be in estimating the time-lag of producers' or consumers' response to the implementation of government programs, as well as to other changes in the socio-economic environment.

As discussed above, a partial equilibrium distribution lag model would enable a researcher to test for the existence of producers' and consumers habitual behaviour, to detect the adjustment pattern, and to measure the length of the adjustment period. Therefore, the Koyck-Nerlove type of distributed lag model will be adopted in this study wherever applicable.

E. Equation Forms

Up to this point, it has been decided to use a simultaneous-equation system approach which is expected to include lagged dependent variables in some of the behavioural equations. A researcher must also make assumptions regarding the form of equation to be used in the analysis. In many studies pertaining to the supply of agricultural products, Cobb-Douglas production functions have been adopted,[66] while in studies of demand equations having curvelinear characteristics have been applied since there is a saturation level of demand for a commodity. The causal relationships between the quantity demanded and other factors are not always linear.[67] If the non-linear equation

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[66]A detailed discussion of this type of equation form is given in M. Nerlove, Estimation and Identification of Cobb-Douglas Production Equations, (Chicago, Illinois: Rand McNally & Co., 1965).

[67]Some of the non-linear consumption functions, in terms of mathematical form and application, are summarized by Z.A. Hassen and W.F. Lu, in Food Consumption Patter in Canada, publication 74/8, (Ottawa, Ontario: Economics Branch, Agriculture Canada, 1974).

form is specified as a polynomial equation, determination of the degrees of polynomial to be used becomes in itself a Monte Carlo study. Furthermore, in a economic model utilizing multiple curvilinear equations, additional equations are required to convert the curvilinear equations to linear forms. Such an increase in the number of equations may result in the inclusion of additional variables in the model thereby reducing the degrees of freedom.

In view of the above-mentioned difficulties and the existence of linearity in the physical and technical relationships within and between the blocks, the behavioural equations specified within an individual block are presumed to be linear in real terms.[68] It is ackowledged, however, that use of curvilinear equations might have described more closely the relationships postulated by theory.

F. Methods of Estimating Structural Coefficients

Methods of estimating structural equations of an interdependent system can be classified into either single-equation methods, or complete system methods. The first approach includes two-stage least squares, limited-information-maximum-likelihood estimation, as well as others. These techniques can be used to solve a whole system, one equation at a time. The second approach included three-stage least squares and full-information-maximum-likelihood estimation, which is capable of solving all equations of a model simultaneously and estimating all coefficients of the system at the same time.

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[68]Many economic assumptions of non-linear relationships such as the Cobb-Douglas form of production function can be treated as log-linear functions. This type of transformation has not been utilized in this study.

According to the Monte Carlo experiment with respect to the study on supply and demand for food, complete system methods are more efficient (less variance) than the single equation methods.[69] However, the complete systems technique requires a rather large number of observations in order to provide a sufficient number of degrees of freedom for estimation. As only a small number of annual observations with respect to the rapeseed industry is available, application of the complete systems technique is impossible in this study. There appears to be little choice but to use the single-equation technique, which may not be the most appropriate to adopt in terms of the various statistical properties of the parameter estimates.

Among the single-equation methods for solving the structural coefficients of an interdependent system, the indirect least squares (ILS), the two-stage least squares (2SLS), and the instrumental variables regression (IVR) are the most commonly applied. The advantages and disadvantages of each, in terms of statistical properties and applicabilities will be briefly reviewed and based on these characteristics, the most appropriate technique will be chosen.

Indirect Least Squares

For purposes of illustration, the structural relationships of a simplified supply-demand model are given as:

3.19 Demand: $Q=a+bP+cY+dT+u$

3.20 Supply: $Q=e+fP+gW+v$

where Q(quantity) and P(price) are endogenous variables; Y(income), T(time trend), and W(weather) are exogenous variables; the structural

[69] J.G. Cragg, "On the Relative Small Sample Properties of Several Structural Equation Estimators", Econometrica, (1967), pp. 89-110.

coefficients a to g are the parameters to be estimated, and u and v are disturbances. If the OLS technique is applied to either of the above equations, the estimated parameters will be biased and inconsistent because P is an endogenous variable; and thus is correlated either with u in Equation 3.19 or with v in Equation 3.20.

In order to obtain consistent estimates, each endogenous variable within the model can be explicitly expressed as a function of all predetermined variables specified in the model. These are known as reduced-form equations. This treatment results in the regressors being uncorrelated with the disturbances. Therefore, in applying the ordinary least squares technique to the reduced-form equations, the estimated coefficients will be consistent. Where the researcher is interested in studying structural relationships, a unique set of structural coefficients can be indirectly obtained by the transformation of the reduced-form coefficients into structural coefficients provided that the system is exactly identified. While the reduced-form coefficients are unbiased and consistent, in many cases the structural parameters derived from those reduced-form coefficients will be consistent but not unbiased.[70]

The rules of identification, as developed by the members of the Cowles Commission at the University of Chicago, indicate that in cases of under-identification it is impossible to obtain estimates of some or all structural coefficients, that in cases of just-identification, a unique set of results can be produced, while in cases of over-identification, the structural parameters cannot be uniquely determined from

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[70] J. Johnston, op. cit., pp. 345-6.

knowledge of the reduced-form parameters.[71]

The necessary or order condition for the identification of an equation belonging to a system is that

> "the total number of (endogenous and predetermined) variables excluded from it but included in other equations must be at least as great as the number of equations of the system less one",[72]

while the sufficient or rank condition for identification states that,

> "in a system of G equations any particular equation is identified if and only if it is possible to construct at least one non-zero determinant of order (G-1) from the coefficients of variables excluded from that particular equation but contained in other equations of the model".[73]

In general, economic models are seldom exactly identified because if any one equation is not identified, N.P., the application of ILS to resolve a medium or large-scale model is limited by the identification requirement.[74] In addition, it is anticipated that this study will have problems related to the shortage of data and thus the degrees of freedom; thereby implying that the ILS technique cannot be used.

Two-Stage Least Squares

This technique has been accepted as the most important of the single-equation methods for solving over-identified economic models.[75] The basic concept of the 2SLS is straight-forward. If

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[71]W.C. Hood and T.C. Koopmans, Studies in Econometric Methods, (New York: John Wiley & Sons, Inc., 1953.)

[72]A. Koutsoyiannis, op. cit., p. 342.

[73]Ibid, p. 343.

[74]K.A. Fox, Intermediate Economic Statistics, (New York: John Wiley & Sons, Inc., 1968), p. 405.

[75]J. Johnston, op. cit., Chapter 13.
An equation is over-identified if the number of the predetermined variables excluded from that equation but included in the system

this technique was used to estimate Equation 3.19, the essence of the approach would be to replace P, the right-hand-side endogenous variable, with the regression-calculated value, P*. In the first stage, the value of P* (calculated value) would be estimated by regressing P (actual observations) on Y, T, and W(all exogenous variables specified in the model). By definition, each exogenous variable would be uncorrelated with the disturbances. Thus, P* would also be uncorrelated with disturbances. The second stage would substitute the computer P* for P, and then apply the OLS to Equation 3.19 to yield consistent estimates. The 2SLS estimates are also asymptotically unbiased, i.e., in large samples the bias tends to be zero, although biasness is not eliminated in small samples. In addition, 2SLS can be applied to estimate an equation when it is over-identified because the structural parameters are not derived from the estimated reduced-form coefficients; it is not necessary to know the exact relationships between these two types of coefficients.[76]

In practice, in a medium or large model, the number of exogenous variables may easily exceed the number of sample observations; or the latter may not be large enough to provide a satisfactory number of degrees of freedom for the regressions. It has long been recognized that, in obtaining regression estimates for single equations, the number of observations must be greater than that of the predetermined variables; otherwise equations would be "singular" and have no

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[75](cont'd.)
being studied is greater than the number of endogenous variables in the same equation less one; a system is identified when all behavioural equations in the system are overidentified.

[76]A. Koutsoyiannis, op. cit., p. 376.

solution. Even where there are sufficient degrees of freedom, in the sense of being able to calculate the estimates, they may not necessarily be sufficient to provide large sample precision.[77] Again, when the number of observations available is less than the number of regressors, solution is not possible. Such a situation has been referred to as the case of the undersized sample.[78] Many econometric models recently built, such as the Osaka model,[79] the Brookings model,[80] and the Trace model,[81] are very large. For example, the latter has 42 behavioural equations and 157 definitional equations, so that there are 199 endogenous variables and 93 exogenous variables. The model has made available estimates, using annual Canadian National Income data for the period of 1953-71. Obviously, such a sample is undersized. While the model that will be constructed in this study is relatively small, compared with the earlier cited models, it is anticipated that because this study will also have the problem of shortage of observations, the 2SLS technique cannot be applied either.

The Instrumental Variables Regression

The basic concept of the IVR is quite similar to that of 2SLS. In the first stage of the IVR, one regresses the endogenous variables appearing on the right-hand-side on a set of selected exogenous

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[77]L.R. Klein, A Textbook of Econometrics, (2nd ed.), (Englewood Cliffs, N.J.: Prentice-Hall, Inc. 1974) p. 183.

[78]J.E. Nehlawi, "Consistent Estimation of Real Econometric Models with Undersized Samples: A Study of the TRACE (Mk IIIR) Econometric Model of the Canadian Economy", International Economic Review, (Feb. 1977), pp. 163-79.

[79]S. Ichimura, et al., op. cit.

[80]J. Duesenberry, et al.,(ed.), op. cit.

[81]J.A. Sawyer, op. cit.

variables instead of on all the exogenous variables specified in the model. In the second stage, one applies the OLS technique to the transformed equation where the computed values substitute for the actual values of the endogenous variables appearing on the right-hand-side of the equation.

Klock and Mennes have suggested a practical solution to the problem of estimating economic equation systems from rather short time-series.[82] Their solution is to use a small number of principal components of predetermined variables to represent the complete set of predetermined variables. The choice of principal components is made by subdividing the predetermined variables into two categories: The first group includes the variables that appear in the equation under computation; the second group includes all the variables that appear in the complete system, but are excluded from the equation under computation. All the predetermined variables belonging to the first group, but only a few among the second group, are used as principal components in the estimation of a given equation.

Fisher has generalized the criteria for selecting instrumental variables which were treated as though they were the only exogenous variables in the system.[83] First, the chosen predetermined variables had to be uncorrelated in the probability limit with the disturbance from the estimating equation by which consistent estimates are assured; secondly, the chosen variables should, directly or

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[82]T. Klock and L.B.M. Mennes, "Simultaneous Equations Estimation Based on Principal Components of Predetermined Variables", Econometrica (Jan. 1960), pp. 45-61.

[83]All non-instrumental variables in the equation were treated as though they were endogenous variables. See F.M. Fisher, "The Choice of Instrumental Variables in the Estimation of Economy-Wide Econometric Models", International Economic Review, (Sept. 1965), pp. 245-74.

indirectly, influence the endogenous variables which appeared on the right-hand-side of the equation to be estimated, and the more direct such an influence is the better, and thirdly the chosen variables have to be independent of other predetermined variables in order to avoid the problem of multicollinearity.[84]

From a statistical point of view, all predetermined variables are, by assumption, independent of residual errors. Hence, according to the above-mentioned first criterion, all predetermined variables are eligible to be selected as instrumental variables. In order to meet the second and third criteria a procedure for exploring a range of alternative combinations by investigating the effect of adding or dropping one or more regressor on variations in the values of the regressand is suggested. In fact, such a procedure amounts to applying the technique of stepwise regression.[85]

The method of selecting a combination of instrumental variables might usefully be discussed at this point. Suppose that there are T observations in a sample. First, regress the endogenous variable, which appears on the right-hand of the equal sign in a given equation, on the first of the T-2 instruments (a regression with one degree of freedom). Second, in the light of *a priori* preferences, drop the least preferred instrument from the regression. If the multiple correlation coefficient does not drop significantly, due to elimination of that

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[84]In Fisher's article, the second and third criteria are considered as one, because the addition of an instrument which is highly correlated with the included one adds little causal information, while using up a degree of freedom. *Ibid.*, p. 264.

[85]The methods of the stepwise regression include forward inclusion, backward elimination or a combinational solution (see N.H. Nie, *et al.*, *Statistical Package for the Social Science*, (2nd ed.), (New York: McGraw-Hill Inc., 1975), pp. 345-6.

variable, then the T-2nd instrument should be excluded because that variable adds little causal information. On the other hand, if R^2 does drop significantly implying that the T-2nd instrument contributes significantly to the causation of the regressand, then that variable should be retained.

Continuing in this way, the T-3rd instrument is tested. If it reduced the R^2 significantly, retain it; if not, omit it and proceed to the next lower-numbered instrument. When all instruments have been so tested, the ones remaining are the ones to be used. However, in principle, it is possible that an instrument dropped at an early stage may pass the test in the absence of variables dropped at a later stage because of the increased number of degrees of freedom, or because of the purge of possible disturbances by high correlation between the three variables dropped earlier and later.[86] Given that there are only three instruments to be selected from among twenty-five predetermined variables, then the number of tests that should be done is 2,300. Therefore, the amount of computational work to apply the technique of stepwise regression for selecting instrumental variables would obviously be too much to be practical. Some reduction of the computational work would appear to be desirable.

In this study, the choice of instrumental variables will be made utilizing the stepwise regression technique. However, rather than selecting a variable only once, all the endogenous variables on the right-hand side in a given equation will be regressed on arbitrarily selected (n-2) on all the predetermined variables sepecified within

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[86]The collinearity between two variables brings about a loss of identification because identifiability depends on the separate exclusion of one variable or the other from each equation.

the system, in order to obtain a matrix of correlation coefficient between each pair of variables.[87] High correlation between the regressand and regressors and low correlation between two regressors were used as criteria to select several potential combinations of the instrumental variables. Among the limited set of combinations it was possible to select one which had the best estimation of the regressand in the first stage and provided best explanation from an economic standpoint of the behavioural equation in the second stage.

In sum, among the single-equation methods of solving structural coefficients for a simultaneous-equation system, the methods of ILS, 2SLS, and IVR yield biased but consistent estimates, while the OLS estimates will be both biased and inconsistent. "On the question of bias there is fairly general agreement among the emperical studies",[88] unless the system can be developed in a recursive fashion. As regards the property of asymptotic consistency, the consistent estimates are obviously preferrable to the OLS estimates. Unfortunately, due to the identification problem or the problem related to the shortage of data, ILS and 2SLS cannot be used in this study. Therefore, the technique of IVR will be adopted in this study because of the choice of instrumental variables to a certain extent is arbitrary. In this way the most serious problem concerning the shortage of degrees of freedom can be overcome.

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[87]Where "n" is the number of observations used in this study. Accounting for the constant term as a variable, there is one degree of freedom.

[88]J. Johnston, <u>op</u>. <u>cit</u>., p. 410.

IVR estimates are biased but they are asymptotically consistent provided that a set of appropriate instrumental variables are chosen. Nonetheless, this technique has some disadvantages. For example, since the choice of instrumental variables is arbitrary, each choice would correspond to a set of parameter estimates. The results would not be unique depending on how the variables were chosen. Furthermore, as a consequence of the inclusion of some of the exogenous variables specified in the model as instrumental variables, the influence of the non-instrumental variables on the endogenous variables appearing on the right-hand-side of the equation could be ignored. Thus, even if the sample size was sufficiently large, one could not be sure that the IVR estimates would be consistent because the dependence of the independent variables and the error terms could not be completely cured.

In addition, given that this study works with small samples, the asymptotic properties of the estimates are of little assistance in choosing an appropriate estimation technique. Alternatively, a small-sample property of the mean square error, which is defined as the sum of the squares of the bias of an estimator and the variance about its expected value can be used as a criterion for selecting a particular estimation technique.

Many Monte Carlo studies have been reviewed to compare bias, variance and the mean square error between the OLS estimates and those obtained from other methods. Unfortunately, "there is no widely accepted method or technique for drawing conclusions from such a varied collection of empirical studies".[89] For instance, Quandt's study

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[89]Ibid., p. 409.

showed that, in many cases, the OLS bias was smaller than that of the 2SLS bias;[90] while Summer's study indicated that no noticeable difference in estimation errors was found between OLS and 2SLS.[91] The available Monte Carlo evidence suggests that the OLS estimator tends to have a larger bias and a smaller variance than 2SLS or LIML. If the mean square error is used as a criterion in comparing the single-equation estimators, the results are mixed. In some cases the OLS estimator performs better than 2SLS or LIML, in others worse, and sometimes about the same. While the OLS estimates are inconsistent, this method is frequently used in applied works.[92] It is particularly preferred when the number of observations is relatively small.

This study is interested in obtaining not only accurate structural coefficients but also efficient predictions: OLS may be inferior to IVR in terms of the property of asymptotic consistency, nonetheless, it is not certain that either IVR or OLS will have a smaller MSE or which one will provide a better predictive performance. Therefore, both IVR and OLS methods will be applied in this study. The judgement on the suitability or the superiority of one method over another for this study will be made in the light of empirical results.

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[90] R.E. Quandt, "On Certain Smaller Sample Properties of Class Estimators", International Economic Review, Vol. 6, (1965), pp. 92-104.

[91] R. Summers, "A Capital Intensive Approach to the Small Sample Properties of Various Simultaneous Equation Estimators", Econometrica, Vol. 33, (1965), pp. 1-41.

[92] J. Kmenta, Elements of Econometrics, (New York: The MacMillan, Inc., 1971), pp. 583-4 or J. Kmenta and R.F. Gilbert, "Small Sample Properties of Alternative Estimators of Seemingly Uncorrelated Regressions", Journal of the American Statistics Association, (1968), pp. 1180-1200.

G. Methods of Estimating Reduced-Form Coefficients

The methods of estimating the structural coefficients of behavioural equations within a simultaneous-equation system have been discussed in the previous section. However, a researcher may be interested in estimating reduced-form coefficients. Since a simultaneous-equation system can be converted into a set of reduced-form equations where the latter express each of fhe endogenous variables as a function of all the predetermined variables specified in the system.

From the standpoint of application, a structural coefficient of a variable in a given equation within the simultaneous system indicates only a partial cause-effect relationship in a single segment of the market. For example, the coefficient for margarine prices in the margarine consumption function shows the responsiveness of the quantity of margarine consumed to changes in margarine prices. In contrast, the corresponding coefficients in the reduced-form equations, indicates the "total" effect of a change in the price of margarine on its consumption, after taking into account the interdependencies among all endogenous variables specified in the model.[93] In addition, a structural coefficient is unable to provide the causal relationship between the associated variable and other endogenous variables specified elsewhere in the model but not in the given equation. Using the previous example, the structural coefficient for margarine prices cannot provide ancillary information on the impact of a change in the price of margarine on the amount of rapeseed oil used, or the amount

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[93]Such a coefficient in the normal terminology of economists is known as a "multiplier".

of rapeseed exported. In contrast, the latter information can be obtained from a reduced-form coefficient matrix. It is clear that for many applications, the reduced-form, rather than the structural form of the model, will be of greater interest.[94] There are two distinct methods of obtaining the coefficients associated with reduced-form equations.

Direct Estimation of Reduced-Form Coefficients

As discussed earlier, the indirect least squares method is designed to obtained reduced-form coefficients by directly applying OLS to the reduced-form equations, and indirectly deriving the structural coefficients from the estimated reduced-form coefficients. But as indicated earlier, this method is not applicable in this study because there is only a limited number of observations and the number of predetermined variables specified in the system may exceed the number of available observations.

In this regard, Liu has proposed a method to obtain the reduced-form coefficients, by directly apply the OLS to the reduced-form equations.[95] His argument is that, in economic reality, since many variables have important influences on the dependent variable in any structural equation; the high intercorrelation among the large number of explanatory variables so included would almost certainly result in large standard errors of estimate or even wrong signs for some of the estimated structural coefficients. The complexity of modern economic society, and the limitations of existing

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[94]A.S. Goldberger, Econometric Theory, (New York: John Wiley & Sons, Inc., 1964), p. 364.

[95]T.C. Liu, "A Simple Forecasting Model of the U.S. Economy", International Monetary Fund Staff Papers, (Aug. 1955).

statistical techniques, result in the "true" structural relationships being underidentified.[96] Therefore, with but rare exceptions, no reliable estimates can be made of the coefficients in the structural relationships. Hence, in forecasting the reliability and usefulness of the reduced-form coefficients derived from the structural coefficients will be weakened.

Nonetheless, Liu has further suggested that all relevant variables should be included in the initial stage of model specification. In order to ensure that the number of explanatory variables can be reduced to manageable proportions, all the relevant variables should be classified into groups with high internal intercorrelation; then a "representative variable" should be selected from each group for inclusion in the forecasting equation, so that the combined effect of a change in the magnitude of the group of highly correlated variables on the regressand can be measured.[97]

The main advantage of the direct-estimate method is simplicity. Applying the OLS method to the reduced-form system, consistent estimates of reduced-form coefficients can be obtained. The counter-argument to this is that the derived reduced-form estimates, incorporating restrictions, will be at least asymptotically - more efficient than the direct estimates.[98]

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[96]T.C. Liu, "Underidentification, Structural Estimation and Forecasting", Econometrica, (October 1960); Also reprinted in J.W. Hooper and M. Nerlove (ed.), Selected Readings in Econometrics from Econometrica, (Cambridge: The MIT Press, 1970).

[97]Ibid.

[98]L.R. Klein, "The Efficiency of Estimation in Econometric Models", in Essays in Economics and Econometrics, (Chapel Hill, N.C.: University of North Carolina, 1960), pp. 216-32.

If the primary purpose of a study is forecasting, Liu's approach might be recommended. However, the economic relationships within each segment and between segments of the rapeseed industry can be best reflected by the magnitude of the structural coefficients which Liu's approach is unable to obtain. Obviously, the alternative method appears to be more appropriate for this study.

Derived Reduced-Form Coefficients

By this approach, the reduced-form coefficients are estimated by a two-step procedure. First, the structural coefficients of the behavioural equations within a simultaneous-equation system are estimated by the technique of IVR or OLS, and the structural coefficients of the identical equations of the system are determined from extraneous information which may be available from economic theory, or institutional and statistical prior information. Secondly, the reduced-form coefficients are derived from the given structural coefficients.

The application of econometric models to test economic hypotheses, to make predictions, and thus to support policy analysis, is made as the second step of a two-step procedure. In the first instance, the parameters of a model are estimated from sample data according to criteria, such as goodness of fit. In the next step, the estimated parameters are applied to non-sample situations. Following econometric processing, the estimates of reduced-form coefficients are developed to serve as a base for forecasting.

For purposes of showing how a reduced-form coefficient matrix can be derived from already estimated structural coefficients, a generalized structural relationship in a simultaneous system model is expressed in matrix notation as:

$$AY = BX + U$$

The reduced-form equations are then given by

$$Y = A^{-1}BX + A^{-1}U = CX + V; \; C = A^{-1}B, \text{ and } V = A^{-1}U$$

where A is an m by m matrix of structural coefficients for the endogenous variables,

Y is an m by 1 vector of the endogenous variables,

B is an m by n matrix of structural coefficients for the predetermined variables,

X is an n by 1 vector of the predetermined variables,

A^{-1} is an inverse matrix of matrix A,

C is an m by n matric of the coefficcients for the reduced-form equation,

U is an m by 1 vector of the structural disturbances assuming that the Gauss-Markoff conditions hold, and

V is an n by 1 vector of reduced-form disturbances assuming that the Gauss-Markoff conditions also hold.

The above system is complete in the sense that there are m endogenous variables and the same number of structural equations. As the values of the structural coefficients and thus those of matrix A and matrix B are known, and since the number of endogenous variables and equations is the same, a unique set of reduced-form coefficients of the system can be derived by algebraic manipulation. Thus, matrix C is called the derived, reduced-form coefficient matrix. Given that the estimates of the structural coefficient matrixes A and B are consistent, then estimates of the reduced-form coefficient matrix, C, will be consistent as well.[99]

The disadvantage of derived estimates is that the minimum variance property does not carry over from the structural to the

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[99]A.S. Goldberger, _op. cit._

derived reduced-form coefficients, and small sampling errors in individual structural coefficients may build into large sampling errors in the derived estimates.[100]

In realistic applications, if the structure of the economy remains the same in the forecast period, as existed in the sample period, direct estimates will be adequate for forecasting. If, however, some structural change is known to have occurred and structural estimates are available, they may be modified appropriately and revised reduced-form estimates derived from them. If only direct reduced-form estimates are available, it will be difficult to make the appropriate modifications. In some cases, a policy variable can be used in the estimating equation, although it may not fully reflect the structural changes. In addition, estimates of structural coefficients are themselves of interest because they help explain how the Canadian rapeseed industry has grown. Therefore, for all the above reasons the derived reduced-form approach will be applied in this study.

H. Criteria Used in Evaluating Regression Estimates

Econometrics is concerned with specifying and quantifying the relationships between and among variables in a system, using the tools of economic theory, mathematics, and statistical inference. Regression analysis is an econometric technique which has been used extensively in estimating the structural coefficients in such a system. Often, however, the underlying assumptions necessary for the usual application

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[100] L.R. Klein, "The Efficiency of Estimation in Econometric Models", in Essays in Economics and Econometrics, (Chapel Hill, N.C.: University of North Carolina, (1960), pp. 216-32.

The minimum variance estimates contain the maximum amount of information concerning the determination of the jointly dependent variables that can be extracted from the data.

of this approach are not fulfilled.

The general criteria used in evaluating the results of regression analyses are the performance of the model, judged against the statistical significance of the coefficient of determination, as tested by the F-test; the statistical significance of regression coefficients, tested by the student t-test; and the degree of consistency between the sign and size of a regression coefficient and orthodox economic theory.[101] For many cross-sectional analyses, the problem of heterosdasticity, the case where assuming constant variance of the disturbance terms is invalid, has been examined.[102] For time-series analyses, in general, the Gauss-Markoff conditions, and problems of autocorrelation and multicollinarity are examined. Since time series data will be used in this study, these issues are discussed below.

The Gauss-Markoff Conditions

If a regression equation is specified as:

$$Y(t) = b(0) + \sum_{i=1}^{n} b(i)X(t,i) + u(t)$$

where: i = 1, 2, ..., n independent variables,

t = 1, 2, ..., T observations,

Y = the dependent variables to be estimated,

X = the predetermined variables which are measured without error; and

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[101] M.H. Yeh, Application of Simple and Multiple Regression Analyses to Economics Problems (reprinted), Technical Bulletin 4, (Winnipeg, Manitoba: Department of Agricultural Economics, University of Manitoba, 1965).

[102] For example, this problem was treated by W.F. Lu and R.G. Marshall in "Demand Analysis for Manufactured Dairy Products in Canada in 1969", Canadian Journal of Agricultural Economics, (July 1974), pp. 55-60. The heteroscedastic problem can, in principle, be solved by Aitken's generalized least squares technique.

U = the residual errors, under the following conditions:

i.e., E(U(t))=0 for all t

E(U(t)U(t))= constant,

E(U(t), U(s))=0, when s not = t,

E(X(t,i), U(T))=0, for all i,

then the unbiased and "best" estimates (those that possess the smallest variances among unbiased estimates) of the regression coefficients b(i) can be obtained by the ordinary least squares method.[103]

Suppose now that the lagged values of the dependent variable appear on the right-hand side of the specified equation, i.e.,

$$Y(t)=a(0)+a(1)Y(t-1)+\ldots a(m)Y(t-m)+\sum_{i=1}^{n} b(i)X(t,i)+U(t)$$

if the assumption of independence between the disturbance term and the current independent variables is valid, but the assumption of independence between the disturbance term and lagged dependent variables is invalid, then the least squares estimates will be biased.

Suppose again that observations Y(1), Y(2),..., Y(T) are generated by the following scheme, such that;

$$Y(t)=a(0)+a(1)\,Y(t-1)+U(t);$$

where U(t) is assumed to be normally and independently distributed with zero mean and constant variance, Y(1) is a fixed number, and the remaining values of Y(2),..., Y(T) depend upon Y(1) and U(2),..., U(t), then the likelihood function for the sample is:

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[103]G.W. Ladd and J.E. Martin, Application of Distributed Lag and Autocorrelated Error Models to Short-Run Demand Analysis, Research Bulletin 256 (Ames, Iowa: Agriculture Experimental Station, Iowa State University 1964), p. 96.

$$Pr(U_2 U_3 \dots U_t) = Pr(U_2)\, Pr(U_3) \dots Pr(U_t)$$
$$= \frac{1}{(\sigma_u^2 2\pi)^{n/2}} \exp\left(-\frac{1}{2\sigma_u^2} \sum_{t=2}^{T} (Y_t - a_0 - a_1 Y_{t-1})^2\right) dU_2, dU_3, \dots dU_t$$

Maximizing this function, with respect to a(0) and a(1), is the same as minimizing [Y(t) - a(0) - a(1)Y(t-1)] -squared. Thus, for the fixed Y(1), the least squares estimates are maximum-likelihood estimates, and posses the properties of consistency and efficiency.[104]

If Y(1) itself is a random variable, then the sequential values are begun with a drawing from the Y(1) distribution. If a distributed lag model is applied, and the value of the first dependent variable is treated as a fixed number, then the maximum-likelihood estimates will be virtually indistinguishable from those estimated by least squares regression; and although the estimates of the regression coefficients will be biased in small samples, they will, nonetheless, be consistent and efficient.

Autocorrelation of the Disturbance Terms

A statistical model includes not only the researcher's assumptions about the appropriate variables in each equation, but also his assumptions about the nature of disturbances in the behavioural equations, as well as any other restrictions that are likely to exist. In general, it is assumed that the distribution of the residuals, computed from an estimating equation over the analytical period, satisfy the assumption of serial independence. The problem of autocorrelation occurs when the disturbance terms between two successive periods are highly correlated. Autocorrelated disturbances result in the regression coefficients being biased, the sampling variances of regression coefficients being underestimated, and, in the predictions made being

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[104] J. Johnston, op. cit., Chapter 10, "Lagged Variables".

inefficient when the ordinary least squares method of estimation is applied.[105]

The von Neumann ratio, the "ratio of the mean square successive difference in residuals to the variance" and the Durbin-Watson "d" statistic are commonly used in testing whether or not the least squares residuals are independently distributed.[106]

The "d" statistic is specified as:

$$d=\sum_{t=2}^{T}(e(t)-e(t-1))^2 \Big/ \sum_{t=1}^{T}(e(t))^2$$

where T is the number of observations and e is the least square residual.

When the lagged dependent variable is used as one of the explanatory variables in a behavioural equation, the above specified Durbin-Watson "d" statistic is biased, and is likely to give misleading information about the degree of autocorrelation, particularly when the magnitude of both the regression coefficient, and the correlation coefficient of two successive residuals is large.[107] Recently, Durbin developed an "h" statistic to test the existence of autocorrelation when lagged dependent variables are present.[108]

$$h = r\sqrt{T/\ 1-T\hat{V}(b)}$$

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[105] Ibid., Chapter 8, "Autocorrelation".

[106] For a detailed discussion, see C.F. Christ, Econometric Models and Methods (2nd ed.), (New York: John Wiley & Sons, Inc., 1967), pp. 523-31: The development of the "d" statistic was initiated by J. Durbin and G.S. Watson, "Testing for Serial Correlation in Least-squares Regression", Biometrika, vol. 37, (1950), pp. 409-28.

[107] Z. Griliches, "A Note of the Serial Correlation Bias in Estimates of Distributed Lags", Econometrica, 29, (1951), pp. 65-73.

[108] J. Durbin, "Testing for Serial Correlation in Least-Squares Regression When Some of the Regressors are Lagged Dependent Variables", Econometrica, 38, (1970), pp. 410-21.

where r = 1-0.5d (d is the conventional Durbin-Watson statistic), T is the number of observations and $\hat{V}(b)$ is the sampling variance of the regression coefficient associated with the lagged dependent variable estimated by ordinary least-squares procedures. The statistic "h" is tested as a standard normal deviate; if h is greater than 1.65, one could reject the hypothesis that there exists autocorrelation with a 95 per cent degree of confidence. In order to circumvent the problem, both the autocorrelation regression proposed by Hildreth and Lu, and the three-pass least squares proposed by Taylor and Wilson have been widely applied.[109] The detailed discussion of the application of these techniques is not given. However, the Hildreth-Lu auto-regression technique will be applied in this study where there exists the problem of autocorrelation.

Multicollinearity

This problem is concerned with both the proper specification and effective estimation of structural relationships, commonly sought through the use of regression techniques.[110] A model specification, in general, begins in the model builder's mind. From a combination of theory and a priori assumptions, a set of variables are chosen to explain the behaviour of a given dependent variable. However, the job does not end with the first tentative specification.

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[109]C. Hildreth and J.Y. Lu, Demand Relations with Autocorrelated Disturbances, Technical Bulletin 276, (Michigan Agricultural Experiment Station, Michigan State University, 1960).

L.D. Taylor and T.A. Wilson, "Three-Pass least Squares: A Method for Estimating Models with a Lagged Dependent Variable," The Review of Economies and Statistics, (Nov. 1964), pp. 329-46.

These two adjustment procedures have been computerized. For example, they are included in M.C. McCraken and A. Leduc, Massager Manual, (Ottawa, Ontario: Information Ltd., 1973. Statistics Canada assumes responsibility for public dissemination).

[110]D.E. Farrar and R.R. Glauber, "Multicollinearity in Regression Analysis: The Problem Revisited", The Review of Economics and Statistics, (Feb. 1967), pp. 92-107; also reprinted in J.M. Dowling and F.R. Glabe (ed.), Reading in Econometric Theory, (Boulder, Colorado: Colorado University Press, 1970).

Before an equation is judged acceptable, it must be tested on a body of empirical data. Should it be deficient in any of the model builder's "a priori hypotheses", the specification is modified and re-tested. The process may go on many times, before discrepancies between a priori assumptions and sample information can be reduced to tolerable levels.[111] In practice, a large number of the economic variables in a given sample are almost certain to be highly correlated. Attempts to apply regression techniques to highly correlated, "independent" variables generally result in the large variances associated with regression coefficients. In turn, the latter indicate the low informational content of observed data, and the poor quality estimated parameters where an explanataory variable exhibits little or no true independent effect on a given dependent variable. Under these circumstances, data limitations rather than theoretical limitations are primarily responsible for the persistent tendency to underspecify or to oversimplify econometric models.[112]

In reality, variables obtained from a sample are seldom statistically, perfectly independent, i.e. they are not internally orthogonal. Since variables are to a degree correlated with each other, multicollinearity is defined in terms of the problem's severity rather than its existence or non-existence. As Johnston stated econometricians are "in the statisticcal position of not being able to make bricks without

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[111] "Theorists have been unable to agree as to whether analyses should be based on aggregate or per capita data, or on deflated or undeflated price and income series" (See F.L. Thomson and R.J. Foote, Agricultural Prices (2nd ed.), (New York: McGraw-Hill Book Co., Inc., 1952), p. 287). Different data increase the number of alternative processes.

[112] T.C. Liu, "Underidentification, Structural Estimation and Forecasting", Econometrica, (October 1960), p. 856.

straw.[113] According to a rule of thumb, if the simple correlation coefficient between any pair of explanatory variables is not greater than 0.7 or 0.8 it is defined as acceptable.

Christ has stated that "if the joint distribution of the independent variables stays the same in the forecasting period as it was in the sampling periods, high covariances among the estimated coefficients are no disadvantage".[114] However, the counterpart to this argument is that successful forecasts with correlated variables require, not only the perpetuation of a stable relationship between dependent and independent variables, but also the perpetuation of stable interdependent relationships among the independent variables. "Both conditions are met, unfortunately, only in a context in which the forecasting problem is all but trivial".[115] There are several ways to treat multicollinearity. For example, the use of time-series and cross-section data in demand studies, in order to remedy the difficulty caused by the high correlation between the explanatory variables, income and prices.[116] However, there are difficulties of specification and interpretation.[117] As one alternative, Klein combined

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[113] J. Johnston, op. cit., p. 64.

[114] C.F. Christ, Econometric Models and Methods, (2nd printing), (New York: John Wiley & Sons, Inc., 1967), p. 389.

[115] D.E. Farrar and R.R. Glauber, op. cit., p. 95.

[116] J.R.N. Stone, The Measurement of Consumer's Expenditure and Behaviour in the United Kingdom, 1920-1938, (Cambridge, Longon, 1954); This approach was applied by W.F. Lu and R.G. Marshall in A Demand Analysis for Fluid Milk in Ontario, Publication AE/73/11, (Guelph, Ontario: Department of Agricultural Economics, University of Guelph, 1973).

[117] J. Meyer and E. Kuh, "How Extraneous are Extraneous Estimates", The Review of Economics and Statistics, (Nov. 1957), pp. 380-93.

several highly correlated explanatory variables into one variable. The coefficient associated with the latter, as estimated from regression analyses, was then treated as the independent effect on the dependent variable.[118] While this approach provided a solution for the multicollinearity problem it created a new variable which could not be interpreted directly as an economic variable. Furthermore, the process of deriving estimates of the original set of variables, based on the estimated coefficient, requires access to additional information and thus contributes to the complexity of the model rather than alleviating the multicollinearity problem.[119]

As far as this study is concerned, solution of the multicollinearity problem lies in deciding which variables to keep and which to drop from the model. In general, complete specification of a model and internal orthogonality of all the explanatory variables are seldom satisfied at the same time. Yet the variables are not always equally important. Therefore only a few, selected, important variables, in terms of economic theory, are present in a regression equation. It would be satisfying to be able to state that the results obtained in the light of the selection made in this study are sufficiently comprehensive and accurate to thoroughly explain the complex workings of the industry, and that no further effort would be needed. Clearly, this would be misleading. As was the case with many other studies, the results obtained in this study have also been subject to data limitations and existing statistical techniques. This study, however, has

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[118] L.R. Klein, Economic Fluctuation in the United States, 1921-41, Cowles Commission Monograph No. 11, (New York: John Wiley & Sons, Inc., 1950).

[119] D.E. Farrar and R.R. Glauber, op. cit.

made the attempt with the firm belief that the results would be useful with respect to the understanding of the workings of the Canadian industry. Nonetheless it is freely acknowledged that for policy analysis and decision making, certain managerial judgement would have to be exercised.

I. Tests of the Stability of Regression Coefficients

A researcher may be interested in testing whether a structural shift has taken place in certain economic relationships between different periods. The test of sensitivity of regression coefficients, with respect to the size of sample or number of observation periods, is essential to the determination of the appropriate forecasting technique to be used.

In general, predictions can be made under conditions of either "unchanged structure" or "changed structure".[120] In the former case, the economic structure being extended into the prediction period is the same as in the observation period, i.e., the feature that do not change during the observation period are assumed not to change during the combined observation and prediction period. Given that predictions are to be made using a process that has already been observed in operation, the effects of exogenous variables upon the endogenous variables can be deduced from observed data and applied to the prediction period.

In the other case, the economic structure in the prediction period is expected not to be the same as in the observation period. Predictions are to be made in circumstances where some features have

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[120] C.F. Christ, op. cit., p. 13.

never been observed before. It is generally agreed that it is very difficult to predict the future in the case of "changed structure", because a researcher has to know something about the structure from the observation period, as well as about the character of the anticipated change itself.[121] Since the history of the rapeseed industry in Canada is relatively short and the available data limited, predictions in the context of a changed structure would presently be indeterminate. However, in order to test whether the application of conditional predictions might be justified, the stability of regression coefficients should be examined. There are two methods that are commonly used for testing the stability of coefficients.

The Dummy Variable Approach

Many economic models include dummy variables representing various factors such as temporal effects, spatial effects, qualitative variables, and broad groupings of quantitative variables.[122] For example, in order to measure shifts of the intercept and the slopes of function over time, two dummy variables, namely D and DX, can be introduced into the most simplified equation as below:

$$Y = a_1 + a_2D + b_1X + b_2DX + U$$

where Y is a dependent variable, X is an independent variable, D is a dummy variable which equals 0 for sub-period 1 and 1 for sub-period 2; DX is another dummy variable which equals 0 for sub-period 1 and X for

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[121] Ibid.

[122] J. Johnston, op. cit., p. 176.
For example, W.F. Lu and R.G. Marshall applied a dummy variable approach to detect the seasonal variations in milk consumption in A Demand Analysis for Fluid Milk in Ontario, Publication AE/73/11, (Guelph, Ontario: Departmental of Agricultural Economics, University of Guelph, 1973).

sub-period 2, and U represents the residuals. According to the t-test, if the regression coefficient is statistically, significantly different from zero, it implies that the intercept of the equation being studied is shifted by the magnitude of a_2 units of Y between two sub-periods. Similarly, if the value of b_2 is significant, the relationships between X and Y being changed over time is implied. The impact of one unit of X on Y is b_1 in the sub-period 1, while that is the sum of b_1 and b_2 for sub-period 2.

The use of two dummy variables in the above equation can be viewed as the addition of two independent variables to the regression analysis. However, mainly due to data limitations, this approach is not likely to be used in this study in testing the stability of the regression coefficients between within and outside the oberservation periods.

The Chow's Test

It is well known that the F-test is used to test the overall significance of a particular regression. Basically, the total variation in the dependent variable of a regression equation is split into two components: the sum of squared deviations which can be explained by the regressors, and the sum of squared unexplained deviations. Then, the F-ratio is calculated by the following formula:

$$F = \frac{SSD/(k-1)}{(1-SSD)/(N-K)}$$

Where: SSD is the sum of squared deviations explained by all regressors,

(1-SSD) is the sum of squared unexplained deviations or residuals,

K is the number of independent variables including the constant term, and

N is the number of observations in the sample.

If the calculated F-ratio is greater than the theoretical F-ratio at the chosen level of significance, then the hypothesis that the independent variables have a significant impact on the dependent variable is not rejected.[123]

Similarly, the basic concept of analysis variance is the disaggregation of the sum of squared deviations of the dependent variable into unexplainable and explainable components. The latter can be further broken down into a sub-set of explanatory variables according to various factors or sources of variation of the component being analyzed. From there, the F-test is applied to test for equality between the means of sub-samples of an enlarged population, in order to conclude whether or not there is any significant difference between the influences of different factors on the variable being studied.[124]

Following the concepts of variance analysis and the test for overall significance of a regression, Chow has developed a method of testing for equality between regression coefficients obtained from different samples.[125] The technique of Chow's test can be applied to investigate the stability of coefficient estimates when increasing the size of the sample. The result of the test will determine whether the regression coefficients are different in an enlarged sample or whether they remain stable over time. Testing the sensitivity of coefficient estimates to changes in sample composition is useful for

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[123]A.M. Mood and F.A. Graybill, Introduction to the Theory of Statistics, (New York: McGraw-Hill Inc., 1963).

[124]A. Koutsoyiannis, op. cit., Chapter 8.

[125]G.C. Chow, "Tests of Equality between Sets of Coefficients in Two Linear Regressions", Econometrica, Vol. 28, (1960), pp. 591-605.

detecting whether the economic structure has changed between two sample periods.

Briefly, the test is accomplished by the following steps.

1) Applying the OLS to the first n observations to yield

$$Y_1 = b_1X_1 + v$$

and the residual sum of squares, v'v;

2) Applying the OLS to the pooled n and m observations to give

$$Y = bX + u$$

and another residual sum of squares, u'u;

3) Computing the F-ratio by

$$F = \frac{(u'u - v'v)/m}{v'v/(n - k)}$$

where k is the number of independent variables specified in the equation; and

4) Finally, employing the null hypothesis to test whether the m additional observations obey the same relations as the first n observations through a comparison of the calculated F-ratio and the theoretical F-ratio, with (m, n-k) degrees of freedom at a chosen level of significance.

In principle, any hypothesis can be proposed but can only be accepted if it is able to pass critical scrutiny, including the checking of suitable test implication through careful observation or experiment. Although extensive testing with entirely favourable results does not necessarily establish a hypothesis conclusively, the test provides more or less strong support for it.[126] Following the same argument, when the hypothesis of the stability of coefficients between the observation

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[126]C.G. Hempel, Philosophy of Natural Science, (Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1966), p. 14.

and the prediction periods is confirmed by the Chow's test, although it is not conclusive, it may strongly imply that the structural relationships being investigated do not change over time. It would be more defensible to use such estimated coefficients as a basis for making forecasts.

CHAPTER 4

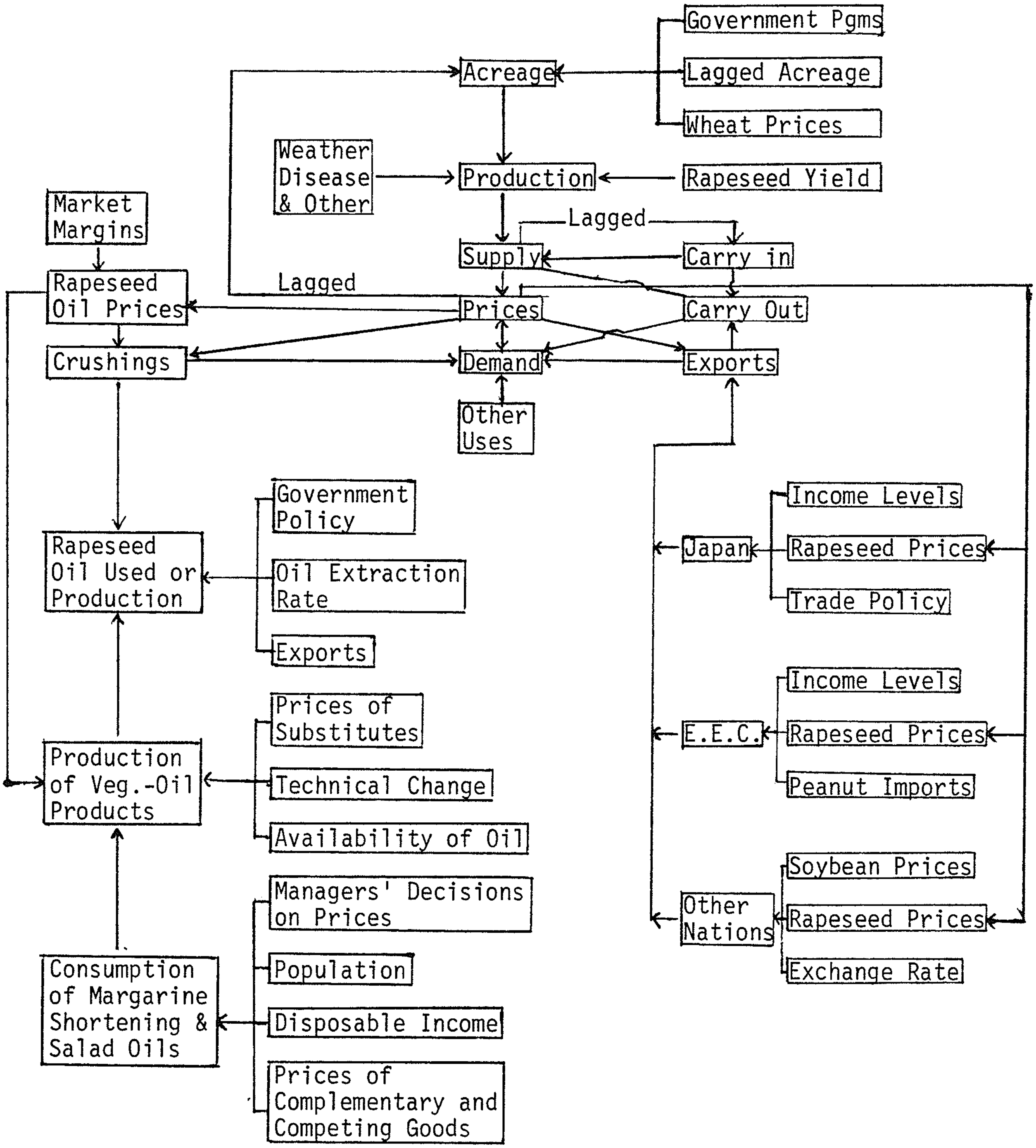
MODEL FORMULATION

A broad framework, embracing all the basic economic relationships at work in rapeseed markets, is essential for policy analysis. The annual variation in the supply of rapeseed, the multi-market outlets of the seed and processed products, the interdependence of the various segments within the industry, and the simultaneous interactions and determination of prices and quantities must be all be incorporated when developing an integrated supply and demand model. The model developed is considered to be an analytical tool and thus useful to decision makers who should thereby become more aware of the likely consequence of changes initiated at any point of the system.

In this chapter, a flow chart showing the operation of the Canadian rapeseed industry will be presented in order to indicate the logic behind the construction of the graphic model. Based on this illustration, an econometric model will subsequently be developed.

A. Graphic Model of Supply and Demand for Canadian Rapeseed and Its Oil

A self-explanatory flow chart summarizing the complex economic relationships and the direction of influence within the industry is presented as shown in Figure 4.1. However, as discussed in Chapter 1, analysis of the demand for rapeseed meal will not be undertaken in this



Arrows indicate the direction of influence

Figure 4.1: A Flow Chart Showing the Operation of the Canadian Rapeseed Industry

study; hence the rapeseed meal aspect is excluded from Figure 4.1. Nonetheless, the hope is that the flow chart will contribute to an understanding of the logic behind the model construction. Before the econometric model is constructed, a graphic model of the rapeseed industry is illustrated by a series of two-dimensional, price and quantity diagrams, based on the operation of the Canadian rapeseed industry as reviewed in Chapter 2. These can be regarded as generalized versions of both the rapeseed and oil markets at given points in time, all non-price factors being held constant.

The three sub-diagrams of Section A in Figure 4.2, although not drawn to scale, illustrate the price-quantity framework with respect to the acreage-supply response function for the three Provinces. The horizontal summation of these supply curves, together with the conversion of acreage to volume by means of an average annual yield, produces the aggregated supply curve, SS of Section B, for rapeseed at a given point in time. This curve links the farm price of rapeseed in the previous year (PS_{t-1}) to the production of rapeseed in the current year (QS_t). The current supply is completely inelastic with respect to current price (PS_t).

The horizontal summation of domestic crushings (Section C) and exports to Japan, the E.E.C. and "other nations" (Section D) form the total demand for rapeseed at the farm level (QS_t in Section B). The total demand curve, represented by DD in Section B, is of course negatively sloped. In this simplified framework, intersection of the total demand and supply curves (at time t, the supply is given as QS_t) produces the equilibrium price for rapeseed (PS_t).

<u>Abbreviation</u>

P: Price
Q: Quantity
SS: Supply of rapeseed
DD: Demand for rapeseed
S: Rapeseed
O: Rapeseed oil
MM: Marketing margin
MA: Margarine
SH: Shortening
SA: Salad oil

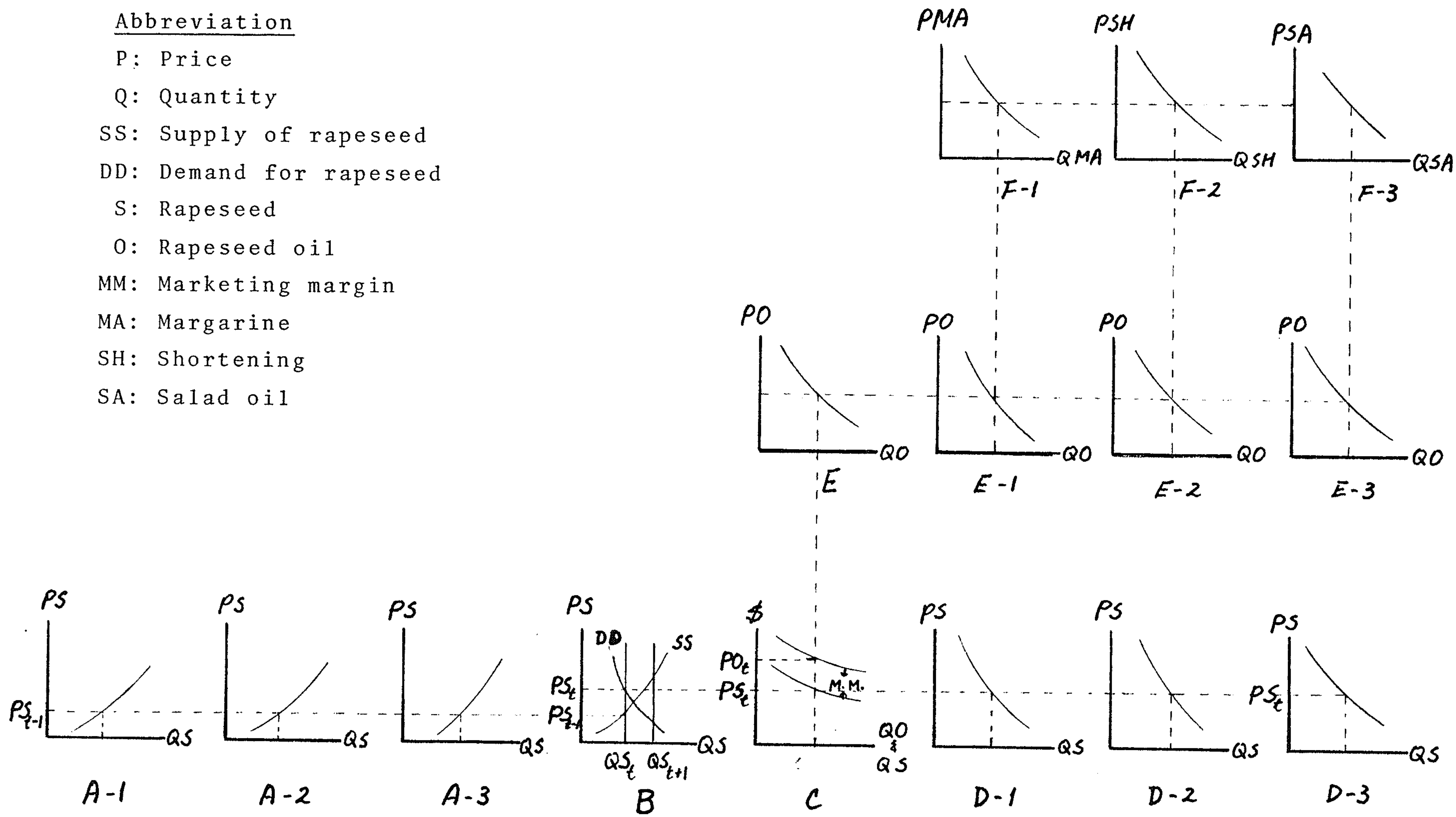


Figure 4.2

Simplified Graphic Model of the Supply and Demand Blocks Related to the Canadian Rapeseed Industry

The linkage between the price of rapeseed oil and the price of rapeseed is shown in Section C. The price differential is equal to the amount of market margin. The demand for crushings is derived from the demand for rapeseed oil. The latter, in turn, is derived from the level of domestic consumption of margarine, shortening, and salad oil. The relationship between the amount of rapeseed oil produced and the amount of rapeseed crushed is established through the vertical connection between Sections C and E. As illustrated, Section E shows that the overall demand for rapeseed oil is the summation of the oil used in manufacturing margarine, shortening, and salad oil (E-1 to E-3). The relationship between the latter and the consumption of those products is illustrated by the corresponding vertical relationships between Sections E and F.

The entire diagram shows how the whole system moves toward equilibrium prices and quantities in a simultaneous manner with all sections interacting with one another. This framework thus can be used to trace market-wide repercussions of specific changes or shifts in one or more sectors of the rapeseed industry.

B. Specification of the Aggregate Model

Following the graphic model presentation above, a fifteen-equation system reflecting the different aspects of the industry at the "disagregate" level was initially built. Ten of the fifteen relationships represented behavioural equations, with each equation indicating the basic economic relationships operating on that segment of the industry. The remaining five equations were technical or identification equations which reflected constraints on the levels of supply and demand. They also served to hold the simultaneous system together.

In view of the fact that time-series data showing prices of rapeseed and soybean oils were available only for the period 1967 through 1974 an attempt was made to extrapolate the time series data backward for the period 1960 through 1966. As might be expected with respect to the "created" data there was some question as to the level of confidence. Moreover, the collection of information by Statistics Canada on these two price series was terminated with the December 1975 publication of Oilseeds Review (Statistics Canada, No. 22-006). According to officials at Statistics Canada, this was due part to the problem of confidentiality but also to a lack of agreement between Statistics Canada and the relevant industries regarding an acceptable method for recording prices in a consistent manner.[1] As a result the "block" representing domestic ulilization of rapeseed oil could not be included in the broad supply-demand system.

It is generally true that the more equations, and thus the more variables used in a system, the more complicated and heavy become the date requirements, with a corresponding growth in computational difficulties. As a result, and as an alternative to the disaggregate model, an aggregate model of the eight-equation system can be constructed: For a researcher might be interested in knowing the operation of the industry at the "aggregate" level, depending on an aggregate export demand function for rapeseed instead of three export demand functions for the principal outlets, vis., Japan, the E.E.C., and the "other nations"; or an aggregate

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[1]A personal communication with J.M. Gray, Agriculture Division, Industry Statistics Branch, Statistics Canada. The monthly data were available only for the period of August 1967 to March 1975.

domestic consumption function for vegetable-oil products as a whole, rather than three functions for margarine, shortening, and salad oils, respectively.

For the benefit of the reader nonetheless, the specification and results of the disaggregate model will be presented in Appendix A. This section will present the aggregate model only. However, it should be stressed that this method of presentation does not imply that the disaggregate model is less important than the aggregate model. On the contrary, the former provides detailed information on the operation of each segment of the industry which is essential for policy analysis.[2] However, the aggregate model may have greater "predictive power" over the disaggregate model because variances associated with grouped regressions (aggregation over individual commodities, regions and time periods) tend to be relatively small compared with those of ungrouped regressions.[3]

In an interdependent economic model, those factors that are determined within the model are known as jointly-determined or endogenous variables. Those that are external to the model are called predetermined or exogenous variables. Some of the latter are under or subject to direct or partial control of a public, or private decision-making entity. Such varibles are called policy tools. In the following model specification, a semi-colon symbol distinguishes the two types of variables, with the endogenous variables shown before and the exogenous variables after the semi-colon.

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[2]A. Koutsoyiannis, Theory of Econometrics, (London, England, The MacMillan Press Ltd., 1973), Chapter 21.

[3]Y. Grunfeld and Z. Griliches, "Is Aggregation Necessarily Bad?", The Review of Economics and Statistics, Vol. XLII, (1960), p. 4.

Many variables were used in the preliminary analysis. Judged against the empirical results, the following model, a detailed specification of which is given below, was considered the best among the alternatives:

Behavioural Equations

Rapeseed acreage function for Canada:

4.1 $(RAC_t;\ LIFT_t,\ PW_{t-1},\ PR_{t-1},\ RAC_{t-1},\ U_{t1})$

Total exports of rapeseed from Canada:

4.2 $(TRX_t,\ PR_t;\ PUS_t,\ JEY_t,\ DUM_t,\ U_{t2})$

Domestic consumption of vegetable oil products in Canada:

4.3 $(QD_t,\ PVO_t;\ PB_t,\ EXP_t,\ QD_{t-1},\ U_{t3})$

Technical and Identification Equations

Supply of rapeseed:

4.4 $QS_t = (AYRS + DYRS_t)\ RAC_t + RSTK_{t-1}$

Market-clearing of rapeseed:

4.5 $QS_t = TRX_t + QRC_t + RSTK_t + OURS_t$

Production of rapeseed oil:

4.6 $QRO_t = (AYRO+DYRO_t)\ QRC_t$

Market-clearing of rapeseed oil:

4.7 $QRO_t = (ARATE+DRATE_t)\ QD_t + XRO_t$

Price linkage through market margin:

4.8 $PVO_t = (AMM+DMM_t)\ PR_t$

The definition of each variable is given below: The subscriptions t and t-1 refer to the current and the previous periods, respectively. They are ommitted.

The Definition of Each Variable

Endogenous variables:

RAC: Rapeseed acreage in Canada in thousand acres, TRX: Total rapeseed exports from Canada in thousand tonnes,

PR: The average farm price of rapeseed in dollars per tonne,

QD: The total domestic consumption of margarine, shortening and salad oils in thousand tonnes,

PVO: The average retail price of vegetable oil products weighted by the consumption of each product in dollars per thousand tonne,

QRC: The amount of rapeseed crushed in thousand tonnes,

QS: The amount of rapeseed supplied or demanded in thousand tonnes,

QRO: The amount of rapeseed oil produced or utilized in thousand tonnes,

LIFT: A dummy variable indicating the impact of the LIFT program on rapeseed acreage in thousand acres,

PW: The average farm price of wheat in dollars per tonne,

PUS: The price of soybeans at Chicago in Canadian dollars per tonne,

JEY: The sum of private consumption expenditures in Japan and the E.E.C. expressed in billions of Canadian dollars,

DUM: A dummy variable reflecting the impact of a change in the structure in Canada's rapeseed markets on the volume of trade in thousand tonnes,

PB: The retail price of butter in dollars per tonne,

EXP: Personal expenditures on goods and services in billions of dollars,

RSTK: Total annual rapeseed stocks on farms and in commercial storage on July 31 in thousand tonnes,

AYRS: The average yield of rapeseed during the 1960-74 period in thousand tonnes per thousand acres,

DYRS: The difference between the actual and the average yield of rapeseed in thousand tonnes per thousand acres,

OURS: The use of rapeseed other than for exports, crushings, and storage, in thousand tonnes,

AYRO: The average yield of rapeseed oil, during 1960-74, i.e., the ratio of oil production to crushings expressed in percentages,

DYRO: The difference of the actual yield and the average yield of rapeseed oil expressed in percentages,

ARATE: The average ratio of rapeseed oil utilized to the total consumption of vegetable oil products, during 1960-74 expressed in percentages, DRATE: The difference of the actual and the average ratio of domestic utilization of rapeseed oil in percentages,

AMM: The average marketing margin between the retail price of a vegetable oil product and the farm price of rapeseed during 1960-74 expressed in percentages,

DMM: The difference between the actual and the average marketing margin, in percentages and

U's: The structural disturbances.

Equation 4.4 defines the supply of rapeseed, while equation 4.5 defines the demand, and together determine the equilibrium price and quantity of rapeseed. Similarly, equations 4.6 and 4.7 define the supply and demand for rapeseed oil and jointly determine the equilibrium price and quantity of rapeseed oil. Finally, equation 4.8 links the raw rapeseed and rapeseed oil markets into an integrated market. Through this linkage, the "general" equilibrium situation between the segments of the industry is ensured.

Reduced-Form Equations

The above-specified structural relationships between equations 4.1 and 4.8 can be combined and expressed in matrix notations as

4.9 $AY_t=BX_t+U_t$

The reduced-form equations, expressing each endogenous variable as a function of all exogenous variables, are then given by

4.10 $Y_t=A^{-1}BX_t+A^{-1}U_t=CX_t+V_t$

where A: is an 8 by 8 matrix of coefficients for the endogenous variables,

Y: is an 8 by 1 vector of the endogenous variables,

B: is an 8 by 19 matrix of the coefficients for the exogenous variables, C: is an 8 by 19 matrix of the coefficients for the reduced-form equations,

X: is a 19 by 1 vector of the predetermined variables,

U: is an 8 by 1 vector of structural disturbances, and

V: is an 8 by 1 vector of reduced-form disturbances.

Matrices A and B, were estimated using OLS and IVR techniques while matrix C was derived from the A and B matrices.

C. Rationale and Data Sources

Given the economic characteristics associated with each segment of the industry, the whole rapeseed market can be categorized into three distinct but connected "blocks". This section will outline the rationale underlying the selection of each variable in each "block" equation as well as the definitions of the variables themselves, and the sources of the data.

The Rapeseed Supply Block

The supply of rapeseed available in any year is determined by the stocks available at the beginning of the year and production in the particular year. The latter, in turn, is determined by the acreage under cultivation and the yield per acre. As Figure 2.1 in Chapter 2 illustrated, there was little correlation between yield and lagged rapeseed farm prices. In addition, the yield-per-acre remained relatively stable over the past two decades. Therefore, it appears evident that changes in the level of production have been due almost exclusively to variations in the acreage seeded.

In connection with the factor of stocks, preliminary analysis has indicated that stocks of rapeseed (carryover from the preceding year) have not been significantly affected by lagged rapeseed farm prices.[4] Houck and Mann concluded that changes in soybean stocks in the U.S. were affected by both the magnitude of the stocks at the start of a year and total production during the year while soybean stocks and prices were statistically uncorrelated.[5] Their findings might also be applicable to rapeseed. The demand for rapeseed in foreign and domestic markets has been flucturating unpredicatbly. It is also difficult to segregate stocks held for speculation purposes from the regular carryover stocks. In view of the apparent difficulty in establishing causal relationships between variations in rapeseed stocks and economic factors, stocks and yield are treated as exogenous variables in this study.

Furthermore, the national acreage model alone, instead of the three provincial models, is included as part of the overall integrated model because the agricultural environment in each province on the Prairies is similar; although the individual provinces exhibit different growth rates in rapeseed acreage. Economy in the number of equations specified in this study is also desirable in view of the limited number of observations available.

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[4]The same conclusion was arrived at by W.J. Craddock, "Canadian Rapeseed Price Prediction - A Preliminary Report", unpublished report, (Winnipeg, Manitoba: Department of Agricultural Economics, University of Manitoba, 1973), p. 29.

[5]J.P. Houck and J.S. Mann, An Analysis of Domestic and Foreign Demand for U.S. Soybeans and Soybean Products; Technical Bulletin 256, (St. Paul, Minnesota: Agricultural Experiment Station, University of Minnesota, 1968), p. 19.

The most significant government program affecting the supply of rapeseed was the wheat acreage reduction program commonly known as Lower Inventory for Tommorrow (LIFT). When the grain surplus problem reached crisis proportions in Western Canada during the late 1960's, large payments were made by the Federal Government.[6] Farmers in the Prairie Provinces suffered from an acute shortage of cash, and it was in those circumstances that he LIFT program was announced by the Minister responsible for the Canadian Wheat Board. The program was used as an emergency measure to alleviate the wheat surplus problem in the crop year 1970-71. Under the program a wheat acreage reduction payment of six dollars per acre was made for any land held out of production in 1970, if the land was cultivated but not used for forage in 1969.[7] This program resulted in a reduction of wheat acreage by 50 per cent, from 24 million acres in 1969 to 12 million acres in 1970, but a doubling of rapeseed acreage from 2 to 4 million acres during the same period.[8]

By using regression analysis the impact of this government program can be quantified through setting a particular value for a dummy variable during the period when the program was in effect and assigning another value, for other periods. To ignore this impact in regression analysis invites bias in the estimates of the parameters as well as an increased

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[6]The Miniter of Agriculture (Hon. E.F. Whelan) reported that the total amount paid under the LIFT program was slightly more than 63 million dollars; See Official Report of House of Commons Debates, 1st session of 30th Parliament, March 25, 1976, p. 12140.

[7]W.J. Craddock and R.K. Sahi, "Estimating the Effect of Operation LIFT on 1970 Prairie Land Utilization", Canadian Farm Economics, (Dec. 1971).

[8]Statistics Canada, Quarterly Bulletin of Agricultural Statistics, Cat. No. 21-003.

variance.[9] It is evident that the LIFT program led to an increase in rapeseed acreage and a corresponding increase in rapeseed supply. Thus, the regression coefficient associated with LIFT can be expected to be positive.

Historically, wheat production has dominated the agricultural industry in Canada. Therefore, it is reasonable to assume that grain producers are likely to shift wheat acreage to the production of alternative crops such as rapeseed when wheat stocks are burdensome. In general, the dominant position of wheat in the Prairie Provinces has made farmers extremely vulnerable to changing market conditions. Adverse or ideal conditions in the wheat economy are quickly reflected by other sections of the agricultural industry. The extreme variability in Canadian wheat exports and production causes severe fluctuations in level of carryover from year to year. The "normal granary" concept is not an integral part of Canadian Wheat marketing policy.[10]

During the period 1960 to 1974, the annual wheat carryover averaged 549 million bushels, ranging from a low of 295 million to a high of 1,009 million bushels. Based on these data, it was assumed in this study that 650 million bushels, or about 100 million bushels above the average annual carryover, would be a critical point. If the wheat carryover exceeded this critical level, wheat acreage would be reduced, the acreage used for rapeseed production being greater than it would have been under normal

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[9] R.J. Wonnacott and T.H. Wonnacott, Econometrics, (New York: John Wiley and Sons, Inc. 1970).

[10] Federal Task Force on Agriculture, Canadian Agriculture in the Seventies, (Ottawa, Ontario: Queen's Printer, 1969), pp. 63-4.

wheat marketing conditions. Therefore, another dummy variable for measuring the impact of abnormally high wheat carryovers on acreages cultivated with rapeseed could be used in equation (4.1). It is expected these variables will be positively correlated.

Preliminary statistical analyses confirmed the hypothesis that a shift from wheat to rapeseed production occurs when stocks of wheat are greater than the maximum acceptable level. However, it is desirable to reduce the number of dummy variables used in one equation in circumstances where the available data are limited. Thus, the dummy variable representing stocks of wheat was dropped in the final analysis.

On the other hand, while one would expect overall profitability to determine the allocation of resources, the prices of competing crops can be used as an approximation of profitability, assuming that farm costs are not substantially different. Therefore, the wheat price variable was designated an independent variable in equation 4.1. To a large extent, wheat prices in Canada are subject to the demand-supply situation in world wheat markets. In turn, these prices affect domestic wheat stocks and rapeseed acreage, as explained above. In any case, prices of the particular crop being studied as well as those of competing crops, are traditionally included in a supply function provided that the problem of multicollinearity is not very serious.

According to preliminary analysis, wheat prices were considered the best indicator of the prices of those crops considered competitive with rapeseed when compared with several combinations of the weighted average price of wheat, barley, oats, and flexseed. Furthermore, during the 1960-74 period, the simple correlation coefficient between the prices of wheat and rapeseed was 0.67, implying that the problem of multicollinearity was tolerable. Therefore, both variables, i.e. average wheat and average rapeseed prices received by producers were used in the final analysis. Economic theory suggests that rapeseed acreage in the current period and its own lagged price will be positively correlated while the reverse situation will be true between rapeseed acreage and lagged wheat prices. In other words, the coefficient associated with the rapeseed price variable will be positive but the wheat price coefficient will be negative.

Most economists agree that resources used in the production of farm products do not immediately respond to current price-income stimuli because crops have a relatively long growth period. In addition, there is no guaranteed price for rapeseed in Canada. Production decisions appear to be made by farmers according to expected prices, as determined in the period immediately preceeding the planting season. However, theory does not suggest exactly which past prices should be used in the formulation of expectation prices.[11]

As reviewed in the previous chapter, Koych and Nerlove assumed that the expected price is a distributed lag function of past prices. The relationship between supply and prices was assumed to be such that the response was the highest immediately after the change in price, and then declined geometrically as the lag increased. The expected price generated from a distributed lag model, inspired by Koych and Nerlove, was simply the previous year's price when the lagged dependent variable was also used as an independent variable. Through Koych's reduction transformation procedure, one series of past prices represented the situation as if the previous year's price were the only variable adopted in the formulation of price expectations. It would be unfair to say that it was unduly naive to

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[11]B.L. Gardner, "Futures Prices in Supply Analysis", American Journal of Agricultural Economics, (Feb. 1976), p. 81.

formulate price expectations based on a single price. As a matter of fact in this study it is anticipated that relatively high rapeseed prices during the planning period would result in increasing the amount sown and subsequently the supply in the next year, and vice versa.

Due to institutional, psychological, and economic rigidities, the response of rapeseed supply to changes in the prevailing socio-economic environment cannot be accomplished instantaneously. It is generally safe to assume that farmers or merchants cannot immediately adjust the quantities of rapeseed supplied according to a given disturbance in the market. In this case, the lagged supply variable can be used to detect the existence of delayed effects on supply, and to measure the length of time required to reach a full adjustment. The Koych-Nerlove type of distributed lag model has been extensively applied in the field of agricultural economics.[12]

As discussed in Chapter 3, the magnitude of the adjustment coefficient (the difference between one and the regression coefficient of the lagged supply) will reflect the degree of habitual behavior of farmers with respect to rapeseed acreage which in turn will affect the quantity produced. For example, if the adjustment coefficient is 1, this implies that the previous decision will be repeated in the current year. On the other hand, if the coefficient is zero the implication is that the current production decision is independent of the previous decision.

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[12]For example, more than 10 articles published in the Canadian Journal of Agricultural Economics and the American Journal of Economics during the most recent 5 years, applied theories, to some extent, related to distributed lag models.

Normally, the magnitude of the coefficient will lie between these two extremes. If the hypothesis relating to the impact of the lagged effect on supply is confirmed through statistical tests, then short-run and long-run elasticities of supply, with respect to price, can be measured.

Data on the average annual prices of rapeseed and wheat received by farmers and rapeseed acreage are reported in an occasional Statistics Canada publication, namely Handbook of Agricultural Statistics, Field Crops, 1921-74 (Statistics Canada, Cat. No. 21-516). Data on wheat stocks at the end of a crop year are obtained from Quarterly Bulletin of Agricultural Statistics (Statistics Canada, Cat. No. 21-003).

The Rapeseed Exports Block

As indicated in Chapter 2, the dramatic growth in rapeseed exports during the past two decades helped to strengthen the Canadian rapeseed industry. In order to maintain its share of international oilseed markets and thus enable Canadian producers to obtain the greatest possible returns from exports, an anlaysis of the demand characteristics for Canadian rapeseed in importing countries would appear to be essential to the formulation of Canadian trade policies.

In measuring export demand functions for agricultural commodities, three types of econometric models have been developed. These are the direct, the substitution, and the market share models. Johnson summarized studies relating to the demand for agricultural products, on the basis of three doctoral dissertations presented at North Carolina State University.[13]

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[13]Paul R. Johnson, Studies in the Demand for U.S. Exports of Agricultural Commodities, Economic Research Report 15, (Raleigh, North Carolina: Department of Economics, North Carolina State University, 1971).

The direct model, as the name implies, proceeds directly towards an estimation of the demand for a commodity by an importing country. The substitution model uses the relative quantities of products exported by two major competitors to an importing market as dependent variables in the export demand function under consideration; forcusing on an estimation of the elasticity of substitution between the products supplied by the two major exporters. The market-share model was developed for use where an estimate of the elasticity of market-share with respect to price was of interest. Capel and Rigaux applied these three methods when analyzing the export demand for Canadian wheat.[14]

The suitability of application of any of the methods depends not only on the preference of the researcher but also on the structure of the particular markets. If the share of world market taken by Canadian rapeseed was large enough to influence the price level prevailing in the international oilseed market, application of the substitution and market-share models would be appropriate. This would be so because the impact of the reactions of rivals to a change in price initiated by Canada on the quantity of rapeseed exports could be explicitly measured. Subsequently, the price policy most advantageous to Canada could be formulated. However, as discussed earlier, Canada is a "price taker" in the international oilseed market. Therefore, the direct model approach seems to be the method that should be applied in this study.

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[14]R.E. Capel and L.R. Rigaux, "Analysis of Export Demand for Canadian Wheat", Canadian Journal of Agricultural Economics, (July 1974), pp. 1-14.

As indicated earlier, in light of the various important factors affecting different importing countries detailed specification of the demand functions for rapeseed exports from Canada to Japan, the E.E.C., and "other nations", will be presented in Appendix A. Here equation 4.2 specifies the aggregate demand function for rapeseed exports. In formulating the export demand function, some indeterminate factors such as the trade policies of importers and the potential reaction of oilseed exporters to price competition were excluded from the model although they might have significant influences on the volume of trade. However, the model included all factors which could be quantitatively assessed in the preliminary analysis. The rationale for each variable used in the model is briefly outlined below.

Income and price levels are the major factors affecting domestic, as well as foreign demand, for agricultural products.[15] Theoretically speaking, the rapeseed price to importers is the best price series to use in export demand functions. However, apart from the E.E.C. and Japan; it is anticipated that it would be very difficult to collect data on prices paid by the large number of importers because of limited accessibility to data as well as the difficulty of conversion of various prices in terms of the many importer's currency into an unique set of comparable prices.

However, prices as the goods leave Canada's ports might be used as an approximation of the prices paid by importers. This price series can be derived by dividing the value of rapeseed exports by the volume of exports. If this price series were used in an aggregate model, an

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[15]M.J. Brennan, Theory of Economic Statics, (3rd ed.), (Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1965), Chapter 27.

additional equation indicating the difference between prices paid by exporters and prices received by farmers would be required in order to ensure that spatial and temporal equilibrium conditions held. In view of the major problem of data shortage experiment in this study, this alternative could not be used either.

As an alternative, the Canadian farm price of rapeseed was chosen as the most available approximation of the price to importers. The main reason behind this treatment was that the unit costs of moving rapeseed from farms to ports were relatively small and stable over time compared to the relevant unit value of rapeseed.[16] Thus, farm prices of rapeseed would reflect export demand. It was thus expected that rapeseed prices and the volume of trade will be negatively correlated.

As reviewed in Chapter 2, Japan and the E.E.C. are the major markets for both U.S. soybeans and Canadian rapeseed. Therefore, U.S. soybeans have been the major competitor for Canadian rapeseed and have naturally been selected to represent the prices of competing goods in international oilseed markets. In order to take account of the impact of exchange rates on trade, U.S. prices were expressed in Canadian dollars. It is recognized that prices of soybean oils and associated end-products have a major influence on the prices of soybeans and influence rapeseed prices accordingly. Therefore, given the high correlation between the prices of soybean end-products and soybeans, and given that we are interested in measuring the elasticity of demand for Canadian rapeseed in international markets, the actual price of soybeans, rather than soybean oil or end-products appeared most appropriate to be used in Equation 4.2.

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[16] There was also the anticipated difficulty in data collection of transport costs. A similar treatment was advanced by Capel and Rigaux, op. cit., p. 2.

Since the physical characteristics of soybean and rapeseed oil are quite similar from an oilseed importer's standpoint, soybeans and rapeseed are close substitutes. Consequently, it can be expected that the regression coefficient associated with U.S. soybean prices will be positive.

Information on private consumption expenditures in Japan and the E.E.C. (JEY) was used to approximate personal disposal income of the importing countries. These two markets have imported more than 85 per cent of the rapeseed exported from Canada annually. Private consumption expenditures for the E.E.C. was computed using the quantity of rapeseed imported from Canada by individual member countries to weight the aggregate. The PCE series was expressed in Canadian dollars with the aid of the pertinent exchange rates between Canadian funds and the currencies of rapeseed-importing countries.

It has been generally believed that processed rapeseed products as well as rapeseed itself are necessary commodities.[17] However, confirmation of this hypothesis cannot be made without certain statistical evidence: If the regression coefficient of JEY is positive and its value lies between 0 and 1, the above hypothesis will be confirmed.

After 1970, partly as a result of expanded production in Canada, rapeseed exports increased substantially. A dummy variable was therefore used in equation 4.2 to determine the impact of changes in the rapeseed

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[17] L.F. Herrmann, et al., World Demand Prospects for Agricultural Exports, Foreign Agricultural Economic Report 60, (Washington, D.C.: EconomicResearch Service, U.S. Department of Agriculture, 1970).

market structure in Canada on the volume of rapeseed exports from Canada. The value of the dummy variable was set equal to 1 for the period after 1970 and 0, otherwise. If there was a substantial impact, as above discussed, positive coefficient for the dummy variable could be expected.

In preliminary study, population in the importing countries was used as a variable in equation 4.2. Later, this variable was dropped due to the problem of multicollinearity between population and income. Domestic production of oilseeds in the importing countries was also excluded as a variable as preliminary results indicated that its effect was negligible or insignificant when compared with the total imports of oilseeds and oilseed oils.

Information on rapeseed exports from Canada was obtained from data recorded in Exports by Commodities (Stat. Can. Cat. No. 65-004); Canadian farm prices of rapeseed were reported in the Handbook of Agricultural Statistics, Field Crops, 1921-74 (Stat. Can. Cat. No. 21-516; U.S. farm soybean prices (No. 1 Yellow, Chicago) were obtained from the U.S. Department of Agriculture publication, Fats and Oils Situation; Information on international private consumption expenditures and exchange rates were from International Financial Statistics published by the International Monetary Fund. In preliminary analysis, information on production and oilseeds trade in oilseed-importing countries was computed from data recorded in Production Yearbooks and Trade Yearbooks published by the Food and Agriculture Organization of the United Nations.

The Consumption-of-Vegetable-Oil-Products Block

Demand theory is based in large measure on the premise that the individual consumer, when confronted with a set of commodities and limited income, chooses among the available alternatives so as to maximize his satisfaction.[18] Put succintly, this means that income and price variables are key determinants of demand. In addition, habitual purchasing behaviour has important implications for general consumer decision-making and as reviewed in Chapter 3, a distributed lag model provides the framework for estimating the impact of such behaviour on current purchasing decisions.[19] Since it is assumed here that purchases of fats and oils are to some degree habitual, a variable representing the quantity of vegetable-oil products consumed in the previous period was, in addition to income and price variables, also introduced into the demand function.

In equation 4.3, the annual total consumption of vegetable-oil products was used as the dependent variable, which was estimated from the product of total Canadian population and per capita consumption of margarine, shortening, and salad oils. Data on the latter are reported in Apparent Per Capita Domestic Disappearance of Food in Canada (Stat. Can., Cat. No. 32-226). Population data are those reported in Estimated Population of Canada by Province (Stat. Can., Cat. No. 91-201).

The time series for prices of vegetable-oil products was the calculated average price of margarine, shortening, and salad oils, weighted by the amount of consumption of each product. Consumer prices and price indexes of food products were reported in Prices and Price Indexes, monthly, (Stat. Can. Cat. No. 62-002). The price-quantity

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[18]C.E. Ferguson, Microeconomic Theory, (2nd ed.), (Homewood, Illinois: R.D. Irwin, Inc., 1969).

[19]J.A. Bayton, "Motivation, Cognition, Learning--Basic Factors in Consumer Behavior", Journal of Marketing, (Jan., 1958), p. 287.

relationship was expected to be negatively correlated.

In general, a commodity may have complementary and/or competing commodities. It is commonly accepted that the quantity of a commodity consumed is inversely correlated with its own price and the prices of complementary commodities. On the other hand, a positive relationship is expected between the quantity of a commodity demanded and the price of competitive commodities. Al-Zand and Hassan have found that margarine is competitive with butter, and shortening with lard.[20] Their findings suggest that animal fats and vegetable-oil products are competitive goods. In view of the fact that the volume of butter consumed is far greater than that of lard and, as well, that the publication continuing prices for lard was terminated in 1975, the price of butter was selected as the indicator of prices of commodities competing with vegetable-oil products in equation 4.3. It was anticipated that the sign of the relevant coefficient would be positive.

According to the Canadian System of National Accounts, personal disposable income can be classified into personal savings and personal expenditure on consumer goods and services. Since the former has little direct impact on the consumption of food, the latter was used as an approximation of consumers' income. Data on personal expenditures on consumer goods and services were reported in National Income and Expenditure Accounts, quarterly, (Stat. Can., Cat., 13-001).

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[20] O.A. Al-Zand and Z.A. Hassan, "The Demand for Fats and Oils in Canada", Canadian Journal of Agricultural Economics, Vol. 25, (July 1977), pp. 14-25.

Generally, a commodity is classified as a "luxury" if the demand elasticity with respect to income exceeds positive one; a commodity is "inferior" if the income elsticity is negative. Between these two extremes, a commodity is defined as a "necessity".[21] George and King, and Brandow independently concluded that margarine, shortening, and salad oils in the United States were "necessary" commodities.[22] If the demand characteristics of vegetable-oil products in Canada were the same as those in the U.S., the regression coefficient associated with income would be positive and smaller than one.

Based on the estimation of the above specified behavioural equations 4.1 to 4.3 coupled with the economic relationships determined in the identity and technical equations 4.4 through 4.8, a set of reduced-form equations as illustrated in equation 4.10 can be derived. The task of the estimation of the structural coefficient and the derivation of the reduced-form coefficient will be carried out in the next chapter.

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[21]L. Auer, "Urban Consumer Incomes and Food Expenditures", (A paper presented at the Canadian Economics Association Meetings, June, 1971, Winnipeg, Manitoba).

[22]P.S. George and G.A. King, Consumer Demand for Food Commodities in the United States with Projections for 1980, Giannini Foundation Monograph 26, (Giannini Foundation of Agricultural Economics, University of California, Davis, 1971);

G.E. Brandow, Interrelations Among Demands for Farm Products and Implications for Control of Market Supply, Bulletin 680, Agricultural Experiment Station, (University Park, Pennsylvania: College of Agriculture, The Pennsylvania State University, 1961).

CHAPTER 5

RESULTS AND IMPLICATIONS

This chapter will detail the design and testing of the model and evaluate the results and their implications. It will, for example, estimate structural coefficients for the Canadian rapeseed acreage function, the export demand function for Canadian rapeseed, and the domestic consumption function for vegetable-oil products; examine the stability of the regression coefficients by testing for equality between the coefficients obtained from the 1960-74 and 1960-75 data using the Chow-test; derive reduced-form coefficients from the given structural coefficients; evaluate performance of the reduced-form equations, in terms of the magnitude of the coefficient of determination associated with each and the forecasting errors within and outside the analytical periods. Finally there will be an interpretation of the results and their implications, as well as a forecast of the values of the endogenous variables specified in the aggregate model for the period from 1976 through 1980.

In preliminary analysis, the methods of ordinary least squares and instrumental variable regression were applied to the 1960-74 and 1960-75 data respectively, in order to estimate the structural coefficients of behavioral equations specified in the previous chapter. A combination of two estimation methods and two data sets produced four different sets of structural coefficients and their corresponding reduced-form coefficients. From those results, one set was chosen according to the criteria commonly applied to evaluate a regression equation and the predictive ability of a system of equations as discussed in detail in chapter 3. It was found that the reduced-form equations derived from the structural coefficients which, in turn, were estimated by the application of IVR to the 1960-75 data exhibited the best performance among the alternatives. Since description of the different results would be similar, in the interest of brevity, only the "best" set of results will be presented in this chapter.

A. Structural Coefficients

The Canadian Rapeseed Acreage Function

Table 5.1 summarized various measures of the components of the function explaining variations in Canadian rapeseed acreage. The structural coefficients were directly estimated applying OLS to the 1960-75 data, while the corresponding long-run coefficients were derived by dividing the short-run coefficients by the coefficient of adjustment. Since all explanatory variables of the function were predetermined, the OLS estimates were expected to be consistent. As well, the short-run elasticity of rapeseed acreage with respect to one of the independent variables, for example, lagged wheat prices at the centroid (the 1960-75 average) was the product of the coefficient of the lagged wheat price and the ratio of the average lagged wheat price to the average current rapeseed acreage during 1960-75. The long-run elasticities were derived by dividing the corresponding short-run elasticities by the coefficient of adjustment.

Similarly, the short-run elasticity of rapeseed acreage with respect to lagged wheat prices during recent years was the product of the short-run coefficient of the lagged wheat price and the ratio of the average lagged wheat price to the average current rapeseed acreage over the 1973-75 period. The latter was chosen because the LIFT program resulted in higher rapeseed acreage both in 1970 and 1971 and a higher rapeseed carry-over in 1972 than would otherwise have been the case.

Table 5.1

Measures of the Components of the Function Explaining Variations in Canadian Rapeseed Acreage, Using the OLS Technique, 1960-75

Variables and (Units)	Regression Coefficient		Elasticity at the Centroid		Elasticity Over 1973-75	
	Short-Run (t-values)	Long-Run	Short-Run	Long-Run	Short-Run	Long-Run
Rapeseed Acreage (thousand acres)	Dependent Variable					
Constant (thousand acres)	-187.67 (-0.76)	-491.28				
LIFT Program (thousand acres)	2441.32 (6.61)***	6390.89				
Lagged Wheat Prices (dollars per tonne)	-17.432 (-1.87)**	-45.633	-0.575	-1.504	-0.629	-1.647
Lagged Rapeseed Prices (dollars per tonne)	17.169 (3.38)***	44.495	0.976	2.556	1.125	2.944
Lagged Acreage (thousand acres)	0.6176 (8.34)***					

Adjustment Coefficient = 0.3824
Corrected Coefficient of Determination = 0.941 (F-ratio = 60.58***)
Durbin-Watson d-statistic = 3.071@

Asteriskes denote that the relevant t-value or F-ratio is significant at the following probability levels: * 25 per cent; ** 5 per cent; and *** 1 per cent.

@ denotes that the hypothesis of no autocorrelation is accepted at the 1 per cent probability level. However, it should be noted that when the lagged dependent variable is used as a regressor and the sample size is small (less than 30), neither the d-statistic nor h-statistic is an appropriate statistic for use in testing for the existence of autocorrelation.

The 1973-75 average might be expected to better reflect the "normal" situation prevailing in recent years.

The Durbin-Watson d-statistic indicated that the hypothesis of no auto-correlation was accepted with confidence at the 99 per cent probability level.[1] The "corrected coefficient of determination", a modified coefficient of determination which takes into account the number of explanatory variables in relation to the number of observations,[2] disclosed that about 94 per cent of the fluctuation in Canadian rapeseed acreage can be explained by the specified independent variables. These variables are government programs, the prices of wheat and rapeseed in the previous year, as well as the lagged rapeseed acreage.

In preliminary analysis, a dummy variable was used to reflect the shift from wheat to rapeseed production when the stock of wheat was greater than the average carry-over for the 1960-75 period by more than two standard deviations. Although the above hypothesis was confirmed by the t-test, this variable was dropped in the final analysis in order to reduce the number of dummy variables used in one equation. It was also found that the carry-over of rapeseed from one year had a negative effect on the acreage seeded the next year. Due to multicollinearity between the latter and the variable for lagged rapeseed acreage, the variable representing rapeseed carry-over was dropped.

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[1]It should be noted that when the lagged dependent variable is used as a regressor and the sample size is small (less than 30), neither the d-statistic nor h-statistic (a modified d-statistic) is an appropriate measurement for use in testing for the existence of auto-correlation.

[2]See J. Kmenta, Elements of Econometrics, (New York: Macmillan Publishing Co., Inc., 1971), pp. 364-6.

The coefficients of most of the explanatory variables were substantially different from zero and hence highly significant. All of the postulated hypotheses regarding the signs of the variables were confirmed by statistical evidence.

The LIFT program announced in 1970 caused an increase in rapeseed acreage in Canada of about 2.4 million acres in the 1970/71 crop year. Since the forage provision of the wheat reduction program was still applicable in 1971/72, it is estimated that LIFT resulted in an increase of approximately 1.2 million acres above the normal situation in that year.

Traditionally, wheat has been the most important field crop, in terms of acreage, on the Prairies. Therefore, wheat prices were chosen to represent the prices of crops competing with rapeseed. As expected, the results revealed that current rapeseed acreage and previous wheat prices were negatively correlated. An increase in the price of wheat of one dollar per tonne would result in a decrease of about 17 thousand acres of rapeseed acreage in the short-run (one year), and, of about 46 thousand acres in the long-run (about 6 years).[3] The corresponding short-run and long-run elasticities of rapeseed acreage with respect to changes in wheat prices were -0.575 and -1.504, respectively, these findings confirmed the hypothesis that wheat and rapeseed compete for land.

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[3]As discussed in Chapter 3, the speed of adjustment to a new equilibrium depends on the magnitude of the adjustment coefficient. In this case, about 6.2 years would be required to complete about 95 per cent of the total potential adjustment in acreage caused by changes in prices.

Uhm recently formulated statistical models, with respect to rapeseed acreage, for each Prairie province, as well as for Canada as a whole.[4] His estimates regarding short-run and long-run elasticities of rapeseed acreage in Canada with respect to changes in wheat prices were -1.141 and -2.454, respectively. While his findings are in the same direction as those reached in this study, the adjustment response appears to be definitely biased upwards. An examination of his aggregate model shows that he included both wheat prices and wheat stocks which, as explained below, amount in effect to double counting. According to his estimates, the short-run and long-run elasticities of rapeseed acreage with respect to wheat stocks were 0.401 and 0.862. Since prices and carry-over of a commodity are generally negatively correlated, the impact of the wheat carry-over should be viewed as a partial impact of wheat prices on rapeseed acreage. Elimination from the model of wheat carry-over or the combined effect of changes in wheat prices and wheat carry-over on rapeseed acreage can be expected to produce results quite similar to the findings of this study.

The short-run coefficient ralating to lagged rapeseed prices indicated that a change in rapeseed prices of one dollar per tonne would result in a change in rapeseed acreage in Canada in the following year of about 17 thousand acres. The corresponding long-run coefficient was about 45 thousand acres.

The estimated short-run and long-run supply elasticities of rapeseed with respect to the previous price of rapeseed were 0.976 and

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[4] I.H. Uhm, <u>A Supply Response Model of Canadian Rapeseed and Soybeans</u>, Economics Branch Publication 75/15 (Ottawa, Ontario: Economics Branch, Agriculture Canada, 1975).

2.556, respectively. These figures implied that a one per cent change in the lagged rapeseed price would result in a change in acreage, in the same direction and about the same proportion in the short-run, and approximately 2.6 per cent in the long-run. In the long-run, as prices of rapeseed rose, farmers would produce more rapeseed provided that they had sufficient time to adjust and were willing to reallocate the resources available to them.[5]

The lagged regression coefficient was 0.618, meaning that a change in acreage of 1,000 acres in the previous year would, other things being equal, result in a change of 618 acres seeded in the same direction in the current year. Here, too, the above estimated coefficient was used to calculate the coefficient of adjustment, defined as the difference between one and the coefficient of the lagged dependent variable. Obviously then, the coefficient of adjustment was 0.382. According to the partial-adjustment type of distributed lag model, this implied that about 38 per cent of the desired amount of adjustment could be made during any one year. The delay in adjustment is usually attributable to such things as technological and biological constraints, institutional rigidities and ingrained habits that are slow to change.

Table 5.1 also indicated that elasticities of rapeseed acreage with respect to lagged wheat prices and lagged rapeseed prices both became more elastic in recent years compared to those at the centroid. For example, the short-run direct-price and cross-price elasticities of rapeseed acreage were 1.13 and -0.63 respectively for

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[5] A. Subotnik, "Short and Long Run Elasticities in Consumer Demand Theory", American Journal of Agricultural Economics, (Aug. 1974), p. 553.

the 1973-75 period, and were 0.98 and -0.58 at the centroid. This indicated that the ratio of lagged rapeseed prices to rapeseed acreage, as well as that of lagged wheat prices to the latter had become greater in recent years; although the ratio of those two prices has been relatively stable over time. In other words, rapeseed producers in the process of determining rapeseed acreage have become relatively more sensitive to changes in the prices of wheat and rapeseed than in non-economic factors in recent years.

The Canadian Rapeseed Export Function

This function included as an independent variable, the price of rapeseed which is one of the endogenous variables specified in the aggregate model. As discussed in the chapter on theory when some of the endogenous variables were used as independent variables, the OLS estimates would likely be inconsistent. In order to eliminate or reduce the severity of this problem the 2SLS technique has been recommended. Unfortunately, for models of even moderate size, the number of predetermined variables in each reduced form equation is very large, so that the 2SLS method is almost never employed in practice.[6] Consequently, the instrumental variables regression (IVR) technique, was used in this study.

In preliminary analysis, several combinations of the predetermined variables specified in the system were tried in order to estimate the price of rapeseed. Then, the latter was used to replace

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[6] J.M. Brundy and D.W. Jorgenson, "Efficient Estimation of Simultaneous Equations by Instrumental Variables", The Review of Economics and Statistics, (August 1971), pp. 207-24.

actual rapeseed prices in the export demand function. Judging by the smallest estimation errors associated with the export demand function, a set of estimated rapeseed prices was chosen by regressing the actual rapeseed prices on a set of chosen instrumental variables. The results indicated that use of a greater number of predetermined variables in the first stage does not necessarily produce better results in the second stage regression. In this study, seven variables judged important were selected as instrumental variables. These were the lagged consumption of vegetable-oil products, lagged rapeseed acreage, lagged rapeseed prices, the prices of butter, U.S. soybean prices, personal expenditure on goods and services in Canada, and the constant term.

Two sets of regression coefficients obtained by the application of OLS and IVR methods to the 1960-75 data had similar signs for corresponding coefficients, but were different in magnitude. This was particularly so with respect to the coefficients associated with the price of rapeseed and the price of U.S. soybeans. The difference between these two sets of estimates was attributable to the difference between the actual and estimated price of rapeseed where the latter was estimated from the selected instrumental variables. The coefficient of the U.S. soybean price obtained by IVR was significantly different from zero, while the OLS coefficient was insignificant. This meant that the estimation technique of IVR was more efficient than OLS. As will be discussed later, the set of IVR estimates will be used as the forecasting base. Thus, the OLS results will not be discussed but will be presented in Appendix B for the interested reader.

Table 5.2 presented various IVR estimates explaining fluctuations in rapeseed exports from Canada during the period from

Table 5.2

Measures of the Components of the Function Explaining Variations in Canadian Rapeseed Exports, Using the IVR Technique, 1960-75

Variables (Units)	Regression Coefficient (t-values)	Elasticity at the Centroid	Elasticity Over 1973-75
Rapeseed Exports (thousand tonnes)	Dependent Variable		
Constant (thousand tonnes)	471.24 (0.07)		
Rapeseed Prices (dollars per tonne)	-2.596 (-2.13)*	-0.715	-0.819
U.S. Soybean Prices (dollars per tonne)	2.631 (1.72)*	0.758	0.688
Importers' Expenditures (billion dollars)	2.040 (3.09)***	0.692	0.878
Changes in Rapeseed Market Structure (thousand tonnes)	472.66 (5.94)***		

Durbin-Watson d-statistic = 2.684@

Footnotes see Table 5.1

The usual interpretation of the coefficient of determination for the Two-Stage Least Squares and the Generalized Least Squares estimations would be misleading. Therefore, R^2 is not reported.

1960 to 1975. The results indicated that the signs of all explanatory variables agreed with theoretical expectation, and that all explanatory coefficients were statistically different from zero according to the two-tailed t-test.

The results disclosed that an increase of the rapeseed price of one dollar per tonne could decrease the amount of rapeseed exports by about 2.6 thousand tonnes, while an increase in U.S. soybean prices of one dollar per tonne could increase Canadian rapeseed exports by a similar quantity. The computed direct-price and cross-price elasticities of rapeseed exports were -0.72 and 0.76 respectively at the centroid; and -0.82 and 0.69 respectively over the 1973-75 period. This implied that, in the sixties, rapeseed importers were more sensitive to changes in soybean prices than to changes in the price of rapeseed itself. However, the inverse situation has been true in recent years. Since the elasticity of export demand for rapeseed with respect to its own price has been relatively inelastic, price competition would not be the most effective method of promoting rapeseed exports. However, if recent trends, indicating a greater responsiveness in export markets to price changes continue, there might be greater opportunity for promoting overseas sales since rapeseed prices generally compare favourably with other oilseed prices.

The coefficient associated with the level of personal incomes in rapeseed importing countries indicated that an increase of about 2 thousand tonnes of rapeseed exports from Canada resulted from an increase of one billion dollars of personal expenditures in Japan and the E.E.C. The elasticity of rapeseed exports with respect to the income level of rapeseed importing countries was 0.69 at the centroid and 0.88

over the 1973-75 period. Accordingly, rapeseed could be classified as a "necessary" commodity in oilseed importing countries because the income elasticity was less than unity.

The coefficient of the "dummy variable" representing changes in market structures of the Canadian rapeseed industry disclosed that the wheat surplus crisis and the corresponding rapid expansion of rapeseed production in the early 1970's caused rapeseed exports from Canada to exceed "normal exports" by about 414 thousand tonnes. This finding could be useful in explaining why annual rapeseed exports exceeded one million tonnes in the early 1970's, while averaging only 219 thousand tonnes in the 1960's.

The Durbin-Watson d-statistic implied that the hypothesis of no auto-correlation was accepted. The coefficient of determination for two-stage least squares and the generalized least squares lies in a range between negative infinity and one rather than between 0 and 1. The usual interpretation of R^2 for 2SLS and GLS estimations would therefore be misleading.[7] Accordingly, R^2 is not reported. However, according to the OLS estimates the magnitude of the corrected coefficient of determination indicated that about 92 per cent of the variations in rapeseed exports could be explained by the above discussed variables. As noted earlier in Chapter 4, other variables such as the production of oilseeds in oilseed importing countries, tariffs, transportation costs, and weather conditions also influenced the amount of Canadian rapeseed exports. However, those variables were not included in the final analysis because they either did not meet the evaluative

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[7] See W.G. Tomek, "R^2 in TSLA and GLS Estimation", American Journal of Agricultural Economics, (Nov. 1973), p. 670.

tests in preliminary analysis or else data were not available.

The Domestic Consumption Function for Vegetable-Oil Products

Since the average price of vegetable-oil products, an endogenous variable of the system, was used as an independent variable of the consumption function under review, an attempt was made at reducing the "simultaneous bias". As treated in the preceding section, a set of seven predetermined variables was used as instrumental variables to generate the time series of estimated prices of vegetable-oil products in the first stage of the IVR. The results obtained from the IVR were similar to those obtained from the OLS but the former were more "efficient" because the estimation errors from the IVR were smaller. Consequently, the coefficients associated with the average price of vegetable-oil products and personal expenditures on goods and services became statistically significant at the 20 per cent probability level. Although the coefficients obtained from OLS were statistically indifferent from zero, the relevant results will be presented in Appendix B.

Table 5.3 summarized various IVR component measures of the function explaining variations in domestic consumption of vegetable-oil products consisting of margarine, shortening and salad oils. The results indicated that an increase in the weighted average price of vegetable-oil products of one dollar per tonne would result in a decrease in the consumption of vegetable-oil products by about 81 tonnes in the short-run (one year) and by about 197 tonnes in the long-run (about 6 years). On the other hand, an increase in the price of butter by one dollar per tonne could lead to an increase in the consumption of vegetable-oil products by about 28 and 67 tonnes respectively in the short and long run.

The short-run elasticities of demand for vegetable oils with respect to changes in the price of vegetable-oil products and the price

Table 5.3

Measures of the Components of the Function Explaining Variations in Canadian Consumption of Vagetable-Oil Products, Using the IVR Technique, 1960-75

Variables and (Units)	Regression Coefficient		Elasticity at the Centroid		Elasticity Over 1973-75	
	Short-Run (t-value)	Long-Run	Short-Run	Long-Run	Short-Run	Long-Run
Total Consumption (thousand tonnes)	Dependent Variable					
Constant (thousand tonnes)	61.871 (1.22)*	149.623				
Price of Veg.-Oil Products (dollars per tonne)	-0.0813 (-1.77)*	0.1966	-0.279	-0.675	-0.299	0.725
Price of Butter (dollars per tonne)	0.0276 (0.77)	0.0667	0.166	0.402	0.155	0.375
Personal Expenditures (million dollars)	1.8064 (1.86)*	4.3685	0.324	0.782	0.419	1.014
Lagged Consumption (thousand tonnes)	0.5865 (2.72)**					

Adjustment Coefficient = 0.4135
Durbin-Watson d-statistic = 1.815@@

Footnotes see Tables 5.1 and 5.2

@@ The d-statistic indicated that the test of autocorrelation was inconclusive.

of butter were -0.279 and 0.166 respectively at the centroid, and -0.299 and 0.155 respectively over the 1973-75 period. This means that domestic consumers were more sensitive to changes in prices of vegetable-oil products than to changes in the prices of their substitutes. As well, the influence of prices of vegetable-oil products on the quantity of vegetable-oil products consumed has become relatively more important in recent years compared with the former influence of the price of butter. The long-run elasticities also had similar implications.

The short-run and long-run coefficients of personal expenditures on goods and services were 1.806 and 4.369, respectively. This meant that an increase in personal expenditures of one million dollars in Canada would result in an increase in consumption of vegetable-oil products by 1.8 thousand tonnes in the short-run and 4.4 thousand tonnes in the long-run. The corresponding short-run and long-run elasticities of demand for vegetable-oil products with respect to changes in incomes were 0.324 and 0.782 respectively at the centroid, and 0.419 and 1.014 respectively over the 1973-75 period. This meant that consumer responsivenesses had become more sensitive with respect to changes in their incomes in recent years as indicated by the increase in the magnitude of the income elasticity.

Also, the above results confirmed the hypothesis that vegetable-oil products in Canada are "necessary" commodities. However, as regards the long-run elasticity of demand with respect to income over the 1973-75 period, vegetable-oil products should be classified as "luxury" rather than "necessary" commodities because the income elasticity was greater than unity. However, it should be noted that excluding population as an independent variable in the domestic demand function, due to the problem of multi-collinearity, could result in the estimated income elasticity being biased upwards. It might thus be more appropriate to interpret the high income elasticity as the combined effects of both the growth in income levels and population than to classify vegetable-oil products as "luxury" commodities. One thing is certain and that is the income level is one of the more important factors affecting the amount of vegetable-oil products consumed.

The coefficient for the lagged consumption of vegetable-oil products was 0.586 implying that consumers' behaviour was habitual: It meant that consumers' decisions about current consumption are, to a fairly large extent, affected by their consumption during the previous year. Based on the magnitude of the coefficient of lagged consumption, the coefficient of adjustment was determined to be 0.414. This suggested that when an equilibrium condition was disturbed by a change in any one of the independent variables, about 42 per cent of the total adjustment required to reach a new equilibrium consumption level was accomplished in the short-run (one year), and a new equilibrium (about 95 per cent of the total adjustment required) could be accomplished in about six years.

The corrected coefficient of determination obtained from OLS was 0.954 implying that about 95 per cent of the variation in the annual consumption of vegetable-oil products could be explained by the above specified variables. The Durbin-Watson d-statistic was 2.09 indicating that auto-correlation was not a problem.

Stability of the Structural Coefficients

In order to test the stability of the structural coefficients and the validity of the model under conditions of continuous updating the Chow-test was applied to the coefficients obtained from the 1960-74 and 1960-75 data for the three behaviorial equations. The results, as given in Table 5.4, disclosed that all computed F-ratios were smaller than their corresponding theoretical F-ratios at the 5 per cent level of significance and for the given degrees of freedom. Therefore, it might be concluded that any pair of the coefficients estimated from the different sample periods would, in a statistical sense, be equal. Differences would be attributable to random variations. The implication here is that the economic relationships specified in the behavioral equations were stable over the two sample periods. The affirmative results regarding their stability also confirmed, in a very loose sense, the validity of using estimated economic relationships for forecasting purposes.

In theory, it would be equally valid to use either set of the regression results from the 1960-74 or 1960-75 period for purposes of deriving reduced-form coefficients and for forecasting. However, use of the former would enable a researcher to evaluate the reliability of the model's performance by examining its ability to accurately forecast values of the endogenous variables outside the analytical period. In this connection preliminary results indicated that the ability of the reduced-form equations derived from the 1960-74 data to predict 1975 values of the endogenous variables was satisfactory. However, the predictive performance of the reduced-form equations derived from the 1960-75 data was somewhat better than that for the 1960-74 results. For the sake of simplicity, only the results obtained from the 1960-75 data will be discussed in subsequent section.

Identification Equations

As specified in Chapter 4, the average rapeseed yield per acre

Table 5.4

Results from Different Sample Sizes Used to Test the Stability of Regression Coefficients

Functions and Estimation Methods	Sum of Squared Errors (SSE) from 1960-74 Data	SSE from 1960-75 Data	Computed F-ratio[a]	Theoretical F-ratio[b]
Canadian Rapeseed Acreage Estimated by OLS	1,530,946	1,562,041	4.92	242 (10,1)
Canadian Rapeseed Exports Estimated by OLS	944,226	1,319,494	2.52	242 (10,1)
Canadian Rapeseed Exports Estimated by IVR	84,062	104,306	2.41	4.96 (1,10)
Consumption of Veg.-Oil Products Estimated by OLS	212,330	222,530	2.08	242 (10,1)
Consumption of Veg.-Oil Products Estimated by IVR	182,846	184,211	13.40	242 (10,1)

a
$$F = \frac{SSE(1960\text{-}75) - SSE(1970\text{-}74)}{SEE(1960\text{-}74) / (n - k)}$$

where n = 15 (the number of observations) and k = 5 (the number of independent variables, including the constant term)

b The numbers within parentheses are degrees of freedom for the numerators and denominators. When the value of the computed F-ratio is smaller than one, the inverse of the computed F-ratio is taken; and the theoretical F-ratio is determined according to the inverse order of the degrees of freedom for the numerator and denominator.
See T. Yamana, Statistics; An Introductory Analysis, (2nd ed.) (New York: Haper and Row, Publishers, 1967), Chapter 21.

(AYRS) was treated as the coefficient of rapeseed acreage in the rapeseed supply function (equation 4.4); the average yield of rapeseed oil in terms of the ratio of rapeseed oil production to rapeseed crushings (AYRO) was treated as the coefficient of rapeseed crushings in the production function for rapeseed oil (equation 4.6); the average ratio of rapeseed oil utilized to the total production (or consumption) of vegetable-oil products (ARATE) was treated as the coefficient of the latter in the market-clearing equation for rapeseed oil (equation 4.7); and the average marketing margin between prices of rapeseed and vegetable-oil products (AMM) was treated as the coefficient of the average farm price of rapeseed in the price linkage equation (equation 4.8).

As the reasons were given in Chapter 2, no futher attempt was made at estimating behavioral equations in order to explain variations in AYRS, AYRO, ARATE, and AMM. In the procedure of determination of appropriate values for those variables to be used in the designed identification equations, certain descriptive statistics regarding the distribution of observations were quantified. The mean of a set of observations is a measure of central tendency of the distribution of observations, while the standard deviation (the square-root of the mean of the squared deviations from the mean) is a measure of the spread or dispersion of the distribution. The coefficient of variation (the ratio of the standard deviation to the mean) measures the spread of a distribution expressed as a percentage of the mean.

Table 5.5 provides annual data relating to AYRS, AYRO, ARATE, and AMM for the 1960-75 period; as well as the means, standard deviations, and coefficients of variation. The coefficients of variation of the AYRS, AYRO, ARATE, and AMM were 6.7, 3.8, 57.2, and 24.4 per cent,

Table 5.5

Ratios between the Four Selected Pairs of Endogenous Variables, 1960-75

Year	Ratio 1	Ratio 2	Ratio 3	Ratio 4
	tonnes per ac	------------per cent		-----------
1960	0.331	278.6	1.7	1,010
1961	0.358	283.4	4.8	962
1962	0.358	262.5	6.6	833
1963	0.397	258.9	7.0	666
1964	0.379	256.3	7.4	633
1965	0.361	254.3	11.8	791
1966	0.383	253.0	14.8	816
1967	0.345	249.0	17.4	1,026
1968	0.417	247.8	19.1	1,040
1969	0.377	249.8	23.1	826
1970	0.404	253.7	23.9	846
1971	0.406	254.5	29.4	943
1972	0.397	260.0	35.2	606
1973	0.383	267.0	32.1	382
1974	0.367	259.2	23.6	442
1975	0.426	248.8	27.4	752
Average	0.381	258.6	17.8	786
Standard Deviation	0.026	9.942	10.2	192
S.D./Ave.	6.71%	3.84%	57.2%	24.4%
1973-75 Ave.	0.392	258.3	27.7	600

Ratio 1 is the rapeseed yield per acre,
Ratio 2 is the ratio of rapeseed crushings to the production of rapeseed oil,
Ratio 3 is the ratio of rapeseed oil used relative to vegetable-oil products produced, and Ratio 4 is the ratio of prices of vegetable-oil products to farm rapeseed prices.

respectively. These statistics revealed that the dispersion of AYRS and AYRO were relatively small, reflecting the fact that the rapeseed yield and the yield of rapeseed oil increased at only a moderate rate. At the same time the quantity of rapeseed oil utilized in the production of vegetable-oil products has steadily increased during the analytical period. The standard deviation of ARATE was as large as 57 per cent of the mean value. The average values of AYRS, AYRO, and ARATE for recent years (1973-75) appear to be appropriate indicators to reflect structural relationships of the system in the near future. On the other hand, marketing margins between the prices of vegetable-oil products and rapeseed farm prices varied irregularly from year-to-year. In this case, the 1960-75 average rather than the 1973-75 average of AMM was chosen to identify the structural relationship in equation 4.8.

Owing to the particular distribution of observations, additional variables showing the annual variation of each from the mean were used in each identification equation in order to ensure that the identical relationship for each year held. For example, the product of the average rapeseed yield per acre and the acreage under cultivation, plus the rapeseed carry-over at the beginning of a year, would not be equal to the total supply of rapeseed for that year, unless the fact of the variation between the actual and the average rapeseed yield was explicitly taken into consideration. Accordingly, an adjustment term was specified in each identification equation.

B. The Reduced-Form Coefficients

Magnitude of the Reduced-Form Coefficients

The reduced-form of a structural model is one in which the endogenous variables are expressed as functions of all predetermined variables specified in the model. The reduced-form coefficients can be obtained directly by applying ordinary least squares to the reduced-form equations; or, by estimating the structural parameters using any appropriate econometric technique, and then to deriving the reduced-form coefficients in terms of the latter. Owing to the small number of available observations, the first approach was not appropriate for this study. Therefore, the second approach was used.

The relationships between the structural coefficients and the reduced-form coefficients were specified in detail in equation 4.10 in Chapter 4. Briefly, the whole system can be expressed in terms of matrix notations as $AY + BX = U$, or $Y = CX + V$; $C = A^{-1}B$. Where Y and X are vectors of endogenous and exogenous variables, respectively; U and V are residual errors; Matrices A and B are the structural coefficients associated with the endogenous and exogenous variables, respectively; and Matrix C comprises the reduced-form coefficients. The structural coefficients estimated by IVR are written in terms of the above-mentioned Matrices A and B, and presented in Tables 5.6A and 5.6B. The solved Matrix C, the product of the inverse of Matrix A and Matrix B, is presented in Table 5.6C. The solved reduced-form coefficients based on the OLS estimates of the structural coefficients are presented in Appendix B.

The "Goodness of Fit" of Reduced-Form Equations

In addition to explaining the operation of the rapeseed industry, the model was also built with a view to forecasting future probable changes within the industry, given certain assumptions about the independent variables. The future is, of course, unknown at any point in time and, for that reason, the accuracy of any forecast is always open to

Table 5.6 A

Estimated Coefficients for the Endogenous Variables of the Aggregate Supply-Demand Rapeseed Model Using IVR, 1960-75

Variables / Equations	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8
Y1	1.000							
Y2	-0.392	1.000						
Y3			1.000	2.596				
Y4		1.000	-1.000			-1.000		
Y5				-7.860	1.000			
Y6						1.000	-2.583	
Y7							1.000	-0.277
Y8					0.081			1.000

Y1=RAC, Y2=QS, Y3=TRX, Y4=PR, Y5=PVO, Y6=QRC, Y7=QRO, and Y8=QD

Table 5.6 B

Estimated Coefficients for the Exogenous Variables of the Aggregate Supply-Demand Rapeseed Model Using IVR, 1960-75

Variables / Equations	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10
Y1	2441.3	-17.432	17.169	0.6176				-187.67		
Y2										
Y3					2.0399	472.67	2.6319	6.461		
Y4									1.0000	
Y5										1.0000
Y6										
Y7										
Y8								61.871		

	X11	X12	X13	X14	X15	X16	X17	X18	X19
Y1									
Y2		1.0000						1.0000	
Y3									
Y4	1.0000								
Y5									
Y6									1.0000
Y7						1.0000	1.0000		
Y8			0.0276	1.8064	0.5865				

X1=LIFT, X2=PW(t-1), X3=PR(t-1), X4=RAC(t-1), X5=JEY, X6=DUM, X7=PUS, X8=CONSTANY, X9=OURS, X10=DMM•PR,

X11=RSTK, X12=RSTK(t-1), X13=PB, X14=EXP, X15=QD(t-1),X16=XRO, X17=DRATE • QD, X18=DYRS • RAC, and X19=DYRO•QRC

Table 5.6C

Derived Coefficients for the Reduced-Form Equations of the Aggregate Supply-Demand Rapeseed Model Using IVR, 1960-75

Equations \ Variables	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10
Y1	2441	-17.43	17.17	.6175	0.0	0.0	0.0	-187.7	0.0	0.0
Y2	957	-6.83	6.73	.2421	0.0	0.0	0.0	-73.6	0.0	0.0
Y3	813	-5.81	5.72	.2059	0.3055	70.8	0.3941	-99.2	-0.8503	0.0495
Y4	-313	2.24	-2.21	-.0793	0.6681	154.8	0.8620	40.7	0.3275	-0.0191
Y5	2464	17.60	-17.33	-.6234	5.2514	1216.0	6.7754	320.0	2.5743	0.8503
Y6	143	-1.02	1.01	.0363	-0.3055	-70.8	-0.3941	25.6	-0.1497	-0.0495
Y7	55	-0.39	0.39	.0140	-0.1183	-27.4	-0.1526	9.9	-0.0580	-0.0191
Y8	200	-1.43	1.41	.0507	-0.4269	-98.9	-0.5508	35.8	-0.2093	-0.0691

	X11	X12	X13	X14	X15	X16	X17	X18	X19
Y1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Y2	0.0	1.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0
Y3	-0.8503	0.8503	-0.0168	-1.099	-0.3568	-2.196	-2.196	0.8503	-0.8503
Y4	0.3275	-0.3275	0.0065	0.423	0.1374	0.846	0.846	-0.3275	0.3275
Y5	2.5743	-2.5743	0.0508	3.327	1.0803	6.650	6.650	-2.5743	2.5743
Y6	-0.1497	0.1497	0.0168	1.099	0.3568	2.196	2.196	0.1497	0.8503
Y7	-0.0580	0.0580	0.0065	0.425	0.1381	0.850	0.850	0.0580	-0.0580
Y8	-0.2093	0.2093	0.0235	1.536	0.4987	-0.541	-0.541	0.2093	-0.2093

question. However, the predictive capability of a model can be evaluated by its forecasting performance as judged by the magnitude of estimation errors for the endogenous variables both within and outside the analytical period. Since reduced-form equations will be used as the forecasting base, and since the "goodness of fit" of reduced-form equations is one of the major factors affecting the forecasting accuracy of the system, it would appear logical to discuss this subject before evaluation of the forecasting performance of the system can be made.

It is well known in regression analysis that variation of the dependent variable, Y, can be divided into the portion due to changes in the regressors, which lead to changes in the calculated values of Y; and the portion due to the effect of random disturbances, i.e., SST = SSR + SSE

where: SST = the sum of squares (the sum of the squares of the total distance of each observed value from the mean),

SSR = the regression sum of squares (the sum of the squares of the distance of each calculated value on the regression line from the mean), and

SSE = the error sum of squares (the sum of the squares of the distance between the observed and the calculated values).

From the above disaggregation of the variation of Y, the coefficient of determination, or R^2, can then be defined as:

$$R^2 = \frac{SSR}{SST} = 1 - \frac{SSE}{SST}$$

In spite of the fact that reduced-form equations can not be estimated by the application of the least squares technique, because of the small number of observations and degrees of freedom, the magnitude of the SSE of the above generalized formula for computing R^2 can be estimated from the difference between the actual and the calculated values of the endogenous variables. Consequently, R^2 can be computed without information about SSR. In this case, R^2 can no longer be interpreted as a measure of that part of the variation of Y attributable to sample regression. But it can be used as a measure of the goodness of fit, or taken as an indicator of the "correctness" of the specification of the model, although there is no real foundation in statistical inference.[8]

Given the solved reduced-form coefficients (Table 5.6C) and the actual data for the predetermined variables over the analytical period (Table 5.7), the values of the endogenous variables can be computed. Preliminary results indicated that the Gauss-Markoff condition where "the sum of residual errors associated with an equation should be equal to zero" was not valid. This implied that the values of the endogenous variables computed from reduced-form equations were biased. Because only seven out of nineteen predetermined variables specified in the system were used as instrumental variables in the first stage of IVR, "simultaneous bias" cannot be completely removed. In order to ensure that the sum of the residual errors of each equation is equal to zero, the constant term of each equation was adjusted accordingly. The revised estimated values of the endogenous variables are presented in Table 5.8.

Based on the revised estimated values and the actual values of the endogenous variables (Table 5.9), the R^2 associated with each reduced-form equation can be calculated. Table 5.10 showed that the magnitude of each R^2 was greater than 0.8 which lies on the upper end of the range between 0 and 1. Since the number of observations is smaller than the number of independent variables, R^2 can not be "corrected". Therefore, R^2 might be slightly biased upwards. However, from a purely operational

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[8] J. Kmenta, op. cit., pp. 232-35.

Table 5.7 A

Parameters of the Aggregate Supply-Demand Rapeseed Model
1960-75

Year	LIFT	PW(t-1)	PR(t-1)	RAC(t-1)	JEY	DUM	PUS	CONSTANT	OURS	AMM•PR
		dollars per tonne		thousand acres	billion dollars		dollars per tonne		thousand tonnes	dollars per tonne
1960		48.5	88.1	214	45.2		95.1	1	117	161
1961		57.7	71.8	763	51.5		95.4	1	26	139
1962		63.2	79.3	710	61.2		100.6	1	28	-42
1963		60.9	89.9	372	78.2		106.8	1	4	-113
1964		63.9	111.1	478	73.3		113.6	1	167	-185
1965		58.4	120.8	791	96.2		117.7	1	166	4
1966		61.7	106.3	1435	100.6		116.6	1	114	32
1967		64.6	108.9	1525	113.8		106.8	1	167	203
1968		59.8	84.6	1620	114.7		103.6	1	90	205
1969	0.5	49.2	80.6	1052	128.5		102.8	1	313	40
1970	1.0	46.6	100.9	2012	155.0	1	113.3	1	656	61
1971	0.5	52.9	102.7	4050	202.2	1	121.1	1	54	149
1972		49.6	95.2	5306	249.9	1	228.9	1	481	-250
1973		68.3	139.3	3270	349.9	1	223.9	1	-185	-1018
1974		164.2	252.2	3150	363.9		230.5	1	135	-1071
1975		154.7	311.3	3160	356.0		196.0	1	211	-75

Table 5.7 B

Parameters of the Aggregate Supply-Demand Rapeseed Model
1960-75

This Table is a Horizontal Extension of Table 5.7A

Year	RSTK	RSTK(t-1)	PB	EXP	QD(t-1)	XRO	DRATE·QD	DYRS·QAC	DYRO·QRC
	thousand tonnes		dollars per tonne	billion dollars	---------- thousand tonnes ----------				
1960	11	3	1548	25.4	163		-45	-47	1.2
1961	48	11	1551	25.9	174		-42	-24	3.7
1962	11	48	1375	27.4	186		-41	-12	0.4
1963	19	11	1296	29.2	196		-41	2	-0.1
1964	29	19	1306	31.3	199		-40	-10	1.2
1965	74	29	1361	33.9	202		-32	-50	-1.9
1966	132	74	1487	36.8	203		-33	-11	-1.1
1967	225	132	1563	39.9	257		-26	35	-4.8
1968	114	225	1572	43.4	263		-23	27	-5.9
1969	82	114	1597	47.4	277		-13	-31	-6.6
1970	250	82	1587	50.3	294		-11	50	-2.8
1971	978	250	1613	55.6	293		5	174	-3.7
1972	468	978	1685	62.2	296		24	17	2.9
1973	280	468	1739	71.2	327	34.8	14	-28	11.4
1974	399	280	1940	83.4	343	27.6	-14	-76	1.1
1975	1041	399	2422	97.0	386	20.0	-1	145	-11.8

Table 5.8

Computed Values of Endogenous Variables Based on Reduced-Form Equations
Derived from 1960-75 IVR Estimates of Structural Coefficients

Year	RAC	QS	TRX	PR	PVO	QRC	QRO	QD
	thous.ac.	--thousand tonnes---		--dollars per tonne---		------thousand tonnes--------		
1960	606	180	66	110	1028	7	2	163
1961	506	172	92	105	969	19	6	175
1962	506	221	159	92	688	39	15	203
1963	517	203	157	113	776	38	15	202
1964	895	347	124	129	829	41	16	204
1965	1,351	496	210	118	933	60	24	204
1966	1,441	614	304	83	692	79	31	233
1967	1,491	739	260	101	1,002	102	41	247
1968	1,216	716	386	60	670	140	56	290
1969	2,204	934	373	80	659	180	72	310
1970	4,410	1,848	784	120	1,010	174	68	287
1971	4,370	2,125	893	123	1,123	215	85	288
1972	3,853	2,494	1,256	130	776	303	116	331
1973	3,026	1,614	1,141	248	935	394	148	355
1974	3,219	1,454	630	280	1,135	303	117	375
1975	4,406	2,259	707	210	1,575	315	127	387

Table 5.9

Endogenous Variables Used in the Aggregate Supply-Demand Rapeseed Model, 1960-75

Year	RAC	QS	TRX	PR	PVO	QRC	QRO	QD
	thous. ac.	---thousand tonnes---		---dollars per tonne---		---- thousand tonnes -----		
1960	763	255	118	72	727	9	3	174
1961	710	265	123	79	760	27	9	186
1962	372	182	195	90	750	34	11	196
1963	478	201	141	111	739	36	14	199
1964	791	320	826	121	766	40	15	202
1965	1435	542	242	106	838	60	24	203
1966	1525	660	317	109	889	97	38	257
1967	1620	692	337	85	872	114	46	263
1968	1052	665	329	81	842	131	53	277
1969	2012	872	307	101	834	169	68	294
1970	4050	1720	636	103	871	178	70	293
1971	5306	2405	1151	95	896	221	87	296
1972	3270	2278	1078	139	842	300	115	327
1973	3150	1676	1194	252	962	386	145	343
1974	3160	1444	616	311	1373	293	113	360
1975	4320	2148	676	221	1623	312	125	380

Table 5.10

Coefficient of Determination Associated with Reduced-Form Equations as derived from IVR Estimates, 1960-75

Equations Identified by Endogenous Variables	Coefficients of Determination
RAC	0.956
QS	0.982
TRX	0.932
PR	0.882
PVO	0.803
QRC	0.995
QRO	0.995
QD	0.969

viewpoint, the results disclosed that the goodness of fit, or the correctness of the specification of the reduced-form equations, was reasonably satisfactory.

Predictive Reliability of the Model

The most commonly applied evaluative measures to indicate the predictive reliability of a model within chosen analytical periods are the average absolute error of estimation (AAE), and the square-root of the mean squared error of estimation (RMSE). Based on the information on the actual and the computed values of the endogenous variables, measures of AAE and RMSE associated with each endogenous variables can be computed. In view of the size of the measures which vary according to the particular unit measure of the variable being used, they were, in order to permit more useful evaluation, further expressed as percentages of their relevant means.

As shown in Table 5.11, the overall magnitude of AAE, as computed from the set of reduced-form equations derived from the structural coefficients, which were, in turn, estimated by the application of IVR to the 1960-75 data, was slightly smaller than that estimated from alternative sets of reduced-form equations. This meant that performance of the reduced-form equations, as determined from IVR estimates, was somewhat superior to that derived from OLS estimates. When the RMSE was used as the evaluative criterion, a similar conclusion could be made as well. The results of RMSE computed from various reduced-form equations were not reported.

According to the AAE of estimation, obtained from IVR estimates of the structural relationships, reduced-form equations for total exports of rapeseed from Canada showed the poorest performance.

Table 5.11

Average Absolute Estimation Errors of the Reduced-Form Equations derived from OLS and IVR Estimates, 1960-74 and 1960-75

Endogenous Variables	OLS Estimates		IVR Estimates	
	1960-74	1960-75	1960-74	1960-75
RAC	10.9	10.1	10.9	10.1
QS	8.1	7.3	8.1	7.3
TRX	16.2	14.5	15.8	14.6
PR	15.7	16.4	11.6	11.3
PVO	18.2	18.9	13.1	13.4
QRC	3.2	5.0	4.0	4.6
QRO	3.1	5.3	4.2	4.8
QD	3.4	4.0	3.1	3.6
Average	9.7	10.1	8.9	8.8

The average estimation error was as large as 15 per cent of the average volume of exports over the 1960-75 period. Errors were probably partly attributable to the fact that "a substantial gap exists between the simplistic nature of econometric models and the complexities of international markets"[9], including the uncertainties of the political and economic environment in foreign markets.

Estimates of cultivated rapeseed acreage and the supply of rapeseed were closely related. The estimation errors associated with the acreage and supply functions represented about 10 and 7 per cent of their respective averages for the period. It appears that farmers' attitudes towards rapeseed production are greatly influenced by unfamiliarity with growing rapeseed as a cash crop, reflecting in particular a lack of experience with such factors as insect and weed control, and harvesting techniques.[10] The omission of such unquantifiable variables in the model should also help explain the relatively large errors of estimation for some years.

Farm prices for rapeseed were derived by solving the demand and supply functions. The estimation errors associated with the latter would thus be reflected in the estimation errors for prices. In some cases, errors in the demand and supply functions could be expected to offset each other. But, in other cases, the reverse might be true. Retail

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[9]W.C. Labys, "The Problems and Challenges for International Commodity Models and Model Builders", American Journal of Agricultural Economics, (December 1975), p. 873.

[10]R.K. Baydock, "Factors Affecting Resource Management Decisions: A Case Study of Manitoba Rapeseed Primary Producer", unpublished M.S. thesis, (Winnipeg, Manitoba: Natural Resource Institute, University of Manitoba, 1977).

prices for vegetable-oil products were similarly determined from the supply and demand for those products. Both the retail and farm prices were also affected by the relationships specified in the price linkage equation. As it turned out, the estimation error for both prices approximated between 11 and 13 per cent of their respective average prices.[11]

The consumption function for vegetable-oil products appeared to exhibit the best performance. Since the fats and oils market in Canada has been relatively stable, variations in consumption can be well explained by economic factors. Estimation errors amounted to less than 4 per cent of average consumption.

The demand for crude rapeseed oil is derived from the demand for fats and oils; and the demand for rapeseed is, in turn, derived from the demand for rapeseed oil. Since the demand for rapeseed oil, and for rapeseed for crushing, were specified by two identity equations; and since variations in the annual yield of rapeseed oil, and in the proportion used as ingredients in the manufacture of vegetable-oil products, were explicitly taken into consideration, the estimation errors associated with the demand for rapeseed oil and that for crushings were also relatively small.

The overall error of estimation for the eight endogenous variables averaged 9 per cent of the corresponding actual price or quantity. The estimation errors though large per se, appeared acceptable,

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[11]The magnitude of the estimation errors seems acceptable when compared with the price forecasts for rapeseed presented in the Agricultural Outlook Conference, sponsored by Agriculture Canada for many years. See various <u>Report of Canadian Agricultural Outlook. Conference</u> (Ottawa, Ontario: Economics Branch, Agriculture Canada).

because, when viewed in the context of the erratic fluctuations of the actual annual data, they were relatively quite small. Detailed information on year-to-year changes in values of the endogenous variables over the three most recent years was presented in Table 5.12. The Table showed, for example, that between 1973 and 1974, the prices of vegetable-oil products and rapeseed went up 43 per cent and 81 per cent, respectively, while the amount of rapeseed exports and crushings decreased 48 per cent and 24 per cent, respectively, during the same period.

Furthermore, in applying the results obtained from an econometric model, adjustments to the estimated endogenous variables, where there has been "irregular" behavior, are frequently necessary.[12] This implies that the occurrence of large estimation errors in some circumstances is not unusual.

A set of reduced-form equations with smaller estimation errors would have a better chance to produce accurate forecasts, provided that the structural relationships during the forecasting period do not change drastically from those that existed during the sample period. Since the IVR estimates showed better performance than the OLS estimates, the former were used for forecasting. Also, in order to assist the reader in visualizing the simultaneous operation of the system, a set of time series charts (Figures 5.1 to 5.8) was prepared to illustrate the actual versus the computed values of the jointly-determined variables over the sample period from 1960 to 1975. They were based on the reduced-form equations

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[12]C. Sonnen, "Overview of Econometric Modelling", a paper presented in Econometric Modelling Seminar, (jointly sponsored by Statistics Canada, Informetrica Ltd., and Systems Dimension Ltd. in Ottawa, June 1977).

Table 5.12

Comparative Changes in Values of the Endogenous Variables, 1973-75

Variables	1973 Over 1972 Values	1974 Over 1973 Values	1975 Over 1974 Values	AAE in 1960-75
	per cent			
RAC	-3.7	3.5	36.7	10.1
QS	-26.5	-13.8	55.1	7.3
TRX	10.8	-48.4	9.7	14.6
PR	46.3	81.0	-29.0	11.3
PVO	14.2	42.7	21.1	13.4
QRC	28.9	-24.2	6.1	3.7
QRO	25.7	-22.1	10.5	3.7
QD	5.1	10.2	5.6	2.9

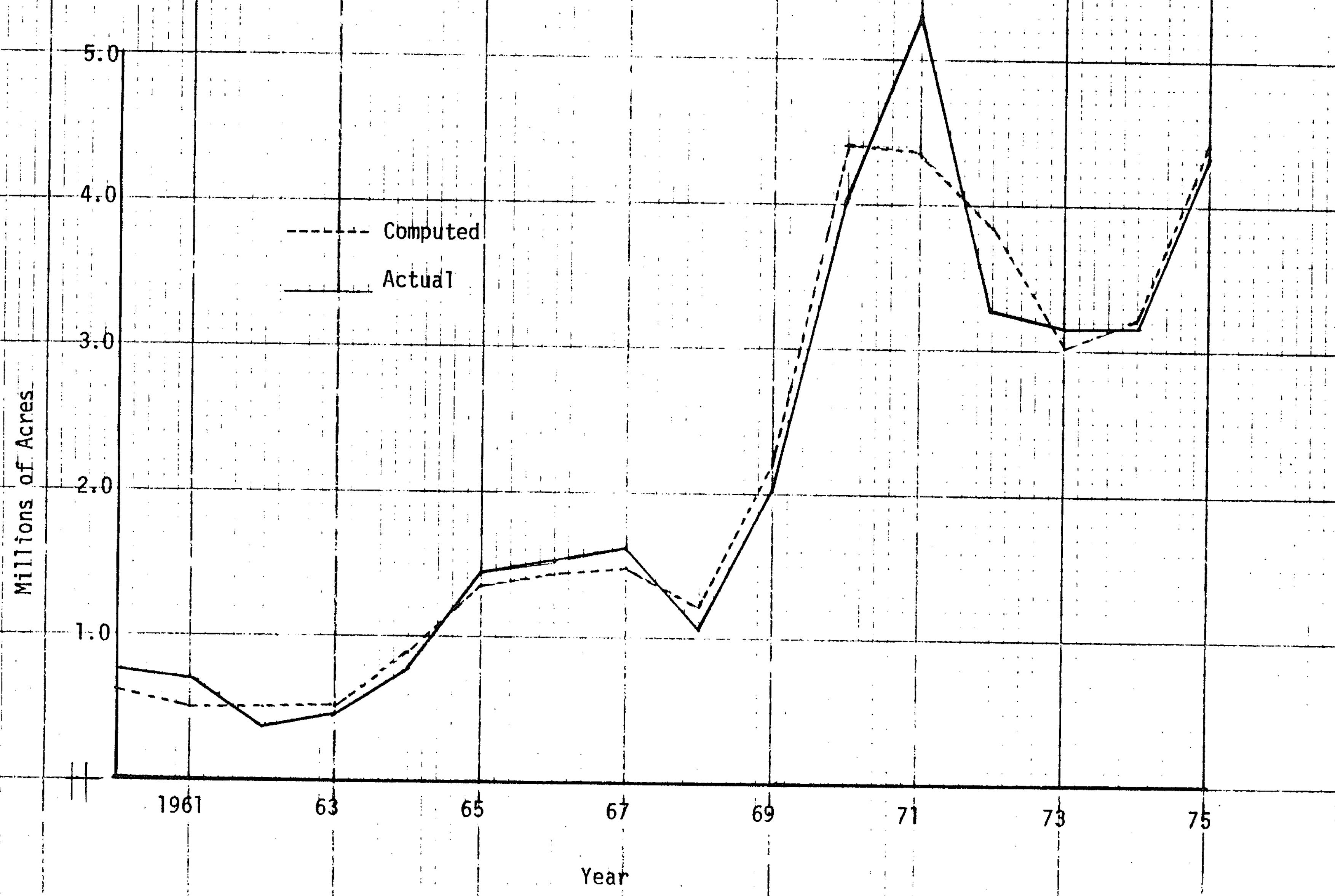

Figure 5.1: Acutal and Computed Rapeseed Acreage Based on Reduced-Form Equations Derived from IVR Estimates, 1960-75.

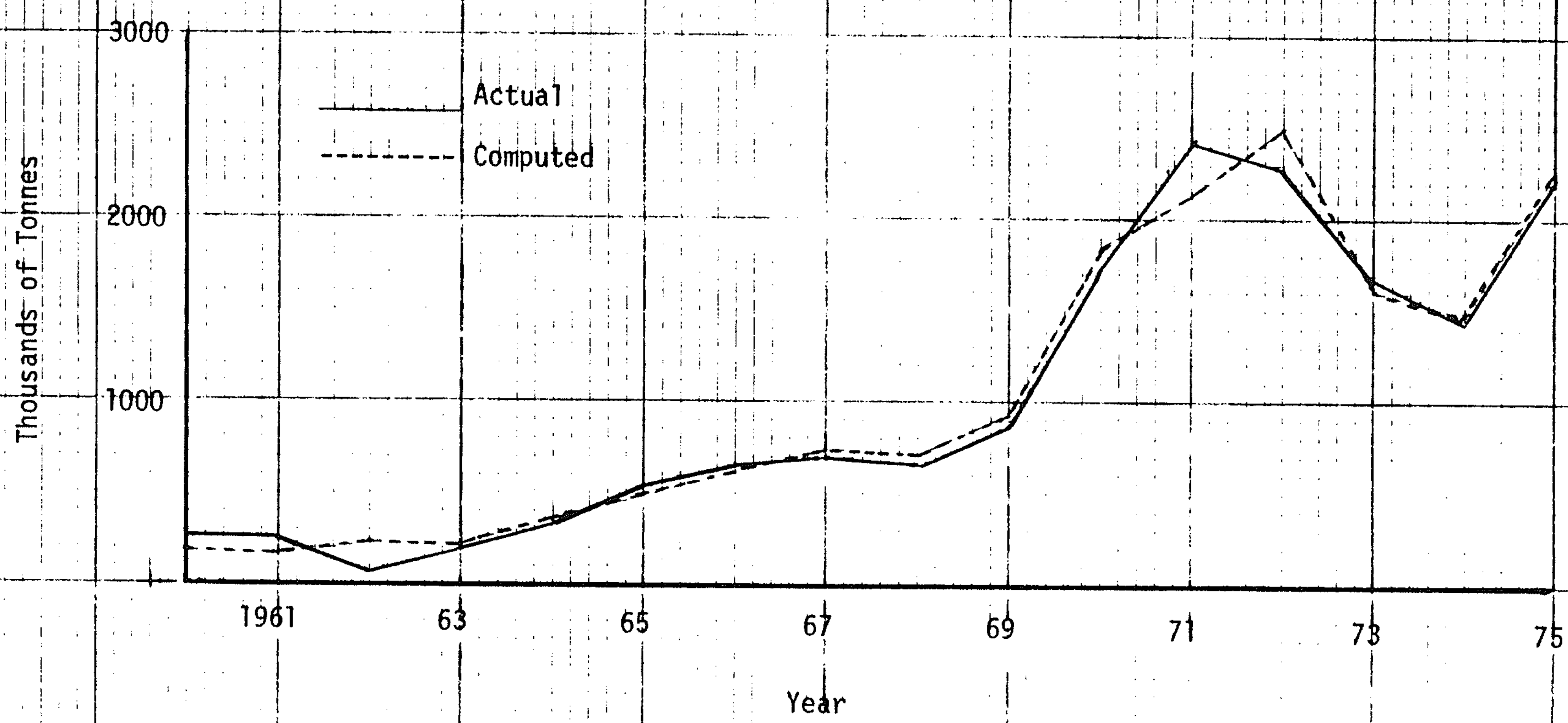

Figure 5.2: Actual and Computed Rapeseed Supply Based on Reduced-Form Equations Derived from IVR Estimates, 1960-75.

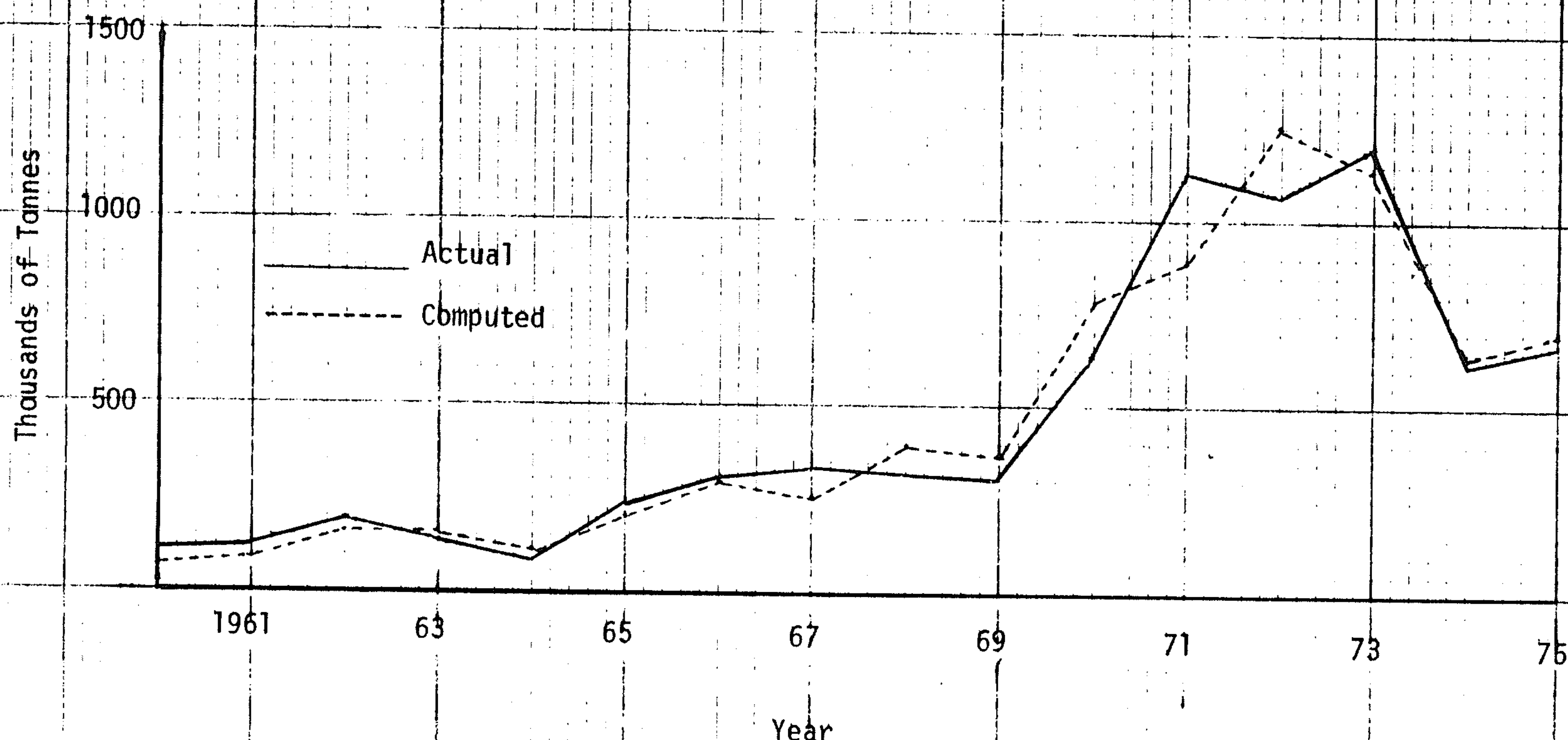

Figure 5.3: Actual and Computed Rapeseed Exports Based on Reduced-Form Equations Derived from IVR Estimates, 1960-75.

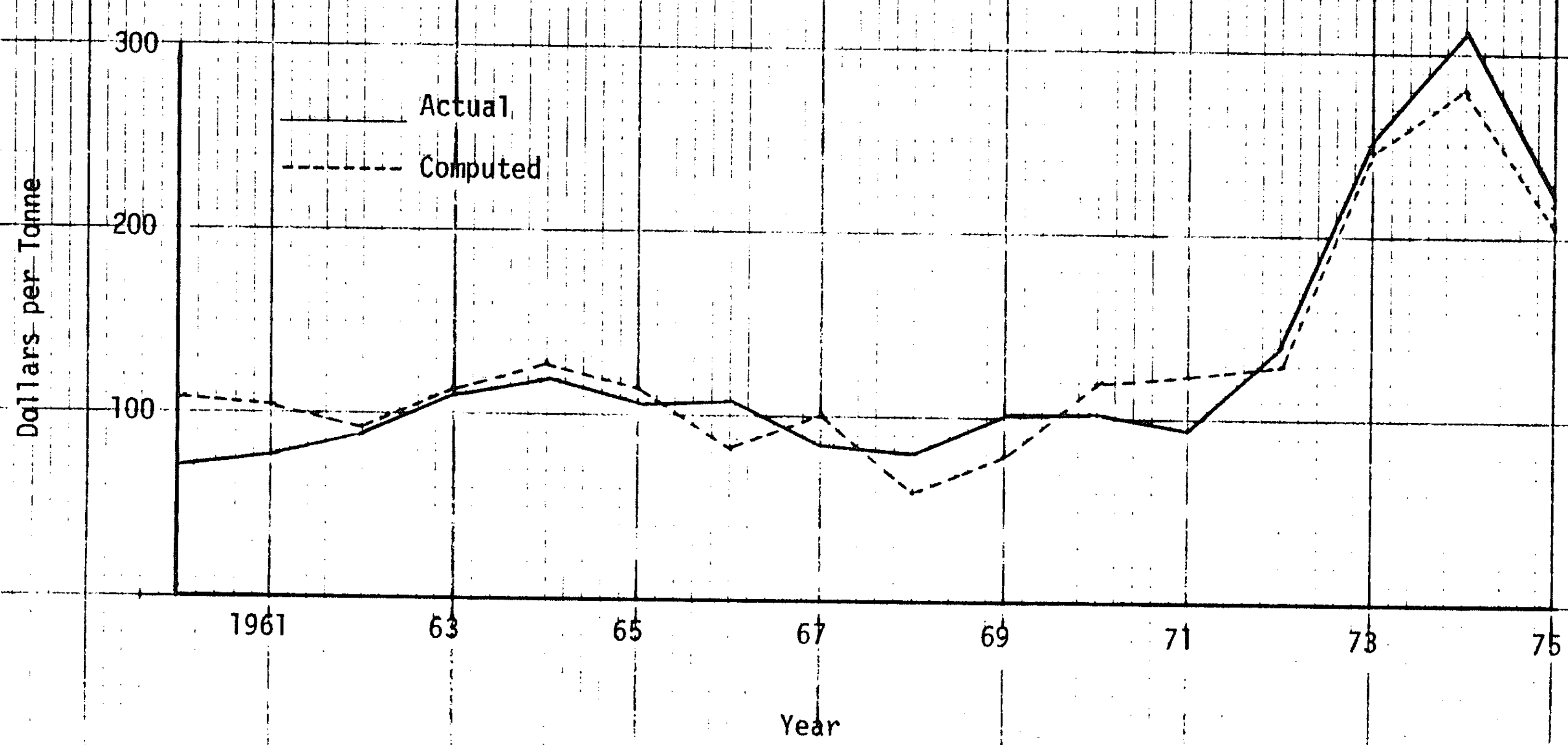

Figure 5.4: Actual and Computed Rapeseed Farm Prices Based on Reduced-Form Equations Derived from IVR Estimates, 1960-75.

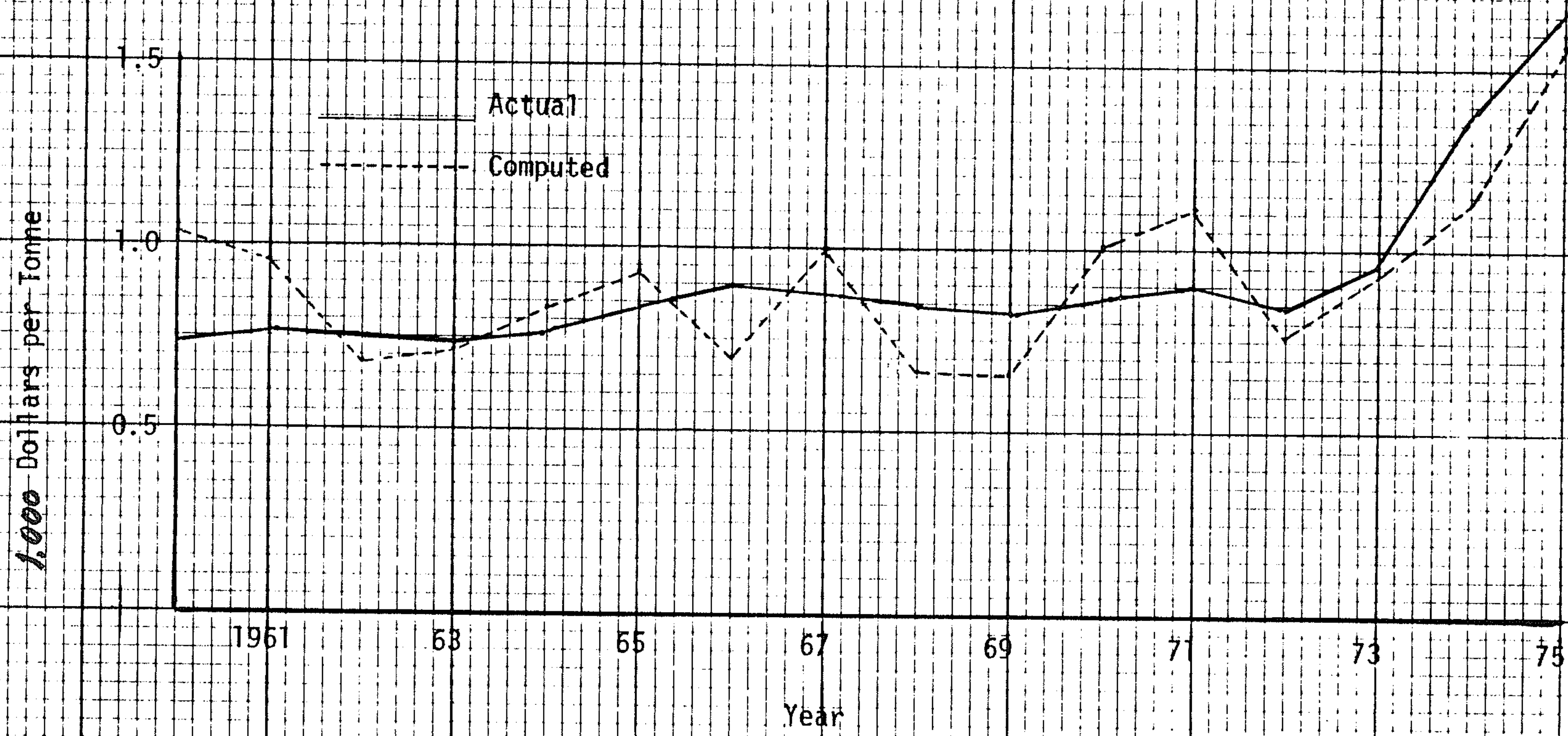

Figure 5.5: Actual and Computed Retail Prices of Veg. Oil Products Based on Reduced-Form Equations Derived from IVR Estimates, 1960-75.

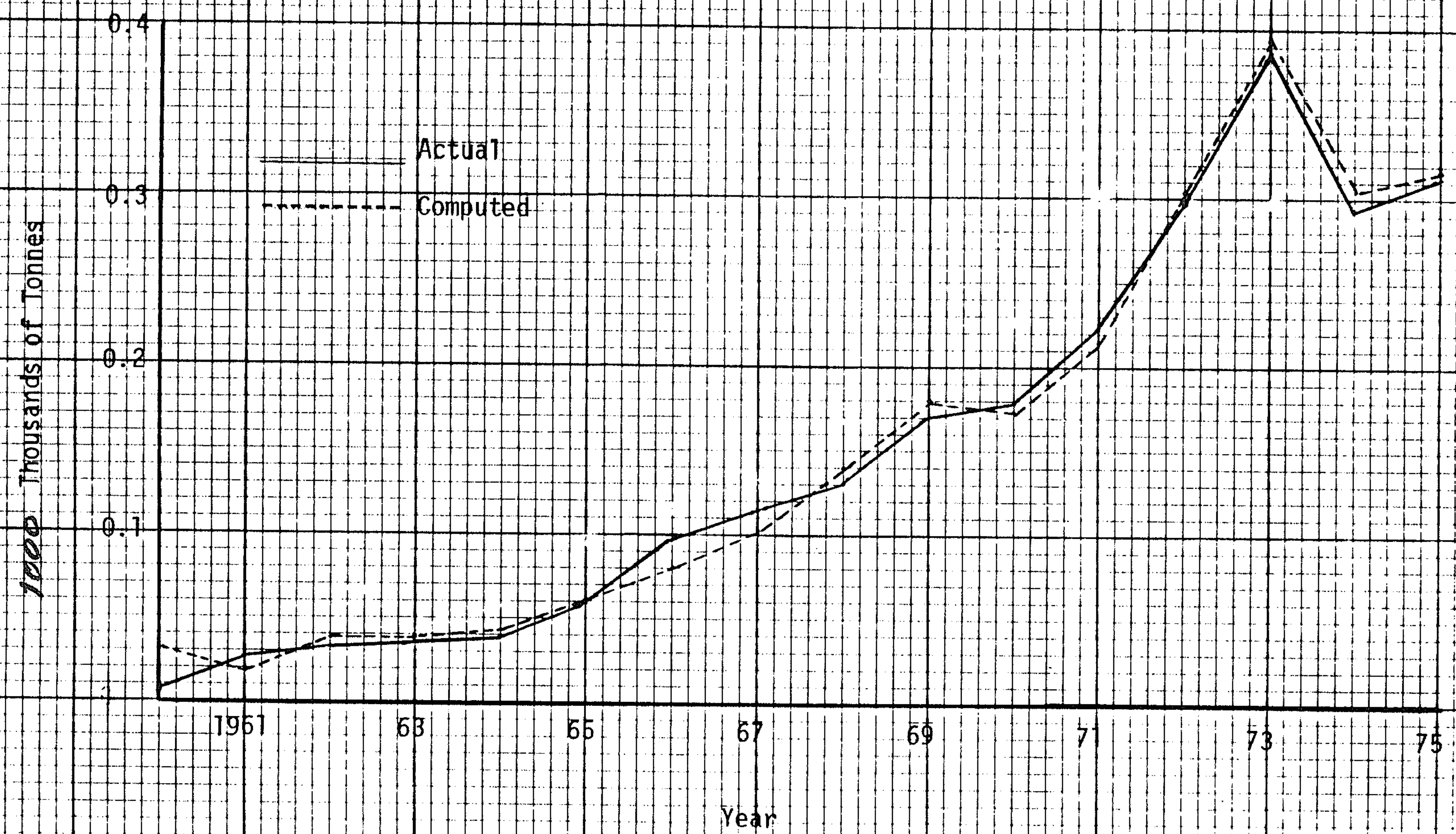

Figure 5.6: Actual and Computed Rapeseed Crushings Based on Reduced-Form Equations Derived from IVR Estimates, 1960-75.

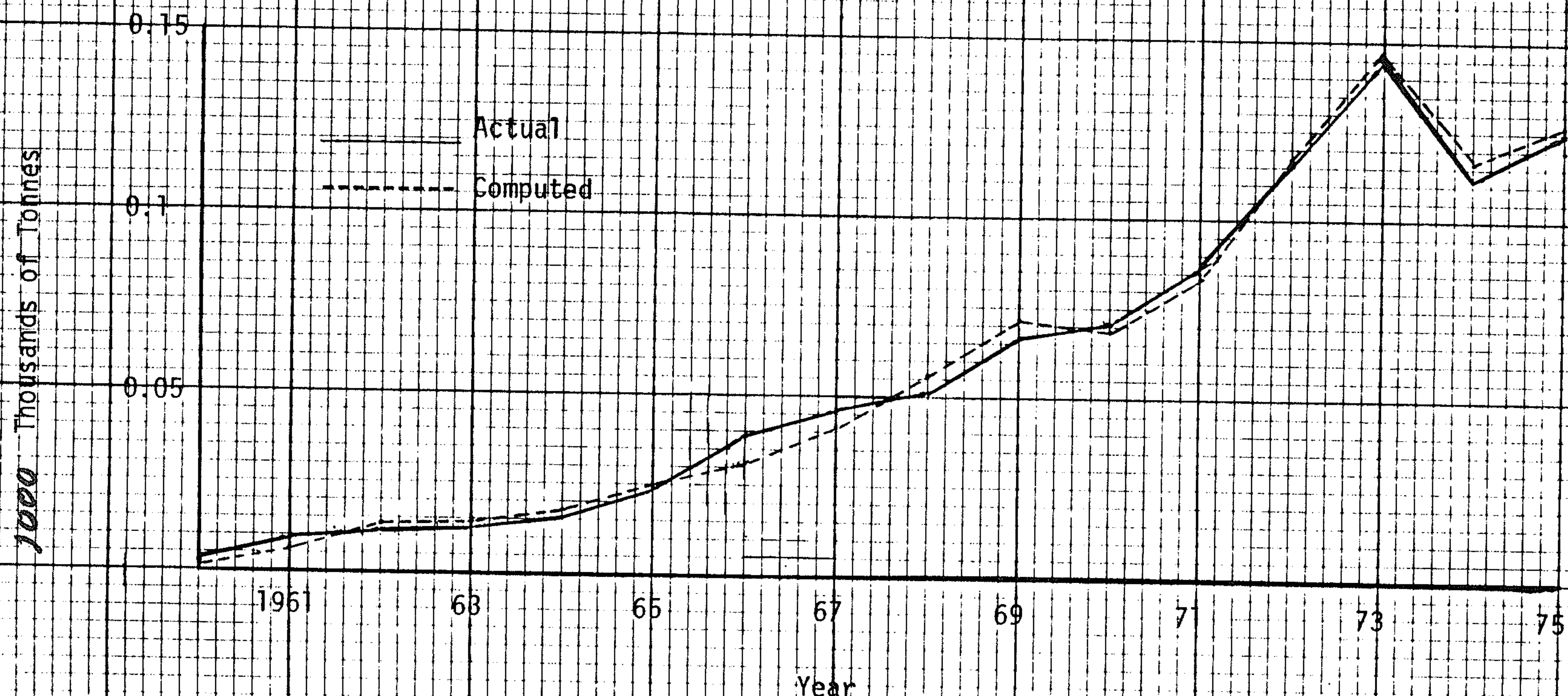

Figure 5.7: Actual and Computed Rapeseed Oil Production Based on Reduced-Form Equations Derived from IVR Estimates, 1960-75.

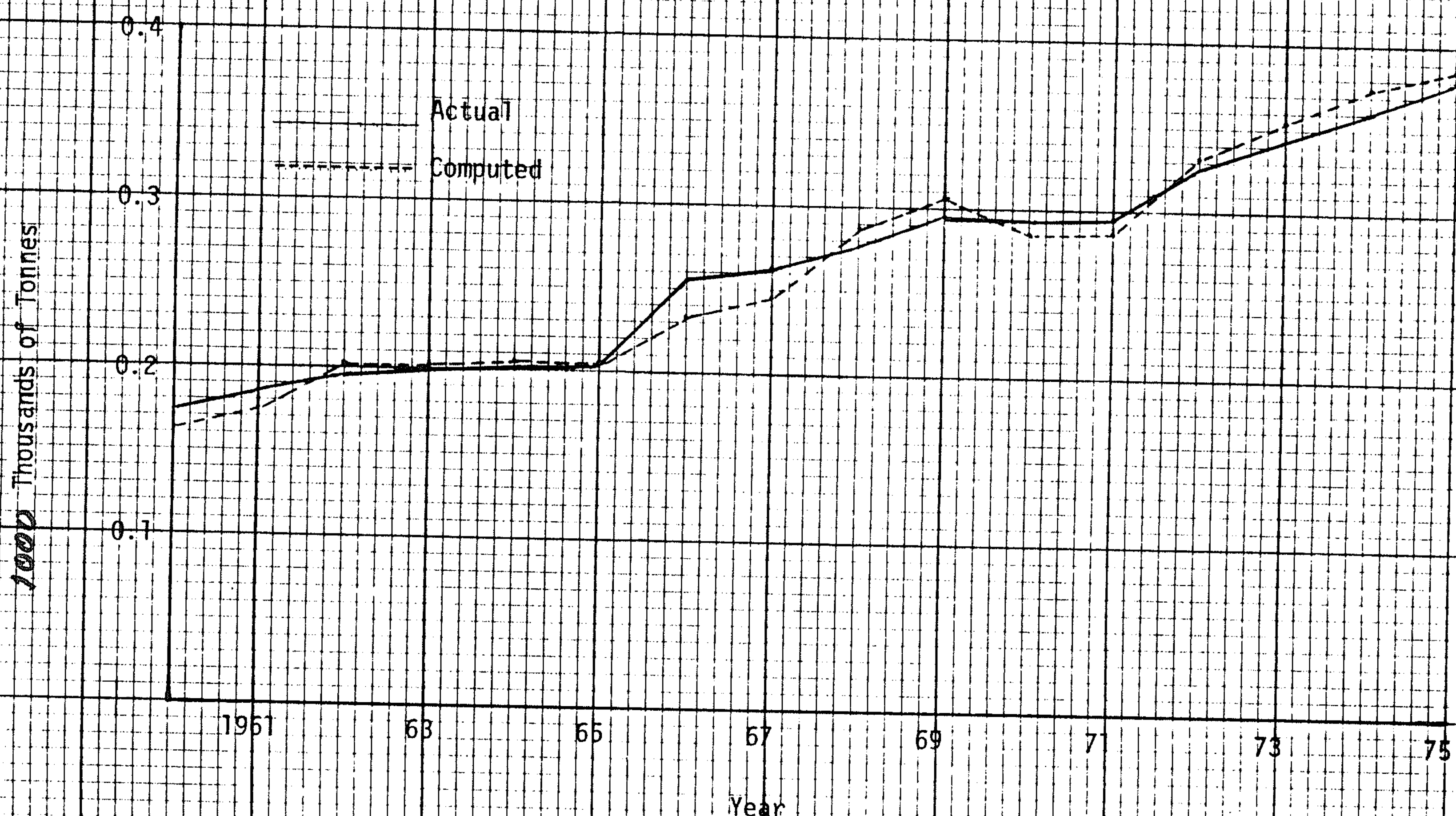

Figure 5.8: Actual and Computed Consumption of Veg. Oil Products Based on Reduced-Form Equations Derived from IVR Estimates, 1960-75

that were derived from the structural coefficients using the IVR technique.

Estimation Errors of the 1975 Endogenous Variables

Perhaps the most crucial feature of the reliability of model performance by the reduced-form equations, in addition to those already discussed, is the ability to accurately forecast the values of endogenous variables outside the analytical period. Theil's inequality U-coefficient has been commonly applied to evaluate the predictive ability of a model when the observations outside the analytical period are large enough to compute the U-coefficient. For example, Kulshreshtha and Wilson used the latter to test the predictive efficiency of various equations designed to reflect relationship in the Canadian beef cattle industry.[13] However, Theil's coefficient cannot be applied backwards. It would be misleading, for example, to apply it to test the goodness of fit for a regression line.[14]

Unfortunately, because the 1976 data for some variables were not yet available, the 1976 values and the associated estimation errors of the endogenous variables, i.e., outside the 1960-75 analytical period, could not be computed. As a test, however, the reduced-form equations derived from the 1960-74 data were used to predict 1975 values for the endogenous variables, using all the 1975 data on exogenous variables that

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[13]S.N. Kulshreshtha and A.G. Wilson, "An Open Econometric Model of the Canadian Beef Cattle Sector", American Journal of Agricultural Economics, (Feb., 1972), pp. 84-91.

[14]R.M. Leuthold, "On the Use of Theil's Inequality Coefficients", American Journal of Agricultural Economics, (May 1975), pp. 344-6.

were then available. Table 5.13 indicated that the average absolute error of estimation for the 1975 values of the endogenous variables was 5.3 per cent of the actual 1975 price or quantity. This meant that the predictive capability of the 1960-74 model with respect to values outside the analytical period was highly satisfactory compared to the magnitude of estimation errors over the whole analytical period as indicated in Table 5.11 in the previous section.

One further step was taken, 1975 estimates of the endogenous variables were also computed from the 1960-75 model. As manifested in Table 5.13 the predictive performance of the 1960-75 model was even better than that of the 1960-74 model. The AAE associated with the 1960-75 model only accounted for about 3 per cent of the 1975 actual values. In view of the relative accuracy of forecasting endogenous variables in recent years, the 1960-75 model appears to be the more desirable one for use as a forecasting base. In order to provide a better understanding of the operation of the 1960-75 model, some of the factors contributing to the estimation errors of the 1975 values are briefly examined below.

As discussed earlier, the rapeseed acreage cultivated at a particular time has been mainly determined by rapeseed and wheat prices in the immediately preceding period. Farm rapeseed prices increased by 23 per cent in 1974, rising to 311 dollars per tonne from 252 dollars in 1973. On the other hand, farm wheat prices decreased from 164 dollars in 1973 to 155 dollars per tonne in 1974. The rapeseed, wheat price ratio in 1974 was about 2:1 in favour of rapeseed. Since this ratio was substantially higher than in 1973, rapeseed acreage in 1975, according to the model, was expected to be much greater than that in 1974. In reality, farmers responded to changes in the prices of rapeseed and its competing

Table 5.13

1975 Actual, and Computed Values of the Endogenous Variables based on Reduced-Form Equations derived from IVR Estimates Over the 1960-74 and 1960-75 Periods

Variables and Units	Actual Values	Computed from 1960-74 Data	Computed from 1960-75 Data
RAC(thous. acres)	4,320	4,652	4,406
(per cent)*		(7.7)	(2.0)
QS(thous. tonnes)	2,239	2,355	2,259
(per cent)		(5.2)	(0.9)
TRX(thous. tonnes)	676	803	707
(per cent)		(18.8)	(4.6)
PR(dol. per tonne)	221	217	210
(per cent)		(-1.7)	(-5.2)
PVO(dol. per tonne)	1,662	1,636	1,575
(per cent)		(-1.6)	(-5.2)
QRC(thous. tonnes)	331	317	316
(per cent)		(1.9)	(1.6)
QRO(thous. tonnes)	124	127	126
(per cent)		(2.7)	(2.3)
QD(thous. tonnes)	380	388	387
(per cent)		(2.2)	(1.9)
AVE(per cent)		(5.2)	(3.0)

* Numbers within parentheses are estimation errors in terms of percentages of the corresponding 1975 actual values.

crops, by increasing acreage from 3.2 million acres in 1974 to 4.3 millions in 1975, which was almost identical to the estimation of 4.4 million acres by the model.

However, although the model results appeared quite accurate the small upward bias had an effect on the estimation errors of other components. By definition, the supply is the sum of the product of acreage and the yield per acre, plus rapeseed carry-over at the beginning of a period. Since the rapeseed yield and stocks were predetermined variables, the magnitude of the estimation error for supply was relatively small compared to that for rapeseed acreage because the latter is only one of several factors affecting supply.

The over-estimation of rapeseed acreage and the supply of rapeseed also resulted in over-estimations of rapeseed exports and crushings. The estimation error for rapeseed exports of about 5 per cent was greater than the error for crushings, which was about 2 per cent. This was attributable to the fact that the amount of exports was affected both by domestic and foreign conditions. For example, the weighted private expenditures in Japan and the E.E.C. decreased from 364 billion dollars in 1974 to 356 billion dollars in 1975; prices of U.S. soybeans decreased from 231 dollars per tonne in 1974 to 196 dollars per tonne in 1975. While these changes were of course beyond the scope of domestic controls, the point is that they were unfavourable to exports of rapeseed from Canada.

Since the consumption function for vegetable-oil products can explain variations in consumption fairly well, the actual oil yield of rapeseed, and the ratio expressing the quantity of rapeseed oil utilized in the production of vegetable-oil products, were used in identical equations to reflect the production and the market-clearing of rapeseed oil. Variations, both in the production of rapeseed oil and the consumption of vegetable-oil products, were mainly affected by the amount of rapeseed crushed. Consequently, as shown in Table 5.13, the estimation errors for QRC, QRO, and QD were quite similar.

In theory, the upward estimation error associated with the supply of rapeseed should, for a given demand curve, have resulted in a downward estimation error with respect to rapeseed prices. Indeed, the results presented in Table 5.13 support this argument. However, the magnitude of price under-estimation was relatively large compared to the magnitude of the supply over-estimation. This was most likely caused by the abnormally high volume of rapeseed stocks in 1975. Both the previous and current rapeseed stocks were explicitly introduced into the reduced-form equations. These two variables have opposite affects on rapeseed prices. If stocks at the end of a period exceed stocks at the beginning of that period, the obvious implication is that the quantity supplied during the current period was reduced by some portion going into storage. The stocks of rapeseed at the end of 1975 (about one million tonnes) were significantly greater than those at the beginning of the period (about 400 thousand tonnes).

Normally, a large carry-over could mean that demand was inadequate because rapeseed prices were too high per se, or that the prices of competing goods were relatively low; or that there was over-supply that could not be absorbed by foreign and domestic markets. In any case, the end result is the supply exceeding the demand which must result in substantial downward pressure on rapeseed prices. According to the model, it was expected that the average rapeseed price in 1975 would be 206 dollars per tonne. In reality, the price decreased from 311 dollars in 1974 to 221 dollars in 1975. The decrease was not as much as expected. In other words, the model under-estimated by about 5 per cent the actual 1975 rapeseed price. Similarly, the computed average price of vegetable-oil products showed an under-estimation of 5 per cent of the 1975 actual price.

Overall, then, the predictive capability of the model appeared satifactory, especially in view of the wide fluctuations prevailing in the industry. Had the above mentioned factors, e.g., rapid increases in both rapeseed prices and stocks, decreases in the income level of the rapeseed importing nations, as well as decreases in the prices of U.S. soybeans, not occurred, the forecasting performance of the model would likely have been much better.

C. Implications of the Results

As illustrated earlier the responsiveness of the endogenous variables to changes in the predetermined variables could be measured with reasonable accuracy through operation of the reduced-form equations. Consequently, the impact of changes in political and economic conditions on the endogenous variables could be fairly well analyzed. For purposes of demonstration, changes in selected predetermined variables were simulated to gauge the impact on the endogenous variables in 1975, using the reduced-form equations derived from the IVR estimates of the structural coefficients. The results are presented in Table 5.14. Similar analyses could be performed for other years, using the changes in the specific predetermined variables and the corresponding reduced-form coefficients presented in Table 5.6C in the previous section. In

Table 5.14

The Impact of 10 Per Cent Increases in Selected Predetermined Variables on Values of the Endogenous Variables in 1975 based on IVR Estimates

Variables and Units	Lagged Wheat Prices	Lagged Rapeseed Prices	Rapeseed Yield	Prices of U.S. Soybeans	Personal Expenditures	Exports of Rapeseed Oil	Combination of Above Variables
RAC (thous. acres)	-269.9	534.5	0	0	0	0	264.6
QS (thous. tonnes)	-105.7	209.6	169.4	0	0	0	273.3
TRX (thous. tonnes)	-89.9	178.1	143.3	9.5	-7.6	-4.4	229.1
PR (dol. per tonne)	34.6	-68.6	-117.1	20.8	6.2	3.6	-120.5
PVO (dol. per tonne)	272.2	-539.4	-920.6	164.1	48.5	28.1	-947.1
QRC (thous. tonnes)	-15.8	31.3	26.1	-9.5	7.6	4.4	44.1
QRO (thous. tonnes)	-6.1	12.1	10.1	-3.6	2.9	1.7	17.1
QD (thous. tonnes)	-22.1	43.8	36.5	-13.3	10.6	-1.1	54.4

the following sections, each endogenous variable is examined separately under *ceteris paribus* conditions.

The Influence of Changes in Lagged Wheat Prices

The data displayed in Table 5.14 indicated that a 10 per cent increase in 1974 wheat prices (about 15.5 dollars per tonne) would result in a decrease in the 1975 rapeseed acreage of about 270 thousand acres. Since wheat and rapeseed compete for limited agricultural land on the Prairies, a relatively favourable wheat price would naturally discourage rapeseed production, and shrink the annual average rapeseed supply of about 106 thousand tonnes. Further chain effects would be reflected in a decrease in both exports and crushings of about 90 thousand and 16 thousand tonnes, respectively. Moreover, the decrease in crushings would mean a decrease in the production of rapeseed oil of roughly 6 thousand tonnes provided that the yield of rapeseed oil or the oil-extraction ratio averaged about 39 per cent. The decrease in the production of rapeseed oil would result in a concomitant decrease in consumption of vegetable-oil products of about 22 thousand tonnes. However, this estimation would only agree with reality provided that the ratio of rapeseed oil used in the production of vegetable-oil products remained at about the 28 per cent level; and that the amount of vegetable-oil products available for consumption was identical to the domestic production of vegetable-oil products.

Conversely, for a given level of demand, the reduction in rapeseed supply would result in an increase of rapeseed prices of about 35 dollars per tonne. The reduction in the production of rapeseed oil would increase the average price of vegetable-oil products by approximately 272 dollars per tonne.

Similar sequences, but in the opposite direction, would occur if lagged wheat prices declined because all the endogenous variables were sensitive to changes in wheat prices. Nonetheless, it should be stressed that the above results were measured under ceteris paribus conditions. In reality, at the same time that wheat prices had changed by 10 per cent, other economic variables, such as the prices of rapeseed and U.S. soybeans, and the level of personal expenditures, would likely have changed too. Therefore, caution should be exercised in interpreting the results.

The Impact of Changes in Lagged Rapeseed Prices

Table 5.14 also indicated that the immediate impact of an increase in the lagged rapeseed price of 31 dollars per tonne, or 10 per cent of the 1974 price, would be an increase of 535 thousand acres of rapeseed acreage. The concomitant effects would be an increase in supply of 210 thousand tonnes. The increased supply would be allocated between the foreign and domestic market outlets in the order of 178 thousand and 31 thousand tonnes, respectively. Furthermore, an additional 12 thousand tonnes of rapeseed oil and 44 thousand tonnes of vegetable-oil products would be produced. On the other hand, at a given level of demand for rapeseed and its products, the current rapeseed price and the average retail prices of vegetable-oil products would drop roughly 69 and 540 dollars per tonne, respectively, as the lagged rapeseed price and the current supply increased.

The Impact of Changes in Rapeseed Yield

The supply of rapeseed could be increased either by increasing acreage or by increasing yield. The impact of a change in rapeseed yield on the endogenous variables would be similar to that of a change in the previous rapeseed farm price; except that the yield would not affect the acreage planted to rapeseed in the current year. In theory, an increase in acreage could result in a scarcity of labour and equipment and thus reduce the yield. No study has been found which has investigated the relationship between intensive and extensive farming and yield. Hence an assumption of "no-casual-relationship" between acreage and yield was adopted in this study.

As shown in Table 5.14, a 10 per cent increase in rapeseed yield would increase supply by about 169 thousand tonnes. Also, rapeseed exports and crushings would increase 143 and 26 thousand tonnes, respectively. As well, there would be increases in the production of rapeseed oil by 10 thousand tonnes and by 37 thousand tonnes in the consumption of vegetable-oil products. In contrast, prices of rapeseed at the farm level and the retail prices of vegetable-oil products would decrease about 117 and 921 dollars per tonne, respectively.

The Impact of Changes in the Prices of U.S. Soybeans

An increase in U.S. soybean prices, ceteris paribus, would favour the export of rapeseed from Canada, because it would mean that rapeseed had become relatively cheaper in international oilseed markets. Given a certain quantity of supply, an increase in exports would result in a corresponding decrease in domestic crushings. The latter would cause decreases in the production of rapeseed oil and likely, in the quantity of vegetable-oil products available for consumption. Here again, it was assumed that the ratio of rapeseed oil used in the manufacture of vegetable-oil products remained unchanged. On the other hand, farm rapeseed prices, and the retail prices of margarine, shortening and salad oil would all increase as a result of the increased export demand for rapeseed and the reduction in the supply of vegetable-oil products.

In 1975, the U.S. soybean price expressed in Canadian currency was 196 dollars per tonne. An increase of 10 per cent in U.S. soybean prices would not affect the rapeseed acreage and the supply, but would increase exports by about 10 thousand tonnes and decrease crushings by the same amount. Furthermore, it would decrease the production of rapeseed oil by about 4 thousand tonnes and vegetable-oil products available for domestic comsumption by roughly 13 thousand tonnes. Conversely, as U.S. soybean proces increased approximately 20 dollars per tonne, farm rapeseed prices would increase by about 21 dollars per tonne, and the average price of vegetable oil products roughly 164 dollars per tonne.

The Impact of Changes in Personal Expenditures

The immediate impact on the rapeseed industry of an increase in domestic personal expenditures would be an increase in the consumption of vegetable-oil products. The indirect, or derived effects, would be an increased demand for crude rapeseed oil and thus crushings. Simultaneously, prices for related raw materials, as well as for final commodities would rise. Conversely, a certain portion of the rapeseed, otherwise exported, would be crushed domestically.

As illustrated in Table 5.14, an increase of 10 per cent or 9.7 billion dollars in personal expenditures in Canada in 1975 would have immediately increased domestic consumption of vegetable-oil products by some 11 thousand tonnes. Moreover, it would have induced an increased demand of 3 thousand tonnes for crude rapeseed oil, as well as an additional 8 thousand tonnes of rapeseed crushings. At the same time, the implication of upward changes in demand, with a given supply, is that farm rapeseed prices would have risen by 6 dollars per tonne and retail prices of vegetable-oil products by about 49 dollars per tonne. However, exports of rapeseed from Canada would have decreased by 8 thousand tonnes if the quantity of "other use" (other than exports and crushings) remained unchanged.

The Impact of Changes in Exports of Rapeseed Oil

Since 1973, Canada has exported rapeseed oil. An increase in oil exports would result in increased demand for oil production and hence seed crushings. At a given quantity of rapeseed supply, an increase in crushings would result in a decline in seed exports. While, at a certain amount of supply of rapeseed oil, an increase in oil exports would result in a decline in domestic utilization of crude rapeseed oil and thus the availability of vegetable-oil products if other ingredients of the latter remained unchanged. As the above mentioned changes in market structures were initiated by an increase in demand, prices of raw rapeseed and its final products would be increased accordingly, at least in the short run.

For example, an increase in oil exports of 10 percent, or about 2 thousand tonnes of rapeseed oil would require the production of an additional 1.7 thousand tonnes of rapeseed oil and the transfer of 300 tonnes that would otherwise be used for manufacturing margarine, shortening and salad oils. Other related changes would be an increase of 4.4 thousand tonnes of crushings, but a decrease by the same amount of rapeseed exports. In spite of the fact that overall demand and supply conditions associated with raw rapeseed remained unchanged, an increase in exports of rapeseed oil would reduce the supply of rapeseed oil to food manufactures. This would raise the price of crude rapeseed oil. Moreover, assuming that marketing margins remained unchanged, farm rapeseed prices would rise 4 dollars per tonne and retail prices of vegetable-oil products about 28 dollars per tonne. As a result of the latter, consumption of vegetable-oil products would decline by slightly more than one thousand tonnes.

The Combined Impact

The last column of Table 5.14 illustrates the combined effects of all the changes in the above factors. The direction and magnitude of change in the endogenous variables would, of course, depend on the number of predetermined variables included in the analysis and their relative influences. In the aggregate model, 19 exogenous variables were specified. Alternative consequences of changes in different combinations of those exogenous variable could, at different levels, be further traced to analyse the policy implications of planned or potential changes with respect to the production and marketing of rapeseed and vegetable-oil products.

The results displayed in Table 5.14 disclosed that the magnitude of the impact on an endogenous variable, of the combined effect of changes in several independent variables, was smaller than the effect of a single independent variable; for example, lagged farm wheat prices and rapeseed prices had opposite effects on the current rapeseed acreage so that if both prices moved in the same direction, one would substantially offset the other. Therefore, the combined effect was smaller than the individual effect. In contrast, lagged rapeseed prices and current rapeseed yield had similar effects on rapeseed supply. If both variables moved in the same direction, each would reinforce the other. In this case, the combined effect would be greater than the individual effect. This implied that in order to appropriately measure the impact of changes in an independent variable on values of endogenous variable, the impact of the change in that independent variable on other independent variables should first be determined. Then the overall impact of changes in that independent variable on the endogenous variables should be assumed in terms of the combined effects of its change with that of other relevant independent variables.

D. Projections of Endogenous Variables to 1980

In order to formulate sound policies, decision-makers have always tried to anticipate the future. Increasing emphasis is being placed by forecasters nowadays on the application of statistical methodology to assist in making predictions. Three commonly applied techniques are extrapolation, regression and model-building.[15] Extrapolation is an excellent forecasting tool for a quick first approximation and is particularly useful when background data is limited. In regression, the forecasters use explicit statistical methods to assess the relationships among factors under investigation, and then predict the future situation with expection that new data must be generated in conformity with past relationships.

The most formal of the statistical tools is the model building approach. As evolved in this study, theory is first applied to understand the phenomena under consideration, and the most logical relationships are then expressed in a set of mathematical equations. The latter are a representation of the key features of reality in a manageable form. In the process of forecasting, using pre-determined projections for tne exogenous variables, the model generates answers for the endogenous variable which, in turn, represents the phenomena that

[15] E.C.L. Henderson, "The Crystal-Ball Game", Optimum: A form for Management, Vol. 1, No. 4 (1970) Pag. 28.

the forecaster wants to predict. The forecasting results are conditional, in the sense that they are made under given model specifications, and given projected values of the exogenous variables. Therefore, congnizence should always be taken that the model is only an aid to forecasting and not a substitute for judgement and common sense. The results of conditional projections will only agree with reality if the assumptions which constitute the underlying conditions are in fact realized. As one economist succinctly put it:

> " before any reliance can be placed on the actual numerical relationships produced by the model, it will be necessary to take explicity account of the uncertainties surrounding the dynamic casual structure of the model, the estimated coefficients in the equations, and the forecasts of exogenous variables".[16]

In this section five sets of values of the endogenous variables were projected using different assumptions with respect to the predetermined variables, as discussed below. These projections were made in a systematic way utilizing the econometric model designed in Chapter 4 and the aid of computer program. Thus, interested users can update the projections as new data becomes available or make alternative projections based on different assumptions.

Specification of Assumption

As discussed in detail in Section A of this Chapter, adjustment factors determined for rapeseed yield, the yield of rapeseed oil, and the ratio of rapeseed oil used in the production of vegetable-oil products were, in the projection period, assumed to remain at the levels prevailing

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[16] J.F. Helliwell, "Econometric Analysis of Policy Choices for an Open Economy", The Review of Economics and Statistics (November 1969), Pg. 398

over the 1973-75 period. Also the marketing margin between retail prices for vegetable-oil products and farm rapeseed prices was assumed to remain at the level of the 1960-75 average as presented in Table 5.5.

After a careful review of the historical data, it was assumed that rapeseed carry-over both at the beginning and end of a year, would remain at the 1973-75 average level; that the "other use" of rapeseed would account for about 22 per cent of the annual average supply of rapeseed; that no new government programs would be introduced and no substantial structural changes in the market would occur. The above basic assumptions were used in each scenario.

For the purpose of illustration, six predetermined variables were arbitrarily chosen as "key factors" affecting the operation of the rapeseed industry. These were lagged wheat prices (LWP), the price of butter (PB), domestic personal expenditures on goods and services (EXP), exports of rapeseed oil from Canada (XRO), private expenditures of rapeseed importing countries (JEY), and prices of U.S. soybeans (PUS). Three different levels of growth rates, namely "high", "normal", and "low", for each of these variables were assumed.

As shown in Table 5.15 the normal growth rates for LPW, PB, JEY and PUS was based on the assumption that these variables would increase in the 1976-80 projection period at a rate between 6.4 and 7.5 per cent annually, commensurate with the growth rates experienced during the analytical period. The normal growth rate of EXP was determined according to the projection of personal disposable income made by TRACE econometric model of the Canadian economy.[17] The annual growth rate would be 9.5 per cent. High and low growth rates

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[17] D.K. Foot, et al., The Ontario Economy 1977-87 (Toronto, Ontario: The Ontario Economic Council, 1977), Table 2.10.

Table 5.15

Average Values for Selected Exogenous Variables
and Growth Rates Assumptions for 1976-80

Variables and Units	1973-75 Average	High Growth	Normal Growth	Low Growth
		per cent		
Lagged Wheat Prices (dollars per tonne)	129.1	8.0	6.4	5.0
Price of Butter (dollars per tonne)	2,034.3	8.0	6.4	5.0
Domestic Personal Expenditures (billion dollars)	83.9	11.0	9.5	8.0
Personal Expenditures in Rapeseed Importing Countries (billion dollars)	356.1	9.0	7.5	6.0
U.S. Soybean Price (dollars per tonne)	216.8	8.0	6.4	5.0
Rapeseed-Oil Exports (thousand tonnes)	27.5	100.0	0.0	-100.0

for LPW, PB, JEY, PUS and EXP would be 1.5 percentage-points above or below their corresponding normal growth rates. Data on XRO prior to 1972 were not available. The 1973-75 average level of exports of rapeseed oil was assumed as the most likely quantity to be exported over the 1976-80 period. The optimistic assumption was for exports to double to 55 thousand tonnes annually. On the other hand, the pessimistic assumption was based on no rapeseed oil exports at all.

The combination of the different growth rates for the different variables resulted in different scenario projections. Table 5.16 summarized the various assumptions made for each scenario.

Scenario 1: (Normal) This projection was made on the assumption that the economic and political environment both in Canada and foreign countries would be fairly stable, i.e. past growth experiences would continue in the near future. The relevant projection results could be referred to as the "normal" scenario. As displayed in Table 5.16, all chosen "key" exogenous variables were assumed to grow at rates prevailing in the analytical period or projected by independent sources.

Scenario 2: (High Crushings) This projection was made on the assumption that the domestic economic environment would positively stimulate growth of the rapeseed industry, particularly the domestic crushing of rapeseed. The projections could be referred to as the "high crushings" scenario. However, it should be remembered that changes in one exogenous variable could have opposite effects on different endogenous variables. A large increase in crushings could, for example, result in a relatively slow growth of exports because the available supply of rapeseed is mainly distributed between crushings and exports.

Table 5.16

Specification of Assumptions Regarding Growth Rates for Selected Exogenous Variables for Alternative Projections

Exogenous Variables	Scenarios of Low Crushings	High Crushings	Normal Growth	High Exports	Low Exports
Lagged Wheat Prices	H	L	N	L	H
Price of Butter	L	H	N	L	H
Domestic Personal Expenditures	L	H	N	L	H
Personal Expenditures of Rapeseed Importing Countries	H	L	N	H	L
U.S. Soybean Prices	H	L	N	H	L
Exports of Rapeseed-Oil	L	H	N	L	H

H: High Growth
N: Normal Growth
L: Low Growth

More specifically, it was assumed that the increase in the lagged farm price of wheat would be about 1.5 percentage-points lower than the normal growth rate, i.e., the growth rate would be 5 per cent instead of 6.5 per cent (Table 5.15). The implication was that, while rapeseed prices would increase at the noraml growth rate, the rapeseed-wheat price ratios would become wider and in favour of rapeseed production with its concomitant consequences.

The second assumption was that the price of butter would increase at a rate of 8 per cent, which was greater than the "normal growth" (Table 5.15). As a result, it was expected that the demand for animal fats (the substitutes of vegetable oil products) would be weakened. This implied that the consumption of vegetable oil products, and thus the demand for domestic crushings, would increase even faster.

In addtion to the favourable domestic conditions for crushings, three additional favourable "foreign conditions" were also assumed. First, it was assumed that the price of U.S. soybeans and the income level of rapeseed importing countries would increase slower than the normal growth rates as specified in Table 5.15. In addtion, a doubling of the volume of exports of rapeseed oil was assumed. Thus, international conditions might create a better opportunity for expanding domestic crushings. This scenario could flow from the fact that price competition in international oilseed markets was strengthened; that the relative purchasing power of rapeseed importers was weakened; that the reduction in exports of rapeseed increased the availability of rapeseed for crushings; and that an increase in exports of rapeseed oil required a concomitant increase in crushings. The possibility that all such conditions for crushings would occur in one year might be marginal.

The projection results can thus be viewed as a very optimistic scenario of expanding domestic crushings.

Scenario 3: (Low Crushings) Conditions opposite to the above scenario was referred to as the "low crushings" scenario. As displayed in Table 5.16, all unfavourable domestic and foreign conditions for crushings were assumed to be occurring at the same time. Briefly, these included low growth rates for PB, EXP and XRO and high growth rates for LWP, JEY and PUS. These rates were specified in Table 5.15. It was expected that crushings would be extremely small under the above postulated assumptions.

Scenario 4: (High Exports) All the assumptions regarding the selected key factors, except the lagged wheat price, were reversed to those postulated in scenario 2. While assumptions relating to other predetermined variables were kept the same as those in the above scenarios, the implication of increasing LWP, PB and EXP at low rates, as specified Table 5.15, would be a faster than normal rate of increase in rapeseed acreage and its related supply but slower than normal growth in the consumption of vegetable oil products and thus crushings. Therefore, the degree of dependency on international markets as an outlet for Canadian rapeseed would be increased.

In addition this scenario also assumed that no rapeseed oil would be exported, and that both U.S. soybean prices and the level of incomes in oilseed importing countries would increase faster than the normal growth rates, as specified in Table 5.15. Thus the rapeseed trade environment would strongly favour Canada. This set of projections was characterized as the "high exports" scenario, because it was very optimistic about trade conditions.

Scenario 5: (Low Exports) In contrast to the above scenario, all unfavourable domestic and foreign conditions for exports were assumed. Detailed specification of the assumptions was given in Table 5.16 and the growth rate for each variable was specified in Table 5.15. It was concluded that not much success could be expected in attempting to export rapeseed under this "low exports" scenario.

Projection Results

The above scenarios were designed to yield ranges of estimates for the endogenous variables according to different assumptions about the future. The projections were made following a computer program as indicated in the following self-explanatory flow-chart showing the procedure underlying annual forecasts of the endogenous variable to 1980 (Figure 5.9).

Table 5.17 shows that under the assumptions made in Scenario 1, rapeseed acreage in Canada in 1980 would be about 4.5 million acres and the supply of rapeseed about 2.3 million tonnes. Insofar as the distribution of supply is concerned, exports would account for 40 per cent, crushings about 20 per cent, and carry-over and other uses 40 per cent. About 168 thousand tonnes of rapeseed oil would be produced, and a half million tonnes of vegetable oil products consumed. The price of rapeseed and vegetable oil products would be around 340 dollars and 2,200 dollars per tonne respectively.

Detailed presentation of the foregoing results is not intended to suggest that this particular scenario of the Canadian rapeseed industry would most precisely reflect conditions in 1980. Rather, they were presented to illustrate the parameters that would confront decision-makers, given the conditions specified in the model.

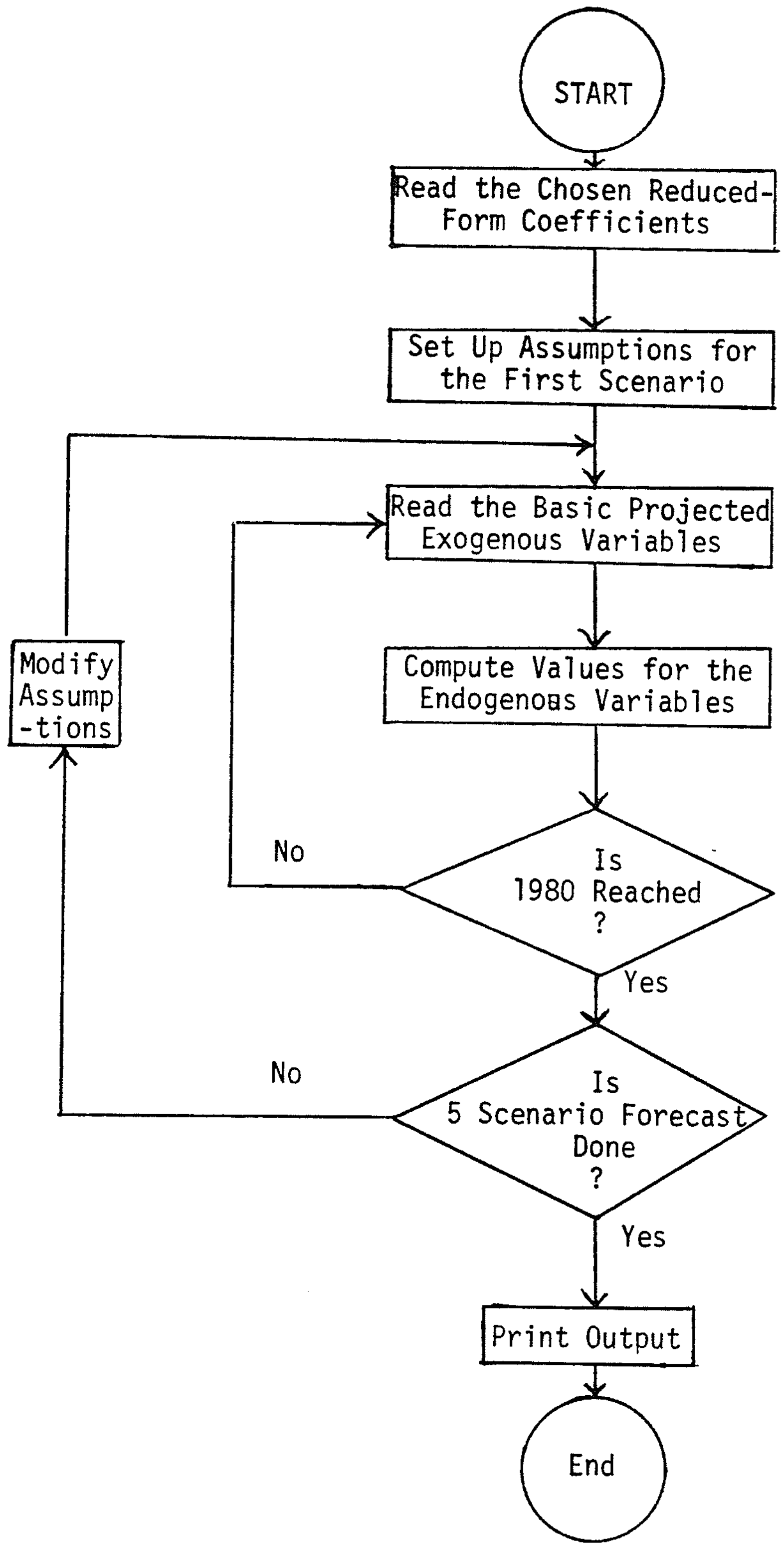

Figure 5.9:

A Flow-Chart Showing the Procedure Underlying Alternative Projections of Values for the Endogenous Variables to 1980

Table 5.17

Conditional Projections of Exogenous Variables for 1976 to 1980: the Normal Growth Scenario

Variables	1976	1977	1978	1979	1980
RAC (thousand acres)	3,194	4,032	4,178	4,334	4,497
QS (thousand tonnes)	2,280	2,142	2,199	2,260	2,324
TRX (thousand tonnes)	755	802	845	891	940
PR (dollars per tonnes)	247	266	290	315	343
PVO (dollars per tonnes)	1,465	1,617	1,804	2,002	2,217
QRC (thousand tonnes)	373	388	402	417	433
QRO (thousand tonnes)	145	150	156	162	168
QD (thousand tonnes)	422	443	463	484	506

Table 5.18 completes the process and presents comparable projections for 1980 for the various scenarios. The forecasting results vary substantially from one scenario to another. For example, the export of rapeseed could lie between a range of 800 thousand tonnes and 1.1 million tonnes, while crushing could vary from 330 to 540 thousand tonnes in 1980. This reveals that the endogenous variables are very sensitive to changes in the six selected variables. This underlines a key fact, often overlooked in modeling and prognosis. Frequently, a model is blamed for poor forecasting results when the problem is more accurately located with the selection of appropriate "environmental" factors in the period where policy tools are expected to operate. In the interest of objectivity, it is always preferable to use independent forecasts of conditions in the relevant period, although these are seldom available in the desired form.

In any case, it must be stressed that, whether developed by the model-builder himself or secured from other sources, an accurate forecast of the pre-determined variables is a curcial and indispensable requisite for making subsequent forecast of those industry characteristics for which policies are designed to affect behaviour in the desired direction.

Table 5.18

Comparative Conditional Projections of Endogenous Variables for 1980, Various Scenarios

Variables and Units	Low Crushings	High Crushings	Normal Growth	High Exports	Low Exports
RAC (thousand acres)	4,368	4,607	4,497	4,607	4,368
QS (thous. tonnes)	2,273	2,367	2,324	2,367	2,273
TRX (thous. tonnes)	991	833	940	1,071**	803*
PR (dol. per tonne)	375	318	343	344	349
PVO (dol. per tonne)	2,471	2,024	2,217	2,230	2,265
QRC (thous. tonnes)	331*	533**	433	345	519
QRO (thous. tonnes)	128	206	168	134	201
QD (thous. tonnes)	463	546	506	482	527

* The lowest crushings or exports.
** The highest crushings or exports.

CHAPTER 6

SUMMARY, CONCLUSIONS, LIMITATIONS AND RECOMMENDATIONS

A. Summary

The Canadian rapeseed industry has experienced such rapid changes in all segments of the industry in a relatively short time period, that many of those involved have been unable to adjust adequately to cope with the new environment. Because the segments of the industry appear to interact so sensitively, it seemed inescapable that any study of the industry should take an appropriately broad view.

Initially, a fifteen-equation system was developed in which ten structural relationships were sub-divided into four blocks: namely, the rapeseed supply block, the rapeseed exports block, the domestic utilization of rapeseed oil block, and the consumption of vegetable-oil products block. The behavioural equations within each block were estimated at the disaggregate level by using ordinary least squares, two-stage least squares or three-stage least squares wherever applicable. All the postulated hypothesis were subjected to the F-test, the t-test, or the Darbin-Watson d-test. Results of the individual behavioural equations supported, in general, the proposed hypothesis and thus could be used to assist in understanding the operation of the industry. Moreover, each behavioural equation specified in the system could be either horizontally or vertically integrated through the relationships indicated by the technical and identity equations, thereby revealing how the equilibrium positions among segments of the industry were simultaneously determined. Unfortunately, annual data for the block relating to the domestic utilization of rapeseed-oil were available only for the period from 1967 to 1974. Because the number of observations were insufficient, that block could not be included in the broad demand-supply model of the industry. As an alternative, a modified aggregate model comprising an eight-equation system, was developed.

One major difference between the disaggregate and the aggregate model was the different treatment of prices of vegetable-oil products. Since there are only a few major manufacturing companies producing vegetable-oil products in Canada, each company supplies a significant portion of the market and thus has its own influence on determination of market prices. To a fairly large extent, each is a "price maker" for its own product. Therefore, the individual prices for each product were treated as predetermined variables in the disaggregate model. However, considering the market for vegetable-oil products as a whole, regardless of the nature of the market structure, the equilibrium price and quantity were of course determined at the intersection of the aggregate demand and supply curves. Since both the quantity demanded and the prices of vegetable-oil products were co-determined, and thus regarded in the aggregate model, they were treated as endogenous variables.

In addition, in the disaggregate model, each of the above mentioned blocks was comprised of three behaviourable equations, except the Canadian rapeseed supply block which was represented by only one equation. In the aggregate model, each block was reduced to a single equation, although the block for the domestic utilization of rapeseed-oil was dropped. However, the utilization ratio of rapeseed-oil was explicitly introduced into the system by using the actual ratio in the identity equation with respect to the market-clearing of rapeseed oil.

The methods of ordinary least squares and instrumental variable regression were applied to the 1960-74 and 1960-75 data respectively, in order to estimate the structural coefficients of the behavioural equations specified in the aggregate model. Consequently, four different sets of structural coefficients and their corresponding reduced-form coefficients were obtained. According to the criteria commonly applied to evaluate regression equations and the predictive ability of a system of equations, the reduced-form equations derived from the 1960-75 structural coefficients which, in turn, were estimated by the IVR method, exhibited the best performance among the alternatives. Based on those results, a number of conclusions were drawn about responsiveness to change in the various segments of the industry.

B. Observation and Conclusion

1. Rapeseed has now firmly established itself at Canada's fourth largest field crop in terms of acreage. However,it still appears to be considered as little more than an inferior substitute for wheat. Since the production of the latter has been particularly sensitive to weather conditions, and uneven food production in the world, the production of rapeseed has been subject to comparable but inverse fluctuations. Accordingly, the acreage devoted to rapeseed has exhibited an erratic growth pattern.

2. Rapeseed production is the product of the yield per acre and the relevant acreage cultivated. Yield has remained relatively stable during the past two decades, and rapeseed breeders have concentrated on the improvement of quality by developing a variety with low erucic acid and low glucosinolate. While there have been increased in the number of rapeseed growers, many lacked production experience and tended to offset whatever yield improvements were made by the experienced producers. As a result, variations in production were mainly attributable to variations in rapeseed acreage.

3. The acreage cultivated to rapeseed varied from a low of about 370 thousand acres to a high of 5.3 million acres over the 1960-75 period, and was affected by a number of economic and non-economic factors. Among these, changes in government programs, lagged wheat and rapeseed prices and lagged rapeseed acreage were able to explain about 94 per cent of the fluctuation in rapeseed acreage in Canada.

4. Introduction of the LIFT program caused Canadian rapeseed acreage in 1970 to be greater than would otherwise have been the case by 2.4 million acres. Such an increase represented more than one-half of the 1970 total acreage. The program aimed at alleviating the wheat surplus problem cost Canadian approximately by 63 million dollars; and while the broad benefits and costs remain unknown, it is certain that the program had a significant impact on producers' decisions regarding the allocation of their land.

5. The short-run elasticity of rapeseed acreage with respect to changes in lagged wheat prices was -0.63, confirming the hypothesis that wheat and rapeseed compete for agricultural land on the Prairies. This short-run elasticity of rapeseed acreage with respect to changes in lagged rapeseed prices was elastic (1.13), implying that rapeseed producers were more sensitive to changes in farm rapeseed prices than to changes in the prices of competing crops.

6. The proceeding conclusion merely reflects the fact that an increase in the price of rapeseed would benefit rapeseed producers and substantially encourage greater cultivation. However, while decreases in the price of wheat would discourage wheat production and stimulate rapeseed growing, it must be recognized that rapeseed is only one of the alternatives to grain production. Therefore, the responsiveness of

rapeseed acreage to changes in wheat prices would be relatively moderate in terms of wheat acreage. This is really not inconsistent with the above mentioned conclusion for wheat acreage is much greater than rapeseed acreage and a small change in the former could be reflected in a relatively great change in the latter. Nevertheless, the statement that "the wheat industry dominates the Canadian agricultural industry" is still valid. However, rapeseed producers appear to be becoming relatively more sensitive to changes in both farm prices of wheat and rapeseed itself, than to non-economic factors as reflected in the direct-price and indirect-price elasticities of rapeseed acreage for the 1973-75 period and the comparable elasticities over the 1960-75 period.

7. Due to technological and biological constraints, institutional rigidities, and ingrained habits, rapeseed producers are unable to adjust quaickly to the changing environment. When an equilibrium condition was disturbed, for example, only about 38 per cent of the desired amount of adjustment towards a new equilibrium could be made in the short-run (one year); and roughly 6 years were needed to complete the full adjustment.

8. The United States has been experiencing a high rate of increase in the production of soybeans and a relatively slow growth in the consumption of vegetable-oil products. Thus it has a considerable volume of oilseeds avaiable for export, and is expected to continue to dominate international oilseed markets. Because soybeans and rapeseed are fairly close substitutes, and Japan and the E.E.C. are the major destinations both for U.S. soybeans and Canadian rapeseed, it was concluded that the availability of U.S. soybeans will continue to be the major infuence on opportunities for Canadian rapeseed in world markets

in the near future.

9. Japan has been the largest single market for Canadian rapeseed. In view of their increasing consumption of vegetable-oil products, of their increasing demand for oilseed meal, and of their declining production of oilseeds, it can be expected that Japan will continue to be a major oilseed importer and thus a prime market for Canadian rapeseed.

10. While the European Economic Community has been the second largest market for Canadian rapeseed, there have been significant annual variations in imports from Canada for what might be called political reasons: Eighteen African countries have associate membership in the E.E.C. and receive tariff preferences for their exports to the E.E.C. as well as other economic and technical assistance. Thus economic factors alone cannot fully explain fluctuations in exports of rapeseed from Canada to that region. Accordingly, greater penetration of that market is likely to be more a function of government policies than of the market place. This is reinforced by the fact that as a general rule there are no tariffs on raw oilseeds, but there are on derived products in most of oilseed improting countries as a means of protecting their secondary industries. These and other factors have had a significant influence on the volume of trade. However, to a large extent, influctuation in the quantity of rapeseed exported from Canada can be explained in terms of the following factors: Prices of U.S. soybeans and Canadian rapeseed, the level of personal expenditures in rapeseed importing countries and changes in the rapeseed market structure in Canada.

The elasticities of export demand for rapeseed, with respect to the price of rapeseed and the price of U.S. soybeans were -0.72 and 0.76 respectively over the 1960-75 period; and -0.82 and 0.69 over the 1973-75 period. This implied that during the sixties, rapeseed importers were more sensitive to changes in soybean prices than to changes in the price of rapeseed itself. However, the reverse situation has been true in recent years. In other words, the influence of rapeseed prices on the volume of trade has become relatively more significant in recent years.

11. The elasticity of export demand for rapeseed which can be characterized as relatively inelastic was reflected in the related income elasticity which increased from 0.69 over the 1960-75 period to 0.88 over the 1973-75 period. This meant that although the growth rate of rapeseed imports in those countries under investigation would be slower than that in their income levels, rapeseed could be viewed as a "necessary" commodity in the oilseed importing countries since the income elasticity was less than unity.

12. Rapeseed oil and meal are jointly produced during the crushing of rapeseed. The expansion of rapeseed crushing thus depends on increases in the consumption of both oil and meal. Over the past two decades, while the Canadian livestock and poultry industry has expanded by more than a third, in terms of the numbers of livestock and poultry on farms, the production of feed grains and hay has remained relatively stable. Thus the consumption of oilseed meal has been increasing. Rapeseed meal, in terms of nutritive quality, has been gaining acceptance and its use in all livestock and poultry rations has been increasing in recent years.

13. The demand for rapeseed oil is affected, not only by the volume of rapeseed oil used in the production of vegetable-oil products, but also by the consumption of margarine, shortening and salad oils. While domestic per capita consumption of fats and oils, as a whole, has

not increased to any extent, there has been a notable change in the substitution of vegetable-oils for animal fats over the past two decades.

14. The short-run elasticities of demand for vegetable-oil products with respect to the average price of vegetable-oil products and the price of butter were -0.28 and 0.17 respectively over the 1960-75 period and -0.30 and 0.16 respectively over the 1973-75 period. While demand responsiveness appeared quite moderate in both cases, it was concluded that in the process of substitution between fats and oils, prices of vegetable-oil products had relatively more important influence than the price of butter; and that consumers had become relatively more sensitive to changes in the prices of vegetable-oil products in recent years than to changes in the prices of their substitutes.

15. The short-run elasticities of demand for vegetable-oil products, with respect to personal expenditures, were 0.32 and 0.42 for the period 1960-75 and 1973-75 respectively, suggesting that vegetable-oil products can be classified as "necessary" commodities.

Habit appeared to play a strong role in the consumption of vegetable-oil products as decisions about current consumption were positively affected by previous consumption patterns. At the same time there has been a tendency to substitute vegetable-oils for animal fats and marine oils in the manufacture of the vegetable-oil products. This trend has developed partly because of the belief that vegetable-oils are better for health reasons and also because vegetable-oils have had a competitive price advantage over animal fats and oils.

Among vegetable oils themselves, in spite of the varying rates of use of rapeseed oil in the production of different oil products, there has been a strong trend towards substituting rapeseed oil for soybean and other crude vegetable oils. This substitution was aided by a pronounced improvement in the quality of rapeseed oil, by increased acceptance of rapeseed oil in the manufacturing of oil products, by the continued expansion of the supply of rapeseed oil, and the competitive price advantage of rapeseed oil over the imported crude vegetable oils.

16. The oilseed crushing industry is one of the fastest growing industries in Canada. While soybeans continue to occupy a dominant position as the oil-yield of rapeseed is more than double that of soybeans, rapeseed oil production has exceeded soybean oil production during the most recent years. The expansion of rapeseed crushings as noted earlier; has been mainly attirubtable to the expanded domestic utilization of rapeseed oil by the food processing industry. The latter has, in turn, resulted from the increasing ratio of rapeseed oil used in the production of vegetable-oil products, as well as the increasing substitution by consumers of vegetable-oil products for those made of animal fats. To a lesser extent, the expansion of crushings has been due to the gaining of an increasing share of the international edible oil market.

17. As the Chow-test indicated that the structural coefficients estimated from 1960-74 and the 1960-75 were in a statistical sense, equal, it was concluded that the economic relationships specified in the behavioural equations were stable over the two sample periods.

18. Using the estimated structural coefficients, it was possible to solve the corresponding reduced-form coefficients. In the aggregate model, there were eight reduced-form equations and; each equation, an endogenous variable was expressed as a function of the specified 19 exogenous variables. In light of the evaluation of the reduced-form equations, performance of the model was judged satisfactory, provided

that it was understood that estimation errors could be magnified in circumstances where there was "irregular" behaviour. The predictive capability of the model was also considered to be quite reliable, provided that accurate forecasts of the exogenous variables were available.

19. The combination of different growth rates for the different exogenous variables produced alternative scenarios for the period up to 1980.

The basic projections were made on the assumptions that the economic and political environment both in Canada and abroad would be fairly stable; implying that increases in exogenous variables would be commensurate with growth rates experienced during the analystical period. The results indicated that, in 1980, rapeseed acreage in Canada will be approximately 4.5 million acres, and supply about 2.3 million tonnes. Exports and crushings will amount roughly to 940 and 410 thousand tonnes, respectively; and approximately, 170 thousand tonnes of rapeseed oil will be produced and a half million tonnes of vegetable-oil will be consumed. The prices of rapeseed and vegetable-oil products will be around 340 dollars and 2,200 dollars per tonne, respectively.

20. The acreage devoted to a crop has commonly been used by the argibusiness sector as the most important indicator for gauging the future prospects of that crop. If the projected 4.5 million acres is realized, it would mean that acreage would gradually increase from the depressed 1976 level of about 2 million acres, but not quite break the record 5.3 million acres grown in 1971. Overall, then,

there appears to be a bright future for the Canadian rapeseed industry, particularily, in view of the apparent realignment of crop priorities by Prairie farmers, indicating a shift from wheat to more marketable oilseed production, at least in the near future.

C. Limitations of the Study

As stated on several occassions, the main purpose of this study has been to formulate an econometric model in order to explain the workings of the rapeseed industry as well as to provide a foundation for predicting future potential changes within the industry. This was motivated by a hope that the results would, at least the first approximation, be helpful to decision-makers for formulating sound policies; or, at the very least provide an educational experience. In any case, a word of caution is due, given that this study was undertaken certain limitations.

Realism and Simplicity

Any analyst has to face a choice between realism and simplicity. In this study the final revision of the aggregate model showing the supply and demand for Canada's rapeseed was expressed by a set of eight structural relationships, comprising 8 equations, 8 endogenous variables and 19 predetermined variables. The model specification was based on knowledge of the operation of the industry, and of the available data and statistical techniques. An alternative approach or alternative model specification could be made if the above-mentioned conditions were different.

As reviewed earlier in Chapter 3, the logical arguments for applying the recursive approach were very strong. The oridinary least squares technique could be applied to obtain the best linear unbiased estimates of the structural parameters because each step consisted of only one endogenous variable. In the preliminary analysis, this approach was used. Later, it was realized that many distinct market outlets compete for the available supply of rapeseed at a given point in time. Any changes in the factors affecting the demand in one segment of the industry would reverberate throughout the entire industry. The nature of the mutual influence and interdependence of the segments should not be ignored. The reality of the simultaneous determination of annual prices and quantities led to the use of a non-recursive or interdependent system approach. This was judged to be especially appropriate in the absence of weekly, or even monthly data, to aid in the identification of the real casual relationships. Some day, when the monthly data become available the favoured recursive approach could be used.

Because some data were not available for the whole analytical period and the import of "foreign" variables particularily the prices of U.S. soybean oils had to be omitted in the aggregate model, an oversimplification was unavoidable in this study. While prices of U.S. soybean oils dominate international oilseed and oil markets and influence the price levels of Canadian rapeseed, rapeseed oil and related products; both palm oil and coconut-oil have been growing rapidly as a result of price advantage. Thus, weighted average price of U.S. soybean oil, palm oil and coconut oil was adopted as the more appropriate explanatory variable in the production functions for margarine, shortening and salad oils in the disaggregate model. Later, due to data limitations as noted above, the domestic utilization of rapeseed oil block, comprised of the margarine, shortening and salad oil functions, was not included in the aggregate model.

Consequently, but unfortunately the price of U.S. soybean oil could not be used as an exogenous variable in the aggregate model. It is fair to say that if the latter variable was included, it would have made the model more solid in predictability. In the current study, this serious weakness was compensated for by the inclusion of the price of U.S. soybeans. The latter became one of the explanatory variables of the rapeseed exports demand function.

Limitation in the Availability of Data

The history of Canada's rapeseed industry is short. Rapeseed oil was not extracted for edible purposes until 1956, rapeseed exports to Japan only started in 1960. Since Japan has been by far the largest single market for rapeseed, it would be only natural to include this aspect of demand in any system approach, thereby making it reasonable to select 1960 as the beginning of the analystical period. This would mean that there were, at most, 15 annual observations available when the empirical study was undertaken.

Furthermore, complete information on the prices of rapeseed oil and meal were only available for the period 1968 to 1974. Prior to and after this period they were not available. This has been the most serious obstacle to the integration of the segments relating to the crushings of rapeseed, the utilization of crude rapeseed-oil, and the consumption of vegetable-oil products. This has also limited the possibility of linking the rapeseed industry and the livestock and poultry industries. It is well known that rapeseed meal has been gradually accepted as a supplementary feed grain.

In facing this difficulty of data availability, the use of quarterly or even monthly data might be recommended. However no logical basis has been found for breaking annual supply data into four quarters, because rapeseed is harvested once a year. In the preliminary studies, it was found that the seasonal variations in prices of rapeseed oil were dramatically different from year to year. The normal economic relationships between quarterly (or monthly) prices of rapeseed oil, and the quantities of rapeseed oil utilized, had been significantly affected by irregular price fluctuations.

The first attempt at using quarterly data for demand analysis was not successful. However, interested researchers might like to take the moving-average approach to reduce or eliminate the irregular fluctuations, both in prices and quantities. In that case, result would improve.

Limitation in Statistical Estimation

In solving the simultaneous-equation systems, using the single-equation approach, there are method of direct least squares and indirect least squares. Using the direct least squares, the estimated structural coefficients would be biased and inconsistent, because the disturbance term and some endogenous variables used as explanatory variables in the estimating equation would be correlated.

Alternatively, the indirect least squares approach is to apply the least squares technique to the reduced-form equations and then to derive the structural parameters from the estimated reduced-form coefficients. Since, in a reduced-form equation, one endogenous variable expresses all exogenous variables in the model, the reduced-form parameters are unbiased and consistent. However, in many cases, the structural parameters dervied from unbiased reduced form parameters will be consistent, but will not be unbiased.

In order to improve the poor quality of estimation by the direct least squares method, two-stage least squares and the instrumental variable regression (a modification of 2 SLS) are commonly used. In many cases, two-stage least squares estimations are identical to indirect least squares estimations. In other words, the estimation of the structural parameters are biased but consistent. However, on the question of bias, there has been fairly general agreement among the empirical studies. Many Monte Carlo studies have been reviewed to compare bias, variance and mean square error between the ordinary least squares approach and other methods. Unfortunately, there is as yet no widely accepted method or technique for drawing operational conclusions from the many approaches.

The main reason preventing this study from applying the indirect least squares method was the serious problem of the degrees of freedom. According to the aggregate model specified earlier in this study, there were 8 endogenous variables and 19 pre-determined variables. Also, as noted, there were only 15 observations available. Since, the number of observations was less than the number of pre-determined variables, it was very difficult, if not impossible, to estimate the reduced-form parameters.

Up to this point, there should be no confusion about the deriviation of the 19 reduced-form coefficients. It is true that there are only 15 observations available. These are enough to estimate a single structural equation, although the degrees of freedom are not as numerous as desirable. However once the structural parameters are estimated, the problem of degrees of freedom no longer existes. In other words, there is no problem in deriving a large number of reduced-form coefficients from structural coefficients, although the degree of freedom available for estimating the latter would be relatively small.

In short, given the data and model specification, there seems to be no alternative but to use the direct least squares approach, although it is realized that the existing statistical technique does not produce the best unbiased linear estimates; unless monthly or quarterly data can be generated, or the model specification altered. As a supplement to this statistical limitation, a careful evaluation of performance of the derived reduced-form equations would be necessary.

D. Recommendations for Further Studies

Alternative Forecasting Technique

The forecasts made in this study were conditional, in the sense that they were made under given model specifications, given estimation methods, given projected values of the exogenous variables, and, under the assumption that the economic relationships that existed in the past would continue in the future. In any of the assumed conditions prove invalid, then it would obviously result in forecasting errors.

Due to growing demand for accurate forecasts for planning purposes both by government and the business sector, forecasting techniques have been undergoing extensive development. Recently, an advanced forecasting system, namely the LAECON system,[1] was developed, combining econometrics, Box-Jenkins methodology and aerospace theory.

Econometric techniques are widely used. However, as discussed above certain weaknesses still remain, especially the treatment of residual errors and the problem caused by the existence of correlation between the residuals and the explanatory variables. The Box-Jenkins

[1] The Lochrie & Associates Econometric (LAECON) system was developed with financial support from the General Electric Company. See R. Lochrie, The LAECON System(Milwaukee, Wis., Lochrie & Assoc., Inc., 1976).

technique is a newly developed method for time-series analysis, using advanced mathematical theory to analyze the nature of regression residuals associated with time series data.[2] For economic forecasting and planning purposes, both econometric theory and mathematics theory should be well coordinated; because a thorough understanding of economic theory is essential for successful application in any related subject area, and a command of mathematics is necessary for any empirical study. The aero-space estimation theory is applied as a link between the former to construct a practical forecasting model.

For the purposes of refining forecasting results, this newly developed technique could be applied. However, it should be noted that the LAECON system is still at the developmental stage and more of an educational experiment at this time.

Input-Output Analysis

As presented in the study, many segments constitute the rapeseed industry. However, from the standpoint of Canadian agriculture as a whole, the entire rapeseed industry is but a segment or a sector of the whole agricultural industry. Furthermore, the latter is only a sector of the whole Canadian economy. Therefore, it should be obvious that the rapeseed industry is interdependent with other industries.

In particular, the rapeseed industry is closely related to the livestock, poultry, dairy, oilseed crushing and food manufacturing industries. Unfortunately, mainly due to data limitations, the livestock and poultry industries could not be brouch into this study. In other words, it was implicitly assumed in this study, that determination of the equilibrium prices and quantities of rapeseed was not affected by the demand for rapeseed meal by the livestock and poultry

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[2] G. Box and G.M. Jenkins, Time Series Models for Forecasting and Control (San Francisco, California: Holden-Day, Inc. 1970).

industries. Had it been possible for the latter included, a better understanding of the operation of the rapeseed industry could have been achieved. This shortcoming could be overcome either by introducing into the model behavioural equations indicating the economic relationships between livestock and oilseed industries or by constructing an input-output model.

Since the pioneering work of Leontief in the 1930's, input-output analysis has grown into one of the most widely accepted methods of economic planning and decision-making.[3] Since 1961, Statistics Canada has annually constructed Input-Output tables showing the structure of the Canadian economy with a lag of our years from the reference period.[4] The technique of input-output is primarily concerned with the analysis of interdependence among industries or sectors of an economy.

From the model designed for this study, the demand for rapeseed both in foreign and domestic markets, as well as the demand for vegetable-oil products can be estimated or predicted. Any change in the demand for rapeseed and its related products would influence the quantity of production, and thus change the requirement for primary resources. Furthermore, it would directly or indirectly affect the economic behaviour of other sectors and generate a series of repercussions throughout the entire economy. Thus, findings of this study could aid understanding of the operation of the industry and help to guide more knowledgeable policy formulation.

[3]C.S. Yan, Introduction to Input-Output Economics (New York: Holt, Rinehart and Winston, Inc., 1969).

[4]Input-Output Div., Statistics Canada, "The Input-Output Structure of the Canadian Economy, 1961-66", reprinted from the Canadian Statistical Review, Cat. No. 11-003, (Ottawa, Ontario: Information Canada, February, 1975).

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APPENDIX A

The Disaggregate Supply-Demand Rapeseed Model

Specification of the Model

This appendix outlines the specification of the disaggregate model, in terms of the definition of each variable, the methods of estimation applied, and the results for the structural coefficients. Unfortunately, due to insufficient observations for some relevant variables, the corresponding reduced-form coefficients could not be derived.

The disaggregate model was formulated as a fifteen-equation system. Ten of the fifteen relationships were behavioral equations, with each equation indicating the basic economic relationships operating on that segment of the industry. The remaining five equations were technical and identification equations which reflected constraints on the level of supply and demand. They also served to hold the simultaneous system together.

Many variables were used in the preliminary analysis. Judged against the empirical results, the following model, a detailed specification of which is given below, was considered the best among the alternatives. In the following model specification, a semi-colon symbol distinguishes the two types of variables, with the endogenous variables shown before and the exogenous variables after the semi-colon.

Behavioral equations

Rapeseed acreage function for Canada:

A.1 $(RAC_t \; ; \; LIFT_t, WSTK_t, PR_{t-1}, RAC_{t-1})$

Exports of rapeseed to Japan:

A.2 $(XRJ_t, PR_t \; ; \; JY_t, JTR_t)$

Exports of rapeseed to the E.E.C.:

A.3 $(XRE_t, PR_t ; EY_t, EM_t)$

Exports of rapeseed to the "other nations":

A.4 $(XRO_t, PR_t ; ER_t, DUM1_t)$

Use of rapeseed oil in the production of margarine:

A.5 $(ROM_t, PRO_t ; POM_t, T_t)$

Use of rapeseed oil in the production of shortening:

A.6 $(ROS_t, PRO_t ; POS_t, T_t)$

Use of rapeseed oil in the production of salad oils:

A.7 $(ROA_t, PRO_t ; POA_t, T_t)$

Domestic consumption function for margarine:

A.8 $(QMA_t ; POP_t, PMA_t, PBU_t, Y_t, QMA_{t-1})$

Domestic consumption function for shortening:

A.9 $(QSH_t ; POP_t, PSH_t, PLA_t, Y_t, DUM_t)$

Domestic consumption function for salad oils:

A.10 $(QSA_t ; POP_t, PSA_t, PFV_t, Y_t, DUM_t)$

Technical and identification equations

Supply of rapeseed:

A.11 $QS_t = YQS \cdot RAC_t + RSTK_{t-1}$

Market-clearing of rapeseed:

A.12 $QS_t = XRJ_t + XRE_t + XRO_t + QRC_t + RSTK_t$

Price linkage through market margin:

A.13 $PR_t = PRO_t - MM_t$

Production of rapeseed oil:

A.14 $QRO_t = YRO_t \times QRC_t = 0.40\ QRC_t$

Market-clearing of rapeseed oil:

$$A.15 \quad QRO_t = ROM_t \cdot QMA_t + ROS_t \cdot QSH_t + ROA_t \cdot QSA_t + XRO_t$$

The definition of each variable

Jointly-determined (endogenous) variables:

RAC: Rapeseed acreage in Canada

XRJ: Exports of rapeseed to Japan

XRE: Exports of rapeseed to the European Economic Community

XRO: Exports of rapeseed to the "other nations"

ROM: The proportion of rapeseed oil used relative to the amount of shortening produced

ROS: The proportion of rapeseed oil used relative to the amount of shortening produced

ROA: The proportion of rapeseed oil used relative to the amount of salad oil produced

QMA: Consumption of margarine in Canada

QSH: Consumption of shortening in Canada

QSA: Consumption of salad oils in Canada

PRO: The price of rapeseed oil

PR: The price of rapeseed

QRC: The amount of rapeseed crushed

QRO: The amount of rapeseed oil produced or consumed

QS: The amount of rapeseed supplied or demanded

Predetermined (exogenous) variables:

LIFT: A dummy variable indicating the impact of the program - Lower Inventory For Tomorrow - on rapeseed acreage

WSTK: The years when national wheat stocks exceed 650 million bushels, which is considered unacceptable

JY: Private consumption expenditures in Japan, expressed in Canadian dollars

EY: Private consumption expenditures in the E.E.C., expressed in Canadian dollars

JTR: The Japanses tariff on rapeseed

EM: The amount of peanuts imported into the E.E.C.

YRO: The oil extraction rate of rapeseed

YRS: Rapeseed yield per acre

XRO: Exports of rapeseed oil from Canada

OPM: The average price of soybean, coconut, and palm oils weighted by the amount of each oil used in the production of margarine

OPS: The average price of soybean, coconut, and palm oils weighted by the amount of each oil used in the production of shortening

OPA: The average price of soybean, coconut, and palm oils weighted by the amount of each oil used in the production of salad oil

T: A time trend representing the changing substitutability of rapeseed oil for competitive ingredients in the production of margarine, shortening and salad oils

MM: The market margin between the price of rapeseed-oil and the price of rapeseed

POP: Total population in Canada

PMA: The retail price index for margarine

PBU: The retail price index for butter

PSH: The retail price index for shortening

PLA: The retail price index for lard

PSA: The retail price index for salad oil

PFV: The retail price index for fresh vegetables

Y: Average per-capita disposable income in Canada

DUM: A dummy variable representing the broader coverage of consumption data after 1966 designed by Statistics Canada

DUMI: A dummy variable reflecting the impact of structural change in Canada's rapeseed market on the volume of trade

Equation A.11 states that the supply of rapeseed is the sum of inventory carry-over from the preceding year and production in the year under review. The latter is the product of yield and acreage. In turn, acreage is specified by Equation A.1. Equation A.12 defines the demand for rapeseed and ensures that the total demand in all market outlets for rapeseed is equal to the supply of rapeseed. Specifically, the quantity of rapeseed supplied or demanded (defined by Equation A.11) is equal to exports (defined by Equations A.2, A.3, and A.4), crushings (defined by A.14), and rapeseed inventory at the end of the period. Equation A.14 states that oil production depends on the volume of rapeseed crushings and the oil extraction rate. Equation A.15 is the market-clearing identity which ensures that the supply of rapeseed oil is absorbed by exporters of rapeseed oil and food manufacturers.

Detailed specification of the domestic utilization of rapeseed oil is contained in Equations A.6 to A.10. Finally, Equation A.13 depicts the link which joins the equilibrium price of rapeseed and that of rapeseed oil. From the above, it can be seen that the model embraces all the basic economic relationships at work in rapeseed markets. The model also shows characteristics of the interdependence of the various segments within the industry as well as the simultaneous interaction and determination of prices and quantities.

Methods of Estimation

Given the economic characteristics associated with each segment of the industry, the overall rapeseed industry can be categorized into four distinct, but connected "blocks". According to the number of equations and exogenous variables specified in each block, the most appropriate method of estimation was applied, and these are summarized below in Table A.1.

The advantages and disadvantages of each method were discussed in detail in Chapter 3.

Table A.1

Methods of Estimation Used for Each Block

	OLS	2SLS	SUR	3SLS
The Rapeseed Supply Block	Applied			
The Rapeseed Exports Block	Applied	Applied		Applied
The Domestic Utilization of Rapeseed Oil Block	Applied		Applied	
The Consumption of Vegetable-Oil Products Block	Applied		Applied	

The supply block consisted of only one equation, and all the explanatory variables, being either lagged endogenous or current and lagged exogenous variables, were predetermined. Therefore, only the ordinary least squares (OLS) technique was applied to estimate the structural coefficients. The exports block possessed three equations, and one endogenous was used as an explanatory variable in each equation. In order to obtain the most efficient structural coefficients, the two-stage least squares (2SLS) and three-stage least squares (3SLS) techniques were applied. The domestic utilization of rapeseed-oil block consisted of multiple equations, but no meaningful equation, in a statistical sense, was estimated in the first stage because of limited data. The consumption block had multiple equations but no endogenous variable as an explanatory variable. Therefore, the technique of seemingly uncorrelated regression

(SUR), instead of 3SLS, was applied for those two blocks.

Results

The above methods were applied to estimate structural coefficients for each block. The results are presented below. In general, the signs for each variable, obtained by the different methods, were consistent, although the magnitude of some of the coefficients was different. The coefficients obtained from the SUR and 3SLS were asymptotically more efficient, and had smaller standard errors of estimations than those obtained from the OLS and 2SLS methods. Interpretation of the results has already been discussed in Chapter 5 and thus not repeated here.

The Rapeseed Supply Block: Rapeseed acreage function for Canada, 1960-74.

(5.11) $$RAC = -252.65 + 2{,}420\,LIFT - 0.2011PW(t-1) + 0.1960PR(t-1) + 0.608RAC(t-1)$$

(OLS) (295.11) (386)** (0.1135)$^{++}$ (0.0755)* (0.0798)**

$R^2 = 0.931$ F-ratio= 47.90** D.W.= 3.070(NSC)

The Rapeseed Exports Block: Exports of rapeseed to Japan, 1960-74.

(5.2.1) $$XRJ = 171{,}000 - 1{,}857PR + 854PUS + 3{,}454JY - 7{,}992JTR$$

(OLS) (281,700) (459)** (1123) (623)** (9,387)

$R^2 = 0.936$ F-ratio=52.44** D.W.=2.635 (NSC)

(5.2.2) $$XRJ = 173{,}300 - 1{,}925ESTPR + 891PUS + 3{,}482JY - 8{,}070JTR$$

(2SLS) (356,900) (757)* (1445) (813)** (11,890)

D.W.=2.033 (NSC)

(5.2.3) $$XRJ = 190{,}500 - 1{,}918ESTPR + 845PUS + 3{,}443JY - 8{,}683JTR$$

(3SLS) (219,900) (714)* (1,144) (497)** (6,985)

Exports of rapeseed to the E.E.C., 1960-74.

(5.3.1) XRE=496,400 - 2,401PR+443PUS+3,277EY - 0.3777EM

(OLS) (136,500)** (811)* (984) (2,508) (0.1271)*

R^2=0.785 F-ratio=13.80** D.W.=2.445 (NSC)

(5.3.2) XRE=456,400 - 2,911ESTPR+495PUS+4,433EY - 0.3303EM

(2SLS) $(225,200)^{+}$ $(2,121)^{++}$ (1,250) (5,259) $(0.2353)^{++}$

D.W.=1.981 (ISC)

(5.3.3) XRE=570,600 - 2,354ESTPR+258PUS+3,127EY - 0.4402EM

(3SLS) (152,800)** $(1,514)^{++}$(119) (3,427) (0.1468)*

Exports of rapeseed to the "other nations", 1960-74.

(5.4.1) XRO=1,542 - 246PR+4,627PUS+97,420DMO

(OLS) (33,150) (271) (4,376) (29,110)**

R^2=0.699 F-ratio=11.84** D.W.=2.999 (NSC)

(5.4.2) XRO=6,767 - 108ESTPR+280PUS+99,070DM70

(2SLS) (35,090) (350) (421) (30,230)**

D.W.=2.691 (NSC)

(5.4.3) XRO=9,213 - 102ESTPR+247PUS+102,700DM70

(3SLS) (33,040) (349) (496) (24,590)**

<u>The Domestic Utilization of Rapeseed-Oil Block</u>: Use of rapeseed oil in the production of margarine, 1967-74.

(5.5.1) ROM=10.982 - 1.877PRO+1.608POM+2.696T

(OLS) (2.625)* $(0.725)^{+}$ $(0.725)^{+}$ (0.528)**

R^2=0.877 F-ratio=17.65** D.W.=2.525 (NSC)

(5.5.2) $ROM=11.200 - 1.701PRO+1.422POM+2.736T$

(SUR) (2.616) $(0.706)^{+}$ $(0.704)^{+}$ (0.527)**

Use of rapeseed oil in the production of shortening, 1967-74.

(5.6.1) $ROS=13.150 - 0.722PRO+0.293POS+1.763T$

(OLS) (2.197)** (0.543) (0.489) (0.403)*

$R^2=0.713$ F-ratio=6.79** D.W.=2.569 (NSC)

(5.6.2) $ROS=12.980 - 0.799PRO+0.366POS+1.779T$

(SUR) (2.179)** (0.529) (0.473) (0.402)*

Use of rapeseed oil in the production of salad oil, 1967-74.

(5.7.1) $ROA=26.747 - 0.565PRO - 0.315POA+4.324T$

(OLS) (1.445)** (0.441) (0.437) (0.289)**

$R^2=0.974$ F-ratio=90.15** D.W.=2.509 (NSC)

(5.7.2) $ROA=26.550 - 0.711PRO - 0.164POA+4.292T$

(SUR) (1.437)** (0.428) (0.422) (0.288)**

<u>The Consumption of Vegetable-Oil Products Block</u>: Per capita consumption of margarine in Canada, 1960-74.

(5.8.1) $QMA=-6.095 - 0.00297PMA+0.0449PBU+0.00102Y+0.9055QMA(t-1)$

(OLS) $(4.071)^{++}$(0.01254) (0.0096)** (0.00034)* (0.2039)**

$R^2=0.745$ F-ratio=11.24** D.W.=1.816 (ISC)

(5.8.2) $QMA=-5.476 - 0.00698PMA+0.0459PBU+0.00097Y+0.8856QMA(t-1)$

(SUR) $(3.947)^{++}$(0.01218) (0.0094)** (0.00033)*(0.1977)**

Per capita consumption of shortening in Canada, 1959-73.

(5.9.1) QSH=8.045 - 0.1501PSH+0.0402PLA+0.00661Y

(OLS) (10.020) (0.1101) (0.0408) (0.00104)**

R^2=0.897 F-ratio=41.78** D.W.=0.959 (ISC)

(5.9.2) QSH=9.335 - 0.1282PSH+0.0120PLA+0.00641Y

(SUR) (8.571) (0.0924)$^{++}$ (0.0333) (0.00094)**

Per capita consumption of salad oil in Canada, 1959-73.

(5.10.1) QSA=3.502 - 0.0589PSA+0.0422PFV+0.00152Y

(OLS) (8.039) (0.0451) (0.0289)$^{++}$(0.00156)

R^2=0.912 F-ratio=49.60** D.W.=0.910 (ISC)

(5.10.2) QSA=4.032 - 0.0164PSA+0.0356PFV+0.00291Y

(SUR) (6.682) (0.0365) (0.0235)$^{++}$ (0.00130)$^{+}$

Appendix B

Alternative Results of Aggregate Supply-Demand Rapeseed Model Obtained from Different Methods and Sample Periods

This appendix comprises three alternative sets of self-explanatory tables. Each set consists of structural coefficients, reduced-form coefficients, and computed values of the endogenous variables.

Table B.1 A

Estimated Coefficients for the Endogenous Variables of the Aggregate upply-Demand Rapeseed Model Using OLS, 1960-74

Variables / Equations	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8
Y1	1.000							
Y2	-0.392	1.000						
Y3			1.000	2.523				
Y4		1.000	-1.000			-1.000		
Y5				-7.860	1.000			
Y6						1.000	-2.583	
Y7							1.000	-0.277
Y8					0.028			1.000

Table B.1 B

Estimated Coefficients for the Exogenous Variables of the Aggregate Supply-Demand Rapeseed Model Using OLS, 1960-74

Equations \ Variables	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10
Y1	2419.8	-20.110	19.600	0.6079				-252.65		
Y2										
Y3					3.2704	413.09	0.9232	72.137		
Y4									1.0000	
Y5										1.0000
Y6										
Y7										
Y8								22.574		

	X11	X12	X13	X14	X15	X16	X17	X18	X19
Y1									
Y2		1.0000						1.0000	
Y3									
Y4	1.0000								
Y5									
Y6									1.0000
Y7						1.0000	1.0000		
Y8			0.0292	1.194	0.6605				

Table B.1 C

Derived Coefficients for the Reduced-Form Equations of the Aggregate Supply-Demand Rapeseed Model Using OLS, 1960-74

Variables / Equations	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10
Y1	2420	-20.11	19.60	0.6079	0.0	0	0.0	-252.7	0.0	0.0
Y2	948	-7.88	7.68	0.2383	0.0	0	0.0	-99.1	0.0	0.0
Y3	892	-7.42	7.23	0.2243	0.1930	24	0.0545	-104.2	-.9410	0.0189
Y4	-353	2.94	-2.87	-.0889	1.2197	154	0.3443	69.9	0.3729	-.0075
Y5	-2781	23.11	-22.53	-.6987	9.5864	1211	2.7062	549.2	2.9313	0.9410
Y6	55	-0.46	0.45	0.0141	-.1930	-24	-.0545	5.1	-.0590	-.0189
Y7	21	-0.18	0.17	0.0054	-.0747	-9	-.0211	2.0	-.0228	-.0073
Y8	78	-0.65	0.63	0.0197	-.2697	-34	-.0761	7.1	-.0825	-.0265

	X11	X12	X13	X14	X15	X16	X17	X18	X19
Y1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Y2	0.0	1.0000	0.0	0.0	0.0	0.0	0.0	1.0000	0.0
Y3	-.9410	0.9410	-.0197	-.8039	-.4447	-2.431	-2.431	0.9410	-.9410
Y4	0.3729	-.3729	0.0078	0.3186	0.1762	0.963	0.963	-.3729	0.3729
Y5	2.9313	-2.9313	0.0612	2.5042	1.3853	7.571	7.571	-2.9313	2.9313
Y6	-.0590	0.0590	0.0197	0.8039	0.4447	2.431	2.431	0.0590	0.9410
Y7	-.0228	0.0228	0.0076	0.3112	0.1722	0.041	0.041	0.0228	-.0228
Y8	-.0825	0.0825	0.0275	1.1235	0.6215	-.213	-.213	0.0825	-.0825

Table B.1 D

Computed Values of the Endogenous Variables based on Reduced-Form Equations
as derived from 1960-74 OLS Estimates of the Structural Coefficients

Year	RAC	QS	TRX	PR	PVO	QRC	QRO	QD
	thous.ac.	---thousand tonnes----		--dollars per tonne--		-------thousand tonnes-------		
1960	623	186	60	94	903	13	5	180
1961	453	150	63	101	939	28	9	188
1962	457	201	141	85	628	37	14	200
1963	503	197	150	105	719	40	16	204
1964	923	358	131	109	678	46	17	211
1965	1,414	520	228	102	811	68	27	214
1966	1,454	619	314	73	611	75	30	227
1967	1,501	742	258	109	1,064	109	44	256
1968	1,180	701	383	69	746	130	53	275
1969	2,180	924	378	94	768	166	67	290
1970	4,424	1,853	784	135	1,008	179	71	295
1971	4,362	2,120	886	144	1,283	219	86	294
1972	3,835	2,485	1,253	99	535	299	115	326
1973	3,085	1,636	1,170	260	1,029	387	146	346
1974	3,296	1,483	667	316	1,416	296	114	366

Table B.2 A

Estimated Coefficients for the Endogenous Variables of the Aggregate Supply-Demand Rapeseed Model Using OLS, 1960-75

Equations \ Variables	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8
Y1	1.000							
Y2	-0.392	1.000						
Y3			1.000	1.223				
Y4		1.000	-1.000			-1.000		
Y5				-7.860	1.000			
Y6						1.000	-2.583	
Y7							1.000	-0.277
Y8					0.039			1.000

Table B.2 B

Estimated Coefficients for the Exogenous Variables of the Aggregate Supply-Demand Rapeseed Model Using OLS, 1960-75

Equations \ Variables	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10
Y1	2441.3	-17.432	17.169	0.6176				-187.67		
Y2										
Y3					1.7674	531.02	1.3290	34.150		
Y4									1.0000	
Y5										1.0000
Y6										
Y7										
Y8								48.312		

	X11	X12	X13	X14	X15	X16	X17	X18	X19
Y1									
Y2		1.0000						1.0000	
Y3									
Y4	1.0000								
Y5									
Y6									1.0000
Y7						1.0000	1.0000		
Y8			0.0125	1.2871	0.6834				

Table B.2 C

Derived Coefficients for the Reduced-Form Equations of the Aggregate Supply-Demand Rapeseed Model Using OLS, 1960-75

Equations \ Variables	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10
Y1	2441	-17.43	17.17	.6175	0.0	0	0.0	-187.7	0.0	0.0
Y2	957	-6.83	6.73	.2421	0.0	0	0.0	-73.6	0.0	0.0
Y3	809	-5.78	5.69	.2048	0.2728	81	0.2051	-86.2	-.8456	0.0240
Y4	-661	4.73	-4.65	-.1674	1.2220	367	0.9189	98.4	0.6914	-.0196
Y5	-5202	37.14	-36.58	-1.3158	9.6046	2885	7.2222	773.3	5.4343	0.8456
Y6	147	-1.06	1.04	.0374	-.2728	-82	-.2051	12.6	-.1544	-.0240
Y7	57	-0.41	0.40	.0145	-.1056	-32	-.0794	4.9	-.0598	-.0093
Y8	206	-1.47	1.45	.0522	-.3813	-114	-.2867	17.6	-.2157	-.0336

	X11	X12	X13	X14	X15	X16	X17	X18	X19
Y1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Y2	0.0	1.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0
Y3	-.8456	0.8456	-.0076	-.7788	-.4135	-2.18	-2.18	0.8456	-.8456
Y4	0.6914	-.6914	0.0062	0.6367	0.3381	1.78	1.78	-.6914	0.6914
Y5	5.4343	-5.4343	0.0486	5.0045	2.6572	14.04	14.04	-5.4343	5.4343
Y6	-.1544	0.1544	0.0076	0.7788	0.4135	2.18	2.18	0.1544	0.8456
Y7	-.0598	0.0598	0.0029	0.3015	0.1601	0.85	0.85	0.0598	-.0598
Y8	-.2157	0.2157	0.0106	1.0884	0.5779	-.56	-.56	0.2157	-.2157

Table B.2 D

Computed Values of the Endogenous Variables based on Reduced-Form Equations as derived from 1960-75 OLS estimates of the Structural Coefficients

Year	RAC	QS	TRX	PR	PVO	QRC	QRO	QD
	thous.ac.	---thousand	tonnes---	--dollars per	tonne--	--------thousand	tonnes--------	
1960	606	180	68	138	1,288	7	8	161
1961	506	172	93	128	1,176	18	6	174
1962	506	221	161	92	716	36	14	199
1963	517	203	158	124	906	37	14	200
1964	895	347	127	151	1,040	38	14	200
1965	1,351	496	207	124	1,010	63	25	207
1966	1,441	614	303	53	463	81	32	235
1967	1,491	739	254	102	1,014	108	44	255
1968	1,216	716	381	56	250	145	58	297
1969	2,204	934	373	84	325	181	72	310
1970	4,410	1,848	789	166	1,368	168	66	280
1971	4,370	2,124	894	164	1,384	213	84	286
1972	3,853	2,494	1,247	66	181	312	120	344
1973	3,026	1,614	1,150	277	1,125	383	144	341
1974	3,219	1,454	636	290	1,182	298	115	368
1975	4,406	2,259	701	188	1,372	322	129	395

Table B.3 A

Estimated Coefficients for the Endogenous Variables of the Aggregate Supply-Demand Rapeseed Model Using IVR, 1960-74

Variables / Equations	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8
Y1	1.000							
Y2	-0.392	1.000						
Y3			1.000	3.013				
Y4		1.000	-1.000			-1.000		
Y5				-7.860	1.000			
Y6						1.000	-2.583	
Y7							1.000	-0.277
Y8					0.075			1.000

Table B.3 B

Estimated Coefficients for the Exogenous Variables of the Aggregate Supply-Demand Rapeseed Model Using IVR, 1960-74

Equations \ Variables	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10
Y1	2419.8	-20.110	19.600	0.6079				-252.65		
Y2										
Y3					2.8738	413.61	2.0638	34.675		
Y4									1.0000	
Y5										1.0000
Y6										
Y7										
Y8								51.306		

	X11	X12	X13	X14	X15	X16	X17	X18	X19
Y1									
Y2		1.0000						1.0000	
Y3									
Y4	1.0000								
Y5									
Y6									1.0000
Y7						1.0000	1.0000		
Y8			0.0333	1.7459	0.5822				

Table B.3 C

Derived Coefficients for the Reduced-Form Equations of the Aggregate Supply-Demand Rapeseed Model Using IVR, 1960-74

Equations \ Variables	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10
Y1	2420	-20.11	19.59	.6078	0.0	0.0	0.0	-252.6	0.0	0.0
Y2	948	-7.88	7.68	.2383	0.0	0.0	0.0	-99.1	0.0	0.0
Y3	832	-6.92	6.74	.2091	0.3525	50.7	0.2531	-114.8	-.8774	0.0470
Y4	-276	2.29	-2.24	-.0694	0.8368	120.4	0.6009	49.6	0.2912	-.0156
Y5	-2171	18.04	-17.59	-.5455	6.5772	946.6	4.7230	390.1	2.2887	0.8774
Y6	116	-0.96	0.94	.0292	-.3525	-50.7	-.2531	15.8	-.1227	-.0470
Y7	45	-0.37	0.36	.0113	-.1365	-19.6	-.0980	6.1	-.0475	-.0182
Y8	162	-1.35	1.32	.0409	-.4926	-70.9	-.3538	22.1	-.1714	-.0657

	X11	X12	X13	X14	X15	X16	X17	X18	X19
Y1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Y2	0.0	1.0	0.0	0.0	0.0	0.0	0.0	1.0000	0.0
Y3	-.8774	0.8774	-.0209	-1.096	-.3655	-2.2662	-2.2662	0.8774	-.8774
Y4	0.2912	-.2911	0.0069	0.364	0.1213	0.7521	0.7521	-.2912	0.2912
Y5	2.2887	-2.2887	0.0545	2.858	0.9534	5.9116	5.9116	-2.2887	2.2887
Y6	-.1227	0.1227	0.0209	1.096	0.3655	2.2662	2.2662	0.1227	0.8774
Y7	-.0475	0.0475	0.0081	0.424	0.1415	0.8774	0.8774	0.0475	-.0475
Y8	-.1714	0.1714	0.0292	1.532	0.5108	-.4428	-.4428	0.1714	-.1714

Table B.3 D

Computed Values of the Endogenous Variables based on Reduced-Form Equations as derived from 1960-74 IVR Estimates of the Structural Coefficients

Year	RAC	QS	TRX	PR	PVO	QRC	QRO	QD
	thous.ac.	---thousand tonnes---		--dollars per tonne--		--------thousand tonnes-------		
1960	623	186	66	96	922	8	3	173
1961	453	150	69	102	941	22	7	179
1962	457	201	140	91	675	39	15	203
1963	503	197	150	108	738	40	15	204
1964	923	358	130	115	719	47	18	212
1965	1,415	520	230	106	842	65	26	211
1966	1,454	619	310	83	687	79	31	232
1967	1,502	742	264	104	1,023	102	41	246
1968	1,180	701	380	74	784	133	54	280
1969	2,181	924	372	94	773	172	69	299
1970	4,424	1,853	786	112	945	178	70	293
1971	4,362	2,121	891	127	1,154	214	84	286
1972	3,835	2,486	1,249	128	758	303	116	332
1973	3,085	1,636	1,164	248	934	393	150	354
1974	3,296	1,483	666	294	1,243	298	115	369