AN ANALYSIS OF THE IMPACT OF RAPESEED MEAL QUALITY IMPROVEMENTS UPON THE QUANTITY OF RAPESEED CRUSHED IN CANADA

A Thesis

presented to

The Faculty of Graduate Studies and Research

University of Manitoba

In Partial Fulfilment

of the Requirements for the Degree

Master of Science

---

by

Brian Wilfred Paddock

October 1972

ABSTRACT

AN ANALYSIS OF THE IMPACT OF RAPESEED MEAL QUALITY IMPROVEMENT
UPON THE QUANTITY OF RAPESEED CRUSHED IN CANADA

by

Brian Wilfred Paddock

University of Manitoba
1972

The domestic crushing industry provides Canadian rapeseed with its second largest market, second only to the Japanese market. In the long run, it would appear that there is greatly expanded use of rapeseed products domestically. At the present time, however, problems exist with respect to the quality of rapeseed products which limit their use in Canada and consequently limit the size of the domestic market for rapeseed itself. These quality problems are most critical with respect to rapeseed meal. Because the energy and protein levels in rapeseed meal are lower than those of its most important competitor, soybean meal, and because rapeseed meal contains potentially toxic compounds known as glucosinolates, the use of rapeseed meal is greatly restricted. Plant breeding programs have been initiated with the aim of producing a variety of rapeseed which would yield a meal with increased protein and energy levels and which contains no glucosenolates. This study analyses the impact which improved meal quality would have upon the use of rapeseed meal in Canada and subsequently upon the quantity of rapeseed crushed in Canada. It also analyses the effect of such increases in domestic rapeseed crushings upon farm income. Specifically, this study analyses the effect of increasing the protein content of rapeseed meal from 36 percent to 40 percent, increasing the energy content by 12.5 percent, and removing completely the glucosinolates.

A linear programming approach is utilized to conduct the analysis. One or more representative rations are constructed for each important class of livestock produced in Canada. Using parametric linear programming, the least cost formulation for each representative ration is calculated while the price of rapeseed is increased from 2.0 to 4.0 cents per pound. This gives the quantity of rapeseed meal used in that ration at each price--in other words, a demand curve for rapeseed meal. The demand curves for all of the representative rations are then aggregated to form a total demand curve for rapeseed meal. This procedure is followed for each of the six improved types of meal as well as one for the type of rapeseed meal currently being produced. Each of the six types of improved rapeseed meal possess a combination or one or more of increased protein content, increased energy content and zero glucosinolate content.

The findings of the study are as follows:

1. The presence of glucosinolates in rapeseed meal restricts its use more than its low protein and energy content relative to soybean meal.

Removal of the glucosinolates would increase the use of rapeseed meal by 25 percent.

2. Increasing the protein or energy content without removing the glucosinolates would result in only marginal increases in the use of rapeseed meal. Raising the protein content would increase meal by 7 percent while an increase in the energy content produces only a 1 percent increase.

3. Combining an increase in the protein content with the removal of the glucosinolates would produce an increase in the use of rapeseed meal of either 32 percent or 10 percent. The actual increase would depend upon the size of the overall crushing margin. Combining an increase in

the energy content with removal of the glucosinolates would produce a 29 percent increase in the quantity of rapeseed meal used.

4. Combining increases of both protein and energy with the removal of the glucosinolates would result in a 32 percent increase in the quantity of rapeseed meal utilized in livestock and poultry rations.

5. The increased use of rapeseed meal and subsequently the increased quantity of rapeseed crushed in Canada as a result of the improvements to rapeseed meal quality would produce estimated increases in farm income ranging from 27.6 to 840.7 thousand dollars per year.

ACKNOWLEDGEMENTS

The author wishes to take this opportunity to acknowledge the contributions of those whose assistance greatly facilitated the preparation of this thesis.

Dr. Om P. Tangri, who ably served as chairman of the thesis committee, through time sacrificed from a busy schedule greatly influenced the final form of the thesis. Special thanks are also due to Dr. E.W. Tyrchniewicz and Dr. L.W. Copithorne whose comments were invaluable in the development of the thesis. In addition, Dr. L. Campbell, Dr. S. Stothers and Dr. T. Devlin of the Animal Science Department assisted in the construction of the representative rations.

The financial assistance provided by both the University of Manitoba and the Agricultural Economics Research Council was also greatly appreciated.

The author also wishes to pay special tribute to his wife, Ruth, for her patience and encouragement as well as her more visible contribution as editor and typist.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

(A) RAPESEED IN PERSPECTIVE

Although rapeseed has been grown on the prairies for almost three decades, it is only in recent years that the crop has been of significant importance to the agricultural economy of the prairies. Introduced during World War II it was first used as a lubricating oil for marine engines despite the fact that rapeseed oil has had a long history of use as an edible oil in the Orient, particularly in Japan. Serious consideration of rapeseed oil as an edible oil in Canada did not occur until 1956-57. Since that time rapeseed oil utilization has expanded to the point where in 1971, 9,738,504 bushels of rapeseed were crushed in Canada producing 191,307,000 pounds of rapeseed oil. [1]

The increasing importance of rapeseed to the agricultural economy of Western Canada can be seen, by referring to Table I. In the eight years ending with 1971, rapeseed acreage increased to 7.3 times what it was in 1964. Income from sales of rapeseed rose from 18.0 million dollars in 1964 to 97.3 million dollars in 1970, and the proportion of total crop income derived from sale of rapeseed rose from 1.68% in 1964 to 13.2% in the first nine months of 1971.

---

[1]Statistics Canada, Oils and Fats, Vol. 22 - No. 12 , Catalogue Number 32-006, Ottawa, Canada, The Queen's Printer, December 1971, p. 11.

The value of rapeseed to the prairie economy is not fully conveyed by the income derived from sale of this crop. Its value is further enhanced by its potential as a stabilizing factor in the prairie economy. Western Canadian farmers have, in the past, relied heavily upon wheat for their economic livelihood with the results that whenever income from wheat sales declined, the prairie economy was depressed. To the extent that rapeseed is able to reduce the dependence of the prairie farmer upon a single crop, its value to the prairie economy is further enhanced.

There have been several factors which have played a significant role in the recent expansion of rapeseed acreage. One of these was the declining sales of cereal grains and of wheat in particular which occured during the late nineteen sixties and which forced farmers to look for alternative and more saleable crops to substitute, at least temporarily, for cereal grains. To some extent it would appear that the declining sales of cereal grains played a catalytic role in the increase of rapeseed acreage. Even if sales of cereal grains should return to more normal levels, rapeseed acreage is not likely to decline to its former low level.

Another factor which played a role in expanding production of rapeseed was the recognition that, given proper management, rapeseed produced a gross return which compared favorably with that of other crops (see Table II). This was very important since it made it possible to diversify cropping programs without sacrificing income.

To illustrate the value of rapeseed as an alternative crop, it is useful to analyse its effect upon farm income in the crop years 1968-69 and 1969-70. In view of the large surpluses of wheat existing in Canada during those years it would appear that, had rapeseed not been available

TABLE I

ACREAGE OF AND INCOME DERIVED FROM RAPESEED

Year	Acres of Rapeseed (millions)	Income from Rapeseed (millions of dollars)	Total crop income (millions of dollars)	Rapeseed % of total crop income
1964	.791	17.957	1140.788	1.6
1965	1.435	26.772	1076.004	2.1
1966	1.525	42.718	1281.775	3.3
1967	1.620	43.994	1305.000	3.4
1968	1.052	33.247	1211.405	2.7
1969	2.012	50.544	956.783	5.3
1970	4.050	97.300	825.353	11.8
1971	5.800	98.105*	744.876*	13.2*

* includes only first nine months of 1971

Sources: Column 2: Statistics Canada, Agricultural Division, Quarterly Bulletin of Agricultural Statistics, Catalogue No. 21-003, Ottawa, Canada, The Queen's Printer, Editions 1964.....1971.

Columns 2 and 3: Statistics Canada, Agricultural Division, Farm Cash Receipts, Catalogue No. 61-001, Ottawa, Canada, The Queen's Printer, Editions 1964.....1971.

Column 4: Column 2 multiplied by 100 and divided by Column 3.

as an alternative, the acreage which was devoted to it would have been allocated to either barley or flax. Furthermore, in view of the fact that rapeseed acreage exceeded flax acreage in both years and that to have sown the rapeseed acreage to flax would have more than doubled flax acreage, it is likely that barley was the major alternative to rapeseed. Assuming that the additional barley produced by 1.0 million acres in 1968-69 and 1969-70 could have been sold without affecting barley prices, the effect of replacing rapeseed with barley would have been to reduce gross farm income by 4.4 and 25.2 million dollars in 1968-69 and 1969-70 respectively.

TABLE II

PER ACRE GROSS RETURN FROM PRAIRIE CROPS
(dollars)

Year	Wheat	Rapeseed	Barley	Oats	Flax
1964-65	31.00	45.76	30.10	28.15	29.69
1965-66	38.14	37.84	36.26	35.19	33.88
1966-67	48.75	41.74	42.42	35.00	31.00
1967-68	31.43	29.18	26.36	27.58	27.72
1968-69	28.99	33.67	29.24	27.96	36.86
1969-70	34.36	38.01	25.39	26.30	30.23

Source: Statistics Canada, Agricultural Division, Quarterly Bulletin of Agricultural Statistics, Catalogue No. 21-003, Ottawa, Canada, The Queen's Printer, Editions 1966.....1971.

A recent study has estimated that in Western Canada there are 15.0 million acres which are suited for rapeseed production.[2] The necessity for

[2]Rapeseed Marketing Committee, Rapeseed-Marketing, Ottawa, Canada, 1971.

crop rotations would limit consistent annual production to about 7.5 million acres. However, there clearly are a number of problems which must be solved before such an acreage of rapeseed is feasible. The prospect of relatively large carry-over stocks of unsold rapeseed at the end of the 1971-72 crop year tends to underscore this point. Future increases in rapeseed production will have to be matched by increases in demand if prices are not to be seriously depressed.

The domestic crushing industry has been the second largest market for rapeseed, second only to Japan. In the crop year 1970-71, the domestic market absorbed 15.3% of the total rapeseed sales. In order to evaluate the prospects for increased rapeseed production, it is important to look at the markets for rapeseed oil and meal in Canada.

(B) USE OF RAPESEED OIL IN CANADA

Rapeseed oil is an edible oil, used in the preparation of foods such as margarine, shortening, cooking oils and salad oils. In these uses, it meets competition from other edible oils of both foreign and domestic origin such as soybean, cottonseed, peanut, sunflower, palm and cocoanut oil as well as animal fats such as lard and butter. Western Canada is a net supplier of edible oils in general, and of rapeseed oil in particular, with about 70% of the rapeseed oil produced being shipped to Eastern Canada. Toronto functions as the centre of the edible oil market in Canada with prices in any other point in Canada being determined by the Toronto price and the freight rate of that oil from that point to Toronto. The result is that whether the rapeseed oil is sold in Western Canada or in Eastern Canada, the net price received at the plant is the same.

Rapeseed oil is claiming an increasing share of the Canadian market for oils and fats. Table III shows the production and domestic disappearance of rapeseed oil compared with both the production and domestic disappearance of soybean oil as well as its share of the total oils and fats market. It can be seen that production of rapeseed oil has experienced a rapid growth and that, except for 1970 when production of soybean oil increased substantially, its share of total domestic disappearance of fats and oils in Canada has been expanding. Nevertheless, it would appear that there is still ample room for further growth since despite recent expansion, rapeseed oil comprises less than one fifth of the Canadian consumption of oils and fats.

(C) USE OF RAPESEED MEAL IN CANADA

Rapeseed meal is a high protein feedstuff which is used to increase the protein content of animal rations. Its chief competitors are other high protein feedstuffs such as soybean meal, fish meal, meat meal and urea, the latter being used only in ruminant rations. Because of the relatively high fibre content of rapeseed meal and its content of glucosinolate compounds, (which if fed at too high a rate tend to depress animal growth rates) the use of rapeseed meal is limited in some rations and completely precluded from others.

Rapeseed follows the price leadership of soybean meal and is priced at about 60 percent of the price of soybean meal. Since soybean meal is imported into Western Canada from the North-Central United States, the farther west that it is shipped, the higher its price because of the increased transportation costs. Consequently, despite the fact that Western Canada is a surplus region as far as rapeseed meal is concerned, the price of rapeseed meal is higher in Western Canada than in Eastern

TABLE III

PRODUCTION AND DOMESTIC DISAPPEARANCE OF RAPESEED OIL
(000 lbs.)

	1967	1968	1969	1970	1971*
Production	100,865	116,413	149,315	154,273	139,314
% of soybean oil production	47	61	70	61	79
Domestic disappearance	996,037	123,009	148,376	153,273	N.A.
% of domestic disappearance of all fats and oils (excluding lard)	12	15	17	17	N.A.

* includes only 9 months data.

Sources: Lines 1 and 2: Statistics Canada, Manufacturing and Primary Industries Division, Oils and Fats, Catalogue No. 32-006, Ottawa, Canada, The Queen's Printer, Editions 1967.....1971.

Lines 3 and 4: Statistics Canada, Agriculture Division Apparent per Capita Consumption of Food in Canada, Catalogue No. 32-226, Ottawa, Canada, The Queen's Printer, Editions 1967.....1971.

Canada.[3] This means that the net price received by the crushing plant is much lower for meal sold in Eastern Canada than in Western Canada. It should be stressed that this discrepancy does not appear to be the result of a deliberate attempt to practice price discrimination among markets but results from limitations on the use of the rapeseed meal.

Table IV shows the relative importance of rapeseed meal in the total protein market in Canada. As can be seen, rapeseed meal's share of the vegetable protein market has risen from 8.5% to 11.0%. Similarly its share of the total protein feedstuffs market has grown from 6.5% to 8.5%. These figures point out two important facts: The first is the steadily increasing importance of rapeseed meal in Canada. The other is that rapeseed meal is still only a small contributor and that there appears ample room for future expansion.

It would appear that there is substantial potential for expanding the demand for both rapeseed oil and rapeseed meal. The problem is the choice of method for increasing the demand for these products.

One method of demand expansion is through promotional activities designed to inform potential customers of the merits of rapeseed as a source of meal and edible oils. Such promotion may be carried on at two levels. It may be directed towards potential users of rapeseed products in an effort to expand the demand for rapeseed oil and meal and indirectly expand the demand for rapeseed itself. In circumstances where an oilseed crusher has access to a number of alternate oilseeds to utilize in his

---

[3] Om P. Tangri and E.W. Tyrchniewicz, "The Removal of Crow's Nest Pass Rates on Grain and Grain Products moving to Eastern Canada for Domestic Consumption: Implications for Industrial Expansion and Development in the Prairie Provinces, Especially Manitoba," Winnipeg, Manitoba: Manitoba Department of Industry and Commerce, 1971.

TABLE IV

AVAILABLE SUPPLIES OF HIGH PROTEIN FEEDS
(tons)

	1967	1968	1969	1970
Linseed meal	32,900	29,400	29,500	34,700
Soybean meal	552,400	535,200	608,500	684,800
Rapeseed meal	71,000	82,700	107,200	116,200
Other Vegetable Protein	175,100	211,560	208,753	218,394
Total Vegetable Protein	831,400	858,860	953,953	1,054,094
Fish meal	51,200	69,600	61,900	45,400
Meat meal	199,400	232,000	255,000	247,000
Dairy Protein	16,200	19,600	19,800	19,800
Total Animal Protein	266,800	321,200	366,700	312,000
Total Protein Feedstuffs	1,098,200	1,180,060	1,290,653	1,366,294

Source: Statistics Canada, Agricultural Division, Coarse Grains Quarterly, Catalogue No. 22-001, Ottawa, Canada, The Queen's Printer, Editions 1967.....1971.

plant, promotional efforts may be directed at the crusher himself in an effort to expand the demand for rapeseed directly.

The Rapeseed Association of Canada, an organization composed of representatives from all segments of the rapeseed industry, has been active in this regard. It has sponsored trade missions to existing and potential markets. These missions have included persons knowledgeable in the use of rapeseed and rapeseed products.

A second method of expanding the demand for rapeseed is through improvements in the quality of the rapeseed produced. Such quality improvements would increase the competitive advantage of rapeseed relative to other oilseeds. Quality improvements could be of two types. The first type of improvement would be one where the improved quality of the rapeseed would result in rapeseed products of higher quality. This could take the form of a rapeseed oil with better keeping quality or a more pleasant taste or it could take the form of a rapeseed meal with a higher protein or energy level. The second type of quality improvement, would be one which would not affect the quality of the final products but which would make rapeseed more attractive to the crusher in other ways. This might be through creation of a variety of rapeseed for which crushing costs were lower than conventional varieties. It should be noted, however, that the two methods are not necessarily mutually exclusive. In fact, they can, and usually do, complement one another if used simultaneously.

Canada's rapeseed crushing industry has recently undergone a significant expansion of capacity. Further expansion of rapeseed crushing would appear to depend upon an expanded demand for rapeseed products particularly rapeseed meal. Since rapeseed products encounter more competition in their respective uses than does rapeseed for crushing facilities, it would seem logical to pursue quality improvements which would result in higher quality products particularly higher quality rapeseed meal. The characteristics which most limit the use of rapeseed are its low energy and protein content relative to soybean meal and its content of glucosinolates. These glucosinolates give the meal a bitter taste and as a result rations containing large amounts of rapeseed meal are less palatable than similar rations containing soybean meal. Because of this, intake may be depressed. In addition, goitrogenic compounds in rapeseed meal also tend to depress growth when fed at high rates. Research designed to correct these deficiencies is currently underway. A variety of rapeseed known as Bronowski has already been produced which is free of toxic glucosinolates. Meal from this variety shows none of the growth depressing characteristics of present commercial varieties. In addition, yellow coated rapeseed has been found to be larger in diameter and to have a proportionately thinner seed coat. Since the seed coat is high in fibre, reducing the seed coat proportion of total seed weight would increase both protein and energy content of the rapeseed meal. Efforts are presently being directed toward combining as many of these characteristics into a variety which has sufficiently good agronomic characteristics to make it appropriate for commercial production.

(D) OBJECTIVES OF THIS STUDY

The objective of this study is to estimate the impact, upon meal demand and ultimately on the quantity of rapeseed crushed in Canada, of such improvements. Specifically, the improvements to be analysed are:

(1) complete elimination of content of toxic compounds.
(2) an increase in the metabolizable energy content of rapeseed meal from 800 to 900 kilocalories per pound.

(3) an increase in the protein content of rapeseed meal from 36% to 40%.

The impact will be estimated separately for each improvement as well as for combinations of two or more of the improvements together.

This analysis should provide information concerning the relative benefit of each of the above mentioned quality improvements. Since research funds for pursuing these improvements are limited, information concerning the relative benefits of the quality improvements will be of benefit not only in deciding how much funds should be allocated towards improving the quality of rapeseed meal, but also in deciding how funds devoted to quality improvements should be allocated among the various quality improvements which are possible. It should be recognized that such decisions cannot be made solely on the basis of potential benefits. Information concerning research costs, including estimations of the probability of such research achieving success, are necessary, Thus, the information provided by this study is only part of what is needed to make the above mentioned decisions.

CHAPTER II

A REVIEW OF THE LITERATURE

Marketing studies vary widely in the methods of analysis used. The choice of method, of course, depends upon a number of factors including the objective of the study and the resources which are allocated to such a study. This chapter will review briefly a number of studies using different approaches. Beginning with a semi-quantitative analysis, the review will also include several simultaneous regression models and will then turn its attention to the use of linear models in the analysis of markets. Since this latter approach has seen limited use in demand analysis, the studies of this type which are reviewed will deal with not only oilseed markets but with the demand for other commodities as well.

Several studies of various oilseed markets have been undertaken. One study commissioned by the Rapeseed Association of Canada discussed several import factors affecting the demand for rapeseed in Japan.[1] One such factor was that product differentiation between Canadian rapeseed and United States soybeans often places the former at a disadvantage.

A number of studies of the United States soybean market, including those by Houck,[2] Vandenborre,[3] and Houck and Mann,[4] were conducted during the 1960's. Using a simultaneous eight equation model, Houck estimated

---

[1]Coral Incorporated. A Study of the Japan Market for Rapeseed, (Winnipeg: Nov. 1968) pp. 55-58. Mimeographed.

[2]James P. Houck, Demand and Price Analysis of the U.S. Soybean Market, Technical Bulletin 244, St. Paul, Minnesota: University of Minnesota Agricultural Experiment Station.

of the price elasticity of soybean oil and meal to be -2.51 and -.89 respectively. These elasticities were much higher than those derived by the two later studies. Vandenborre used a model containing ten simultaneous equations and derived estimates of the price elasticity of soybean oil and meal of -.45 and -.28 respectively. Houck and Mann obtained very similar elasticities from this model, estimating the price elasticities of rapeseed oil and meal to be -.51 and -.33 respectively. Vandenborre's study also revealed that a 1% increase in livestock prices in Canada resulted in a 1.47% increase in soybean meal exports to Canada.

As is pointed out in chapter IV, studies such as those outlined above are useful for studying the demand characteristics of an existing market, but are less useful for analysing potential or future demands or for studying the impact of changes in market structure. One study which attempts to analyse potential demand was conducted by Moore and Hedges [5] in 1963. This study attempted to estimate the demand for irrigation water in Tulane county, California, by constructing linear models of irrigation farms. Separate models were constructed for farms on the various soil types. The price of water was varied from zero to $30 per thousand acre

---

[3]Rojer J. Vandenborre, "Demand Analysis of the Markets for Soybean Oil and Soybean Meal," Journal of Farm Economics, November, 1963, pp. 920-933.

[4]J.P. Houck and J.S. Mann, Domestic and Foreign Demand for U.S. Soybeans and Soybean Products, Technical Bulletin 256. St. Paul, Minnesota: University of Minnesota Agricultural Experiment Station.

[5]Charles V. Moore and Trimble R. Hedges, "A Method for Estimating Demand for Irrigation Water", Agricultural Economics Research, October, 1963, pp. 131-135.

feet of water. Above a price of 16.50, the price elasticity of water was estimated at -.702 while at lower prices it was estimated at -.188.

A second study which assessed the impact of a change in market structure was conducted by Horst.[6] This study estimated the effect upon total feed consumption and upon importance of various ration ingredients of a change in price support policy from a system of deficiency payments to one of variable import levie and further to policies which would be necessary for British membership in the European Economic Community. The first section of this study analysed consumption of compound feeds by livestock class and used regression analysis to examine factors affecting this consumption and to project total feed requirements under each set of price support policies. The second section dealt with the distribution of the various feed ingredients among the various types of compound feeds. This was accomplished through the use of linear models of the various compound feeds. The final section dealt with effect of the various price support policies. Using projected consumption levels as well as new ingredient prices which each price support policy would bring about, the linear models of the compound feeds were re-solved in order to find the expected use of each ingredient.

The study projected that introduction of either variable import levies or the type of price support policies which would be used if Britain entered the E.E.C. This would result in a decrease in the use of cereals and cereal products, a small increase in the use of oilseed cake

---

[6]U.S., Economic Research Service, Compound Feeds in the United Kingdom - Effects of Support Policies on Use of Ingredients, (by James Horst) [(Washington) : 1972]

and meal and a larger increase in the use of fish meal, dehydrated alfalfa, beet pulp, tallow and molasses.

Brown and Craddock calculated least-cost rations using rapeseed meal as a protein source.[7] The objective of this work was "to illustrate some of the principles and relationships with protein and energy in ration formulation using rapeseed meal."[8] The work performed was basic in nature in that it considered only two prices for the meal and dealt with only rapeseed meal from current commercial rapeseed varieties.

Some preliminary work has been done, on estimating the impact of improved rapeseed meal quality by J.M. Bell.[9] Using parametric programming, Bell evaluated four types of improved rapeseed meal possessing the following characteristics:

(a) crude protein - 40.5%, digestible energy - 1318 kilocalories/lb.

(b) crude protein - 40.5%, digestible energy - 1500 kilocalories/lb.

(c) crude protein - 48.5%, digestible energy - 1318 kilocalories/lb.

(d) crude protein - 48.5%, digestible energy - 1500 kilocalories/lb.

Current rapeseed meal contains 36.0% protein and 1318 kilocalories of digestible energy/lb. (when used in swine rations).

---

[7]J.C. Brown and W.J. Craddock, "Feed Formulations using Canadian Rapeseed Meal," Canadian Rapeseed Meal in Poultry and Animal Feeding (Winnipeg: Rapeseed Association of Canada, 1972), pp. 28-31.

[8]Ibid, p. 29.

[9]J.M. Bell, "New Developments Concerning Nutritional Characteristics of Rapeseed Meal", Proceedings of the International Conference on Science, Technology and Marketing of Rapeseed and Rapeseed Products (Rapeseed Association of Canada: 1970), pp. 516-524.

Using several different sets of market price data, least cost pig grower rations were formulated. In 48 out of 51 ration formulations, high energy-high protein rapeseed meal was used at significantly higher rates than was standard rapeseed meal, while both high energy and high protein meals were used at higher rates in 30 to 35% of the formulations. The author concludes that increasing the energy content of rapeseed meal is of value only if higher protein levels are simultaneously achieved. Bell also concluded that, "This technique appears to be a useful one in relation to decision making on the merits of striving for potential improvements in the nutritional quality of a feedstuff." [10]

This chapter has reviewed a number of studies exhibiting a number of different approaches to market analysis. Although this study makes use mainly of the approach using linear models, an appreciation of the other methods of analysis is necessary if the proper choice of technique is to be made.

---

[10] Ibid, p. 524.

CHAPTER III

THEORETICAL MODEL

The procedure for estimating the impact of improvements in rapeseed meal quality upon the output of the Canadian rapeseed crushing industry can be presented in three steps. The first step consists of the examination of the markets for rapeseed meal and rapeseed oil - the products of rapeseed crushing - and the production process associated with these products. Examination of these factors is necessary in order to gain insight, concerning the mechanism of output determination.

The second step is to estimate the impact of the variety changes upon the variables which play an important role in determining output. For convenience, this estimation could be subdivided into two parts. The first part would be the impact of variety changes upon the demand for the products. The second part would be the impact of variety changes upon the cost structure of rapeseed crushing. The final step is to estimate the net effect of variety changes upon the output of the industry; that is, to combine the effects of each part in step two and to allow the two parts to interact with one another. The development which follows will proceed along the steps outlined above. Rapeseed meal and rapeseed oil are joint products whose demands, since they are independent of one another, can be analysed separately.

(A) DEMAND FOR RAPESEED MEAL

As noted in chapter II, there are a number of protein feedstuffs which can be substituted for rapeseed meal in livestock rations. To determine the characteristics of the demand for rapeseed meal, it is useful to investigate the relationships among the demands for the various protein feedstuffs. The high protein feedstuffs sector is composed of a relatively small number of feedstuffs in Canada. The most important components are meat meal, fish meal, soybean meal and rapeseed meal. Although these products differ widely in nutritional content, they are all sources of protein and consequently, their prices are all inter-related.

Aside from total protein content, there are other factors which influence the relative value of protein feedstuffs. One of these factors is protein quality. Protein is not an homogeneous entity. Rather, the protein content is a summation of all the different types of protein called amino acids. For non-ruminant animals, not only total protein content but also the level of some of the individual amino acids is important in determining the relative value of the protein source.

The other factors which influence the relative value of protein feedstuffs can be dealt with collectively. Protein feedstuffs, in addition to protein, also contain other nutritional elements such as energy, vitamins, and minerals in varying amounts. The content of these other elements also influences the relative value of each protein feedstuff.

The demand for protein feedstuffs is related to the livestock population during the same time period. The relationship is positive, since an increase in the livestock population will shift the demand for protein feedstuffs to the right. One of the factors determining the livestock population is the production costs associated with the various livestock products. Since feed costs are one component of total production costs, and since livestock production would be expected to be negatively related to production costs, the demand curve for protein feeds is concluded to be downward sloping. In addition, since protein feedstuffs form only a relatively small part of total production costs, the demand curve for protein feedstuffs would be expected to be relatively steep.

The next procedural step is to look at the various subsectors of the protein feeds sector in order to determine the nature of the supply curve of each. Meat meal is a by-product of the meat packing industry. It is composed of meat scraps, blood meal and some ground bone. Meat meal has a high protein content and an energy content slightly higher than that of rapeseed meal as well as a relatively low fibre level. The sale of meat meal makes up a relatively minor proportion of the revenue from meat packing. In addition, because of its perishable nature, it cannot be stored for more than a very short period of time but must be sold for whatever price it will bring. Its supply curve is therefore perfectly price inelastic. The actual quantity supplied is determined by the volume of meatpacking which is carried out by the packing houses. Meat meal can thus be said to earn an economic rent.

Soybean meal production is concentrated in the United States. There is a large number of firms (111 in 1971) involved in the production of soybean meal and no single firm or group of firms produces a large enough proportion of total output to be able to influence the price of soybean meal. The soybean processing industry of the United States produces enough meal to supply the domestic market and also exports a significant volume to other countries including Canada. Canada's imports of soybean meal constitute a relatively small proportion of the total

United States production (see Table V) and as a result Canadian buyers are not able to influence the price of imported soybean meal. The supply curve for soybean meal imported from the United States can thus be represented being perfectly price elastic. Since soybean meal produced in Canada is identical to that produced in the United States the import price of United States soybean meal also determines the price of soybean meal produced in Canada.

TABLE V

UNITED STATES EXPORTS OF SOYBEAN MEAL
(000 tons)

Year	Total U.S. Exports	Exports to Canada
1965	2601.6	234.0
1966	2656.6	238.4
1967	2899.5	227.8
1968	3044.3	262.9
1969	4035.4	270.9
1970	4559.3	242.1

Source: American Soybean Association, Soybean Digest-Blue Book Issue, Hudson, United States of America, 1972 edition.

Fish meal is a by-product from the production of fish oil. From Table VI it can be seen that Canadian production has recently expanded, resulting in an expansion of both exports and domestic utilization of fish meal. Fish meal has a higher content of the sulfurous amino acids such as methionine, than do most vegetable protein sources. Because of this and because there is a substantial export demand for fish meal in the

United States, fish meal has a price per pound of protein which is relatively high when compared to other meals. For example, in 1971, Winnipeg feed mill operators paid an average of 9.3¢/lb. or 13¢/lb. of protein for fish meal. During the same period, operators paid 4.8¢/lb. or 11¢/lb. of protein for soybean meal. As a result of this high price/lb. of protein, fish meal is generally used in small amounts to supply the more scarce amino acids. The balance of the protein is supplied by cheaper meat meal and vegetable proteins. The limited use of fish meal is a result of economic rather than technical constraints since fish meal can safely be used at higher levels.

TABLE VI

SUPPLY AND DISPOSITION OF FISH MEAL IN CANADA
(000 tons)

Year	Production	Imports	Exports	Domestic Disappearance
1965	96.6	.1	58.9	37.8
1966	96.2	nil	53.0	43.2
1967	98.5	1.1	52.1	47.5
1968	135.0	2.7	69.9	67.9
1969	139.5	1.0	80.1	60.4
1970	123.8	.1	79.9	44.8

Sources: Column 1: Statistics Canada, Industry Division, Monthly Review of Canadian Fisheries Statistics, Catalogue No. 24-002, Ottawa, Canada, The Queen's Printer, Editions 1965.....1970.

Column 2: Statistics Canada, External Trade Division, Trade of Canada Imports, Catalogue No. 65-007, Ottawa, Canada, The Queen's Printer, Editions 1965.....1970.

Column 3: Statistics Canada, External Trade Division, Trade of Canada Exports, Catalogue No. 65-202, Ottawa, Canada, The Queen's Printer, Editions 1965.....1970.

Column 4: Calculated from Columns 1, 2 and 3.

It is useful to express the relationships described above in diagrammatic form. First of all, in figure 3.1 panel (a), the demand for high protein feedstuffs is labelled DD´. The supply schedule for meat meal is vertical as was discussed earlier and is labelled S_1S_1´. The horizontal supply curve for soybean meal is labelled S_2S_2´. If S_1S_1´ is horizontally subtracted from DD´, and the supply curve for soybean meal is drawn in more, the demand curve facing rapeseed meal and fish meal is produced. This is contained in figure 3.1 panel (b), and is labelled S_2AB.

As noted on page 22, the price of fish meal per pound of protein is high relative to other protein feedstuffs. As a result, it is used mainly in swine and poulty feeds to supply amino acids which are not less plentiful in other feedstuffs. When fish meal is not used in a ration, these amino acids are often supplied in pure forms which are manufactured synthetically. Although used primarily to supply scarce amino acids, fish meal, because of its high protein content, does make a significant contribution to the total protein content of the ration, and in so doing reduces the demand for rapeseed meal. Furthermore, as the price of rapeseed meal rises it becomes economic to replace increasing amounts of rapeseed meal and synthetic amino acids with fish meal. This increasing substitution of fish meal for rapeseed meal as the latter's price uses is indicated by the positive slope of KK´, the cross price elasticity between the quantity of fish meal used and the price of rapeseed meal, in figure 3.2. Subtracting KK´ from S_2AB yields a demand curve for rapeseed meal, S_2CF, also shown in figure 3.2.

Three further adjustments are required to make the demand curve which has been derived for rapeseed, more accurate. The first adjustment

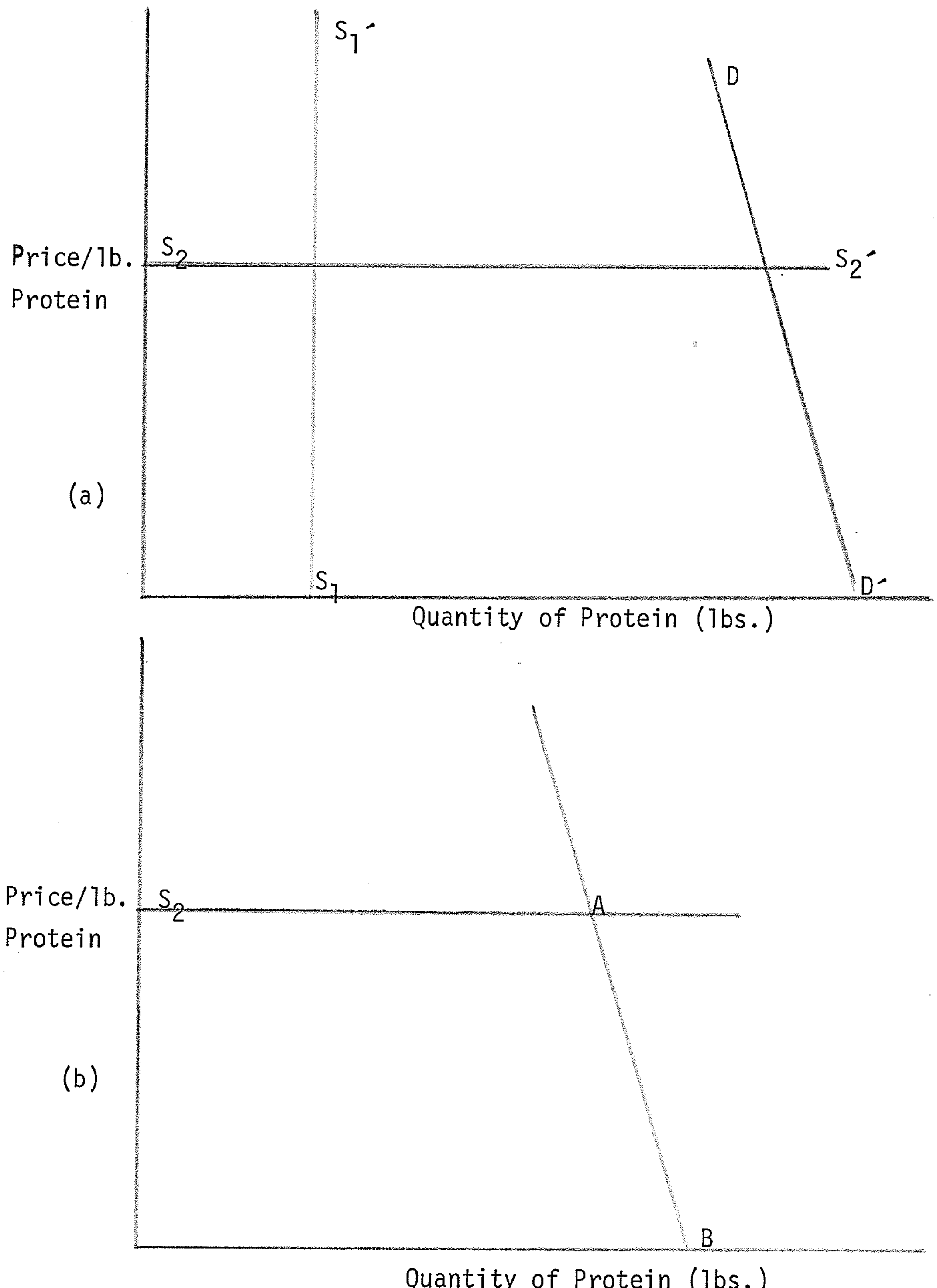


Figure 3.1: Derivation of Demand Curve for Rapeseed Meal and Fish Meal

is of a minor nature. As was discussed earlier, the value per pound of protein of a feedstuff is influenced by its content of other nutritional elements and by the quality of its protein. Because of its lower energy content, rapeseed meal does not substitute for soybean meal at a price of S_2 per pound of protein but at a somewhat lower price. The higher the cost of high energy ingredients such as cereal grains, the more critical becomes the discrepancy between the energy levels of soybean and rapeseed meals. As a result, an increase in the price of cereal grains would result in a widening of the gap between the price per pound of rapeseed meal protein and the price per pound of soybean meal protein.

Secondly, the price at which rapeseed meal is replaced by ingredients of higher energy and protein content is partly determined by the energy and protein requirements of the ration concerned. Because of the weight limitation (2,000 pounds per ton), a high energy and protein requirement in a ration favors the use of less bulky ingredients; that is, ingredients with higher protein and energy content. For given prices of cereal grains, the price at which rapeseed meal substitutes for soybean meal in the least cost ration is lower than it would be for rations of lower energy and protein requirements. Thus, as its price is lowered, rapeseed meal is increasingly included in rations of higher energy and protein content. As a result the demand curve for rapeseed meal is not flat but sloped as shown in figure 3.3.

Finally, it might be concluded from figure 3.2 that rapeseed could actually replace all the soybean meal now used in Canada. However, because of its content of toxic glucosinolates, use of rapeseed meal in some rations is not allowed and in all other rations, there is an upper limit on the quantity of rapeseed meal which may be used regardless of its

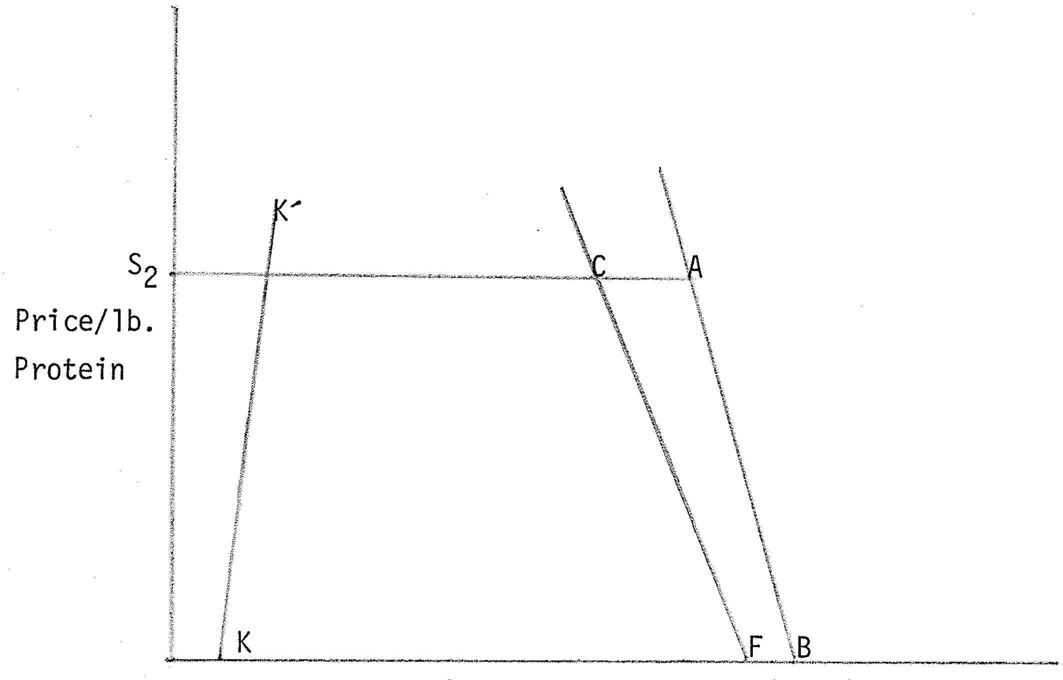


Figure 3.2: Derivation of Demand Curve for Rapeseed Meal from Demand Curve for Rapeseed Meal and Fish Meal

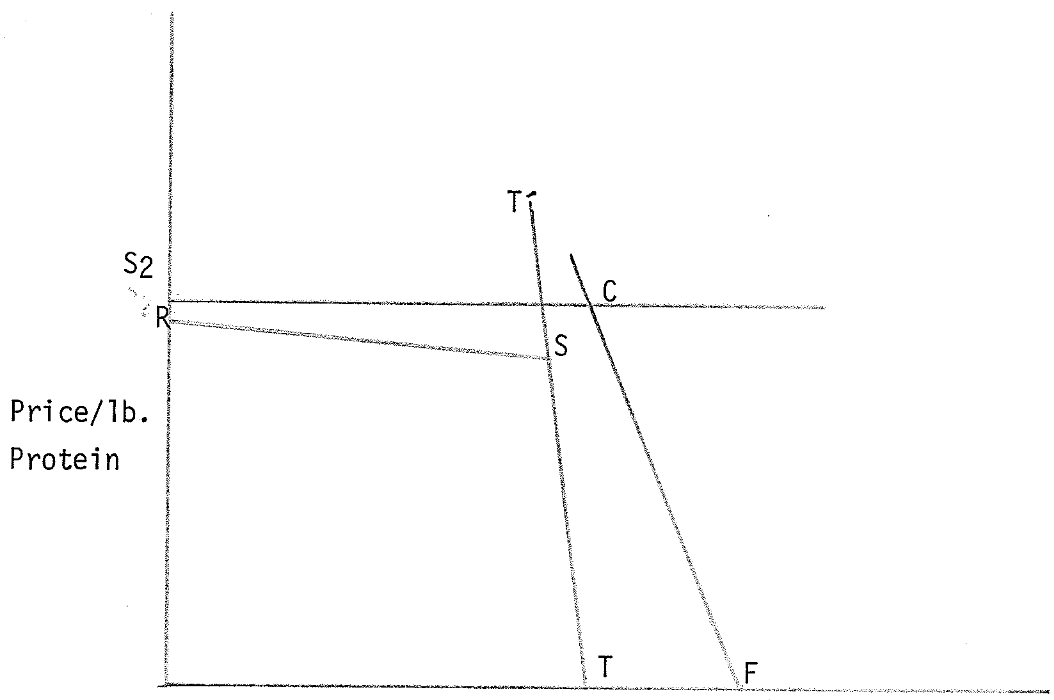


Figure 3.3: Adjusted Demand Curve for Rapeseed Meal

price. This would mean that beyond a certain quantity, the demand for rapeseed meal is perfectly price inelastic. In actual fact, many feed manufacturers adopt upper limits on the use of rapeseed meal which are even more restrictive than those generally advised by animal nutritionists. However, these more restrictive limits are likely to be slightly price responsive. The form of the demand curve for rapeseed meal is shown in figure 3.3. The segment ST is the result of the toxic compounds in rapeseed meal. ST is not vertical because of the price responsiveness of the reservations of feed manufacturers concerning use of meal. The location of the segment RS is determined by the price of soybean meal. It is slightly sloped as discussed previously, because of the different energy and protein levels of the various rations.

As was previously explained, net price received for meal by crushing plants differs according to whether the meal is sold in Eastern or Western Canada. As a result, the market for rapeseed meal must be divided into two parts: the demand for rapeseed meal in Eastern Canada and in Western Canada. The demand for meal in both regions has the form derived in figure 3.3. The flattest portion of the demand curve for Western Canada lies above that for Eastern Canada (AB) while the sloped part of the demand for Western Canada (ST) lies to the left of that for Eastern Canada (BC). Demands for both Eastern and Western Canada are shown in figure 3.4. The demand for Western Canada is labelled RST while the demand for Eastern Canada is labelled ABC.

(B) DEMAND FOR RAPESEED OIL

Rapeseed oil encounters competition from many more sources than does rapeseed meal. These sources may be broken down into three basic

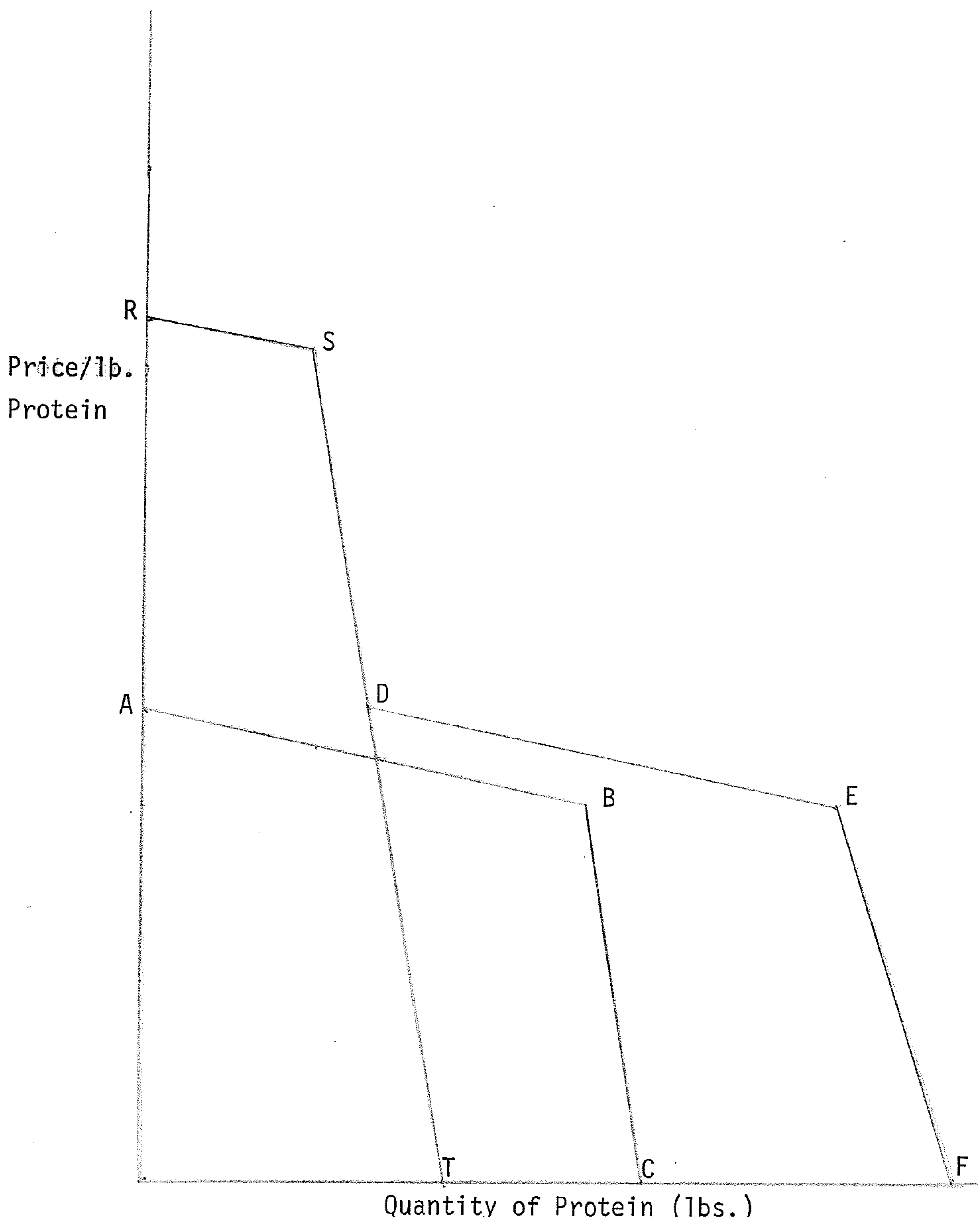


Figure 3.4: Adjusted Demand Curve for Rapeseed Meal with Markets in Eastern and Western Canada

groups - vegetable oils, marine oils and animal fats. The vegetable oil group is the largest and includes coconut, corn, cottonseed, palm, palm kernel, peanut, rapeseed, soybean and sunflower oils. The other two groups are much smaller. Among the marine oils are herring oil, seal oil and whale oil. The animal fats include butter, lard and edible tallow.

Edible oils are used in the production of three types of food products which are shortening oils, margarine oils and salad oils. The degree of competition among the various oils varies according to the end use. Table VII provides an indication of which oils compete strongest for use in the three types of food products listed above. Marine oils are used mainly in the manufacture of margarine and to a lesser extent in shortening oils. Animal fats are used mainly for shortening and margarine oils. Butter, of course, although not used in margarine manufacture competes with margarine. Vegetable oils are the most versatile group. Within that group, rapeseed, sunflower, palm and soybean oils appear to be most versatile. From the point of view of expanding the consumption of rapeseed oil, the distribution of rapeseed oils among the three uses would indicate that it is equally suitable for all three uses.

Although the various oils are substitutes one for another, they are not perfectly interchangeable. Differences in the fatty acid content give to each oil characteristics which are to some extent unique. These oils are blended together in order to yield products with the desired characteristics in terms of shelf-life, texture, palatability, melting and boiling point, etc. Although there are some products which are made from one oil, most are blends of several oils. Because one oil will not substitute directly for another, a change in the amount used of one oil may require that the entire ingredient mix be reformulated. As a result

TABLE VII

DOMESTIC PRODUCTION OF DEODORIZED OILS
1970-71 (000 lb.)

Oil/use	Margarine oil		Shortening oil		Salad oil	
	1970	1971	1970	1971	1970	1971
Coconut	427	991	29,086	29,546	------[1]	74
Corn	5,834	6,649	X[2]	X	X	X
Cottonseed	997	616	19,893	19,964	4,643	------
Palm	5,523	6,818	15,969	19,964	6	------
Palm kernel	------	19	9,913	9,279	------	------
Peanut	------	------	X	X	X	X
Rapeseed	41,354	47,298	43,465	60,724	45,478	32,455
Soybean	59,280	40,732	98,766	74,793	24,896	27,750
Sunflower	44	200	5,801	3,456	22,115	17,338
Herring	22,453	24,330	11,004	10,320	------	------
Seal	1,411	827	------	------	------	------
Whale	1,793	108	216	------	------	------
Lard	2,808	3,455	25,403	34,232	------	------
Oleo	------	37	1,043	406	------	------
Tallow	------		51,715	51,306	------	------

1. Nil
2. X - confidential to meet the requirements of the statistics act.

Source: Statistics Canada, Manufacturing and Primary Industries Division, Oils and Fats, Catalogue No. 32-006, Ottawa, Canada, The Queen's Printer, Edition 1971.

of the large number of substitutes for rapeseed oil and the variety of food products in which it may be used, it would appear that the demand for rapeseed oil would be quite elastic. However, the fact that it does have unique characteristics of its own would imply that the curve would not be perfectly flat.

In contrast with the situation with respect to rapeseed meal, edible oils are more expensive in Eastern Canada than in Western Canada. The price of oil in Western Canada is established by the price in Toronto minus the freight charge of shipping oil to Toronto. Thus the price received at the crushing plant is the same regardless of whether the oil is destined for use in Western Canada or Eastern Canada. Because of this, both Eastern and Western Canada can be treated as a single market.

(C) OUTPUT DETERMINATION - MATHEMATICAL ANALYSIS

Rapeseed crushing is a joint product process. The production function for the simplest case of joint products can be expressed as,

$$X = F(Y, W) \qquad (1)$$

where X is the quantity of input x used and Y and W are the outputs of products y and w respectively. This formulation assumes that Y and W are completely variable. A product transformation curve is the locus of combinations of Y and W which can be produced from a specified X. The product transformation curve, for a given amount X° of input x, can be written as,

$$X^\circ = F(Y, W) \qquad (2)$$

The slope of the product transformation curve is the rate at which W must be given up in order to gain more of Y. The rate of product transformation (RPT) is defined as the negative of this slope; that is,

$$RPT = -\frac{d\,W}{d\,Y}$$

Taking the total differential of (2),

$$d\,X^{\circ} = Fy\ dY + Fw\ dW$$ [1]

but $dX^{\circ} = 0$ for movement along the product transformation curve. Therefore,

$$-\frac{d\,W}{d\,Y} = \frac{Fy}{Fw} \qquad (3)$$

That is, the rate of product transformation of Y into W is equal to the marginal product of x in terms of y divided by the marginal product of x in terms of w.

Rapeseed crushing involves only a small weight-loss (about .5 per cent). Since the weight-loss is constant, the weight of the extracted rapeseed oil and the weight of the rapeseed meal produced by one bushel of rapeseed sum to a constant equal to the weight of one bushel of rapeseed (50 pounds) minus the weight-loss. The production possibility curve for rapeseed crushing can be written as,

$$X^{\circ} = Y + Z + K \qquad (1)$$

where X° is a bushel of rapeseed, Y and Z are the per bushel outputs of rapeseed oil and meal, and K is the constant weight loss per bushel of rapeseed crushed. Taking the total differential,

$$dX^{\circ} = dY + dZ + dK \qquad (2)$$

However, since X° and K are constants for movement along the production possibility curve, dX° and dK are equal to zero. Hence,

$$dY + dZ = 0$$

or,

$$\frac{dY}{dZ} = -1 \qquad (3)$$

---

[1] Fy is the first partial derivative of the function F with respect to Y.

The slope of the transformation curve is -1. This curve is smooth but does not intersect the meal axis. It terminates at a point yielding 21.00 pounds of oil and 28.75 pounds of meal. Further processing neither increases oil output nor decreases output of meal. The product transformation curve for rapeseed crushing is shown in figure 3.5.

Determination of the optimum output combination of oil and meal requires further specification of the structure of the industry. The process of determining optimum output combination will be illustrated using

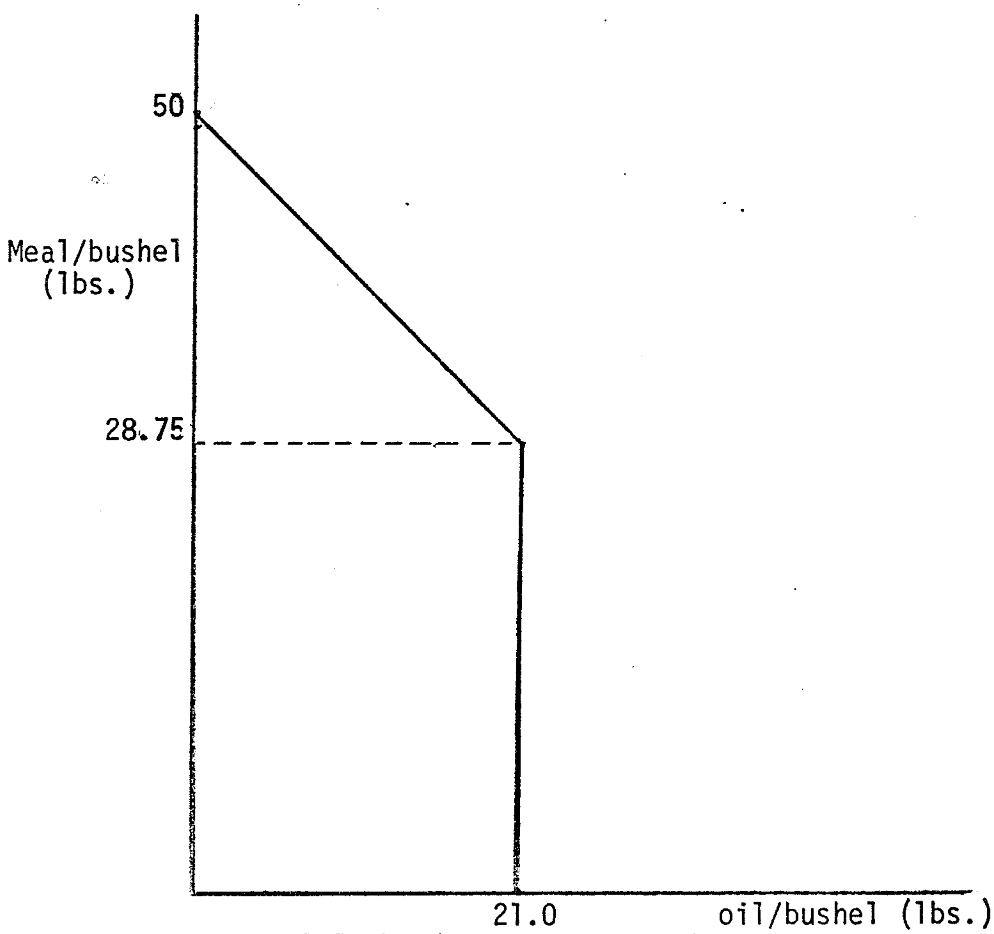


Figure 3.5 Product Transformation Curve for One Bushel of Rapeseed

a cartel model. It is assumed that the cartel acts as a monopolist in determining the optimum output of rapeseed oil and meal. Since the domestic crushing industry must pay the same price to the farmer as do elevator companies purchasing rapeseed for export, and since the crushing industry does purchase less than fifty per cent of Canadian rapeseed, it is assumed that it is a price taker with respect to rapeseed. On the output side it is assumed that the cartel can influence the price of both the oil and the meal.

There are essentially three types of costs involved in rapeseed crushing. The first are the flaking costs. These are constant per bushel costs and cannot be allocated to either the oil or the meal. Flaking produces a kind of rapeseed meal which could be fed to livestock. However rapeseed meal requires further processing to minimize its content of toxic substances. This further processing is the second type of cost and can be fully attributed to the meal. The third type is the oil extraction cost. This cost is attributed fully to the oil.

The objective function of the cartel can now be represented as,

$$Z = G(Y)\ Y + H(W)W - XPx - CX - F(Y) - E(W) \qquad (4)$$

where Y is the output of rapeseed oil,

G(Y) is the price of rapeseed oil which is determined by the output of oil,

W is the output of rapeseed meal,

H(W) is the price of rapeseed meal which is determined by the output of meal,

X is the input of rapeseed,

Px is the price of rapeseed,

C is the per bushel cost of flaking rapeseed (a constant), F(Y) is the cost of extracting oil, related to the quantity of oil extracted and

E(W) is the cost of processing meal, related to the quantity of meal processed.

Substituting in $X = Y + W + K$ and, $Px' = Px + C$ yields

$$Z = G(Y)\,Y + H(W)W - Px'\,(Y+W+K) - F(Y) - E(W) \qquad (5)$$

The first order conditions for profit maximization are,

$$Zy = G(Y) + GyY - Px' - Fy = 0 \qquad (6)$$

$$Zw = H(W) + HwW - Px' - Fw = 0 \qquad (7)$$

Combining (6) and (7) to eliminate Px' yields,

$$G(Y) + GyY - Fy = H(W) + HwW - Ew \qquad (8)$$

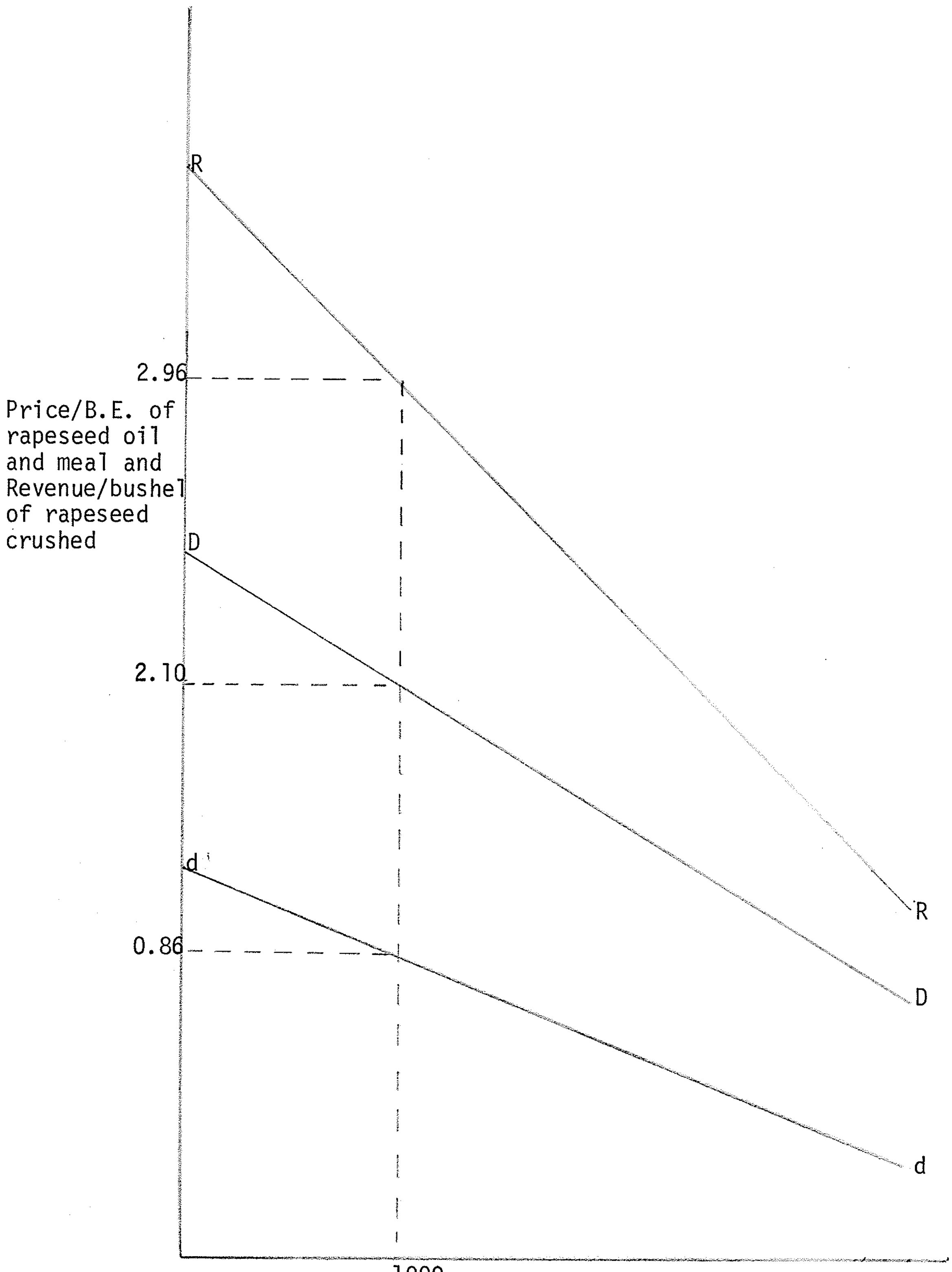
The marginal net revenues for each product must be equal. Since there is an upper limit on the amount of oil in the product combination (21.00 pounds per bushel crushed) it follows that for a product combination to be optimal, the marginal net revenue for rapeseed oil must equal or exceed that of rapeseed meal.[2] Since crushing cost data is not available and since the demand elasticities of oil and meal have not been estimated it is not possible to state what the marginal revenue for each product are. However, since crushing plants do not vary oil yield in response to change in the price of oil and meal, it would appear safe to assert that the marginal net revenue for oil does exceed that of the meal. The optimal product combination thus includes a maximum yield of oil. Since crushers do extract the maximum possible amount of oil from rapeseed, the process can be analysed as one of joint products of fixed output proportions.

---

[2]In the case of perfect competition, the first order conditions require that the price minus extraction cost of rapeseed oil exceed or equal the price minus processing cost of rapeseed meal.

(D) OUTPUT DETERMINATION - GRAPHIC ANALYSIS

A demand curve expresses a relationship between the price per unit of the commodity and the quantity demanded of that commodity. The choice of units of both volume and price makes no difference in the interpretation of the demand curve. Although the choice of units will affect the slope of the demand curve, the elasticities are independent of the units chosen. For joint product processes with fixed output proportions, it is convenient to define a unit, here called a bushel equivalent (B.E.), which is equal to the yield of each product from one bushel of raw rapeseed. Thus, a bushel-equivalent of rapeseed oil would be equal to 21.0 lbs. whereas a bushel equivalent of rapeseed meal would be 28.75 lbs. of that meal. When the demand curves are constructed using these units, the total revenue from the sale of the products of one bushel of rapeseed is simply 28.75 X the price per pound of meal + 21.0 X the price per pound of oil. By carrying out this summation for all outputs along each demand curve, an average revenue per bushel function can be derived. Such a derivation is illustrated in figure 3.6. The meal demand curve dd and the oil demand curve DD are vertically summed to yield the average revenue per bushel function RR. For example, suppose that one point on the rapeseed oil demand curve is a quantity of 21,000 lbs. and 10.0¢/lb. Since the oil yield per bushel of rapeseed is 21 lbs., 21,000 lbs. represents 1,000 bushel equivalents. Since the meal yield per bushel is 28.75 lbs., 1,000 bushel equivalent of meal is 28,750 lbs. Suppose that this quantity of meal will be demanded at a price of 3.0¢/lb. The average revenue per bushel at a quantity crushed of 1,000 bushels is 28.75 (.03) + 21.00 (.10) = \$2.96.



Quantity of rapeseed oil, rapeseed meal and rapeseed

Figure 3.6: Derivation of Average Revenue per Bushel of Rapeseed From Demand Curves for Rapeseed Oil and Meal

Output determination, for an industry utilizing a joint products process with fixed output proportions, will be analysed using a perfectly competitive model and a cartel model. The conclusions of the two models will be compared in order to determine which model is more appropriate for analysis of the rapeseed crushing industry.

Assuming that the industry is perfectly competitive, given the average revenue per bushel curve and a supply curve which can be approximated by a horizontal summation of the marginal cost of crushing curve, output would be determined by the intersection of the average revenue per bushel function and the supply function. This is illustrated in figure 3.7. Panel (a) contains the rapeseed meal demand curves for Eastern (CEC′) and Western Canada (DWD′) as well as the horizontal summation of the two (DWFGB). It is important to remember that the demand curves in panel (a) are those faced by the crushing plant in Western Canada. They represent the price received for oil and meal net of transportation costs.

There are two conclusions which follow from the analysis using the perfectly competitive model. The first relates to geographic or aviations in price. As shown in figure 3.7, the net price received for rapeseed oil is the same regardless of its destination. The same is true for rapeseed meal. This implies that the market prices for rapeseed oil and rapeseed meal should exceed their respective prices in Western Canada by the cost of transportation to Eastern Canada.

The second conclusion relates to the responsiveness of the industry to changes in the crushing margin. This margin is defined as the average revenue per bushel minus the price per bushel of raw rapeseed. With a perfectly competitive model, changes in the crushing margin

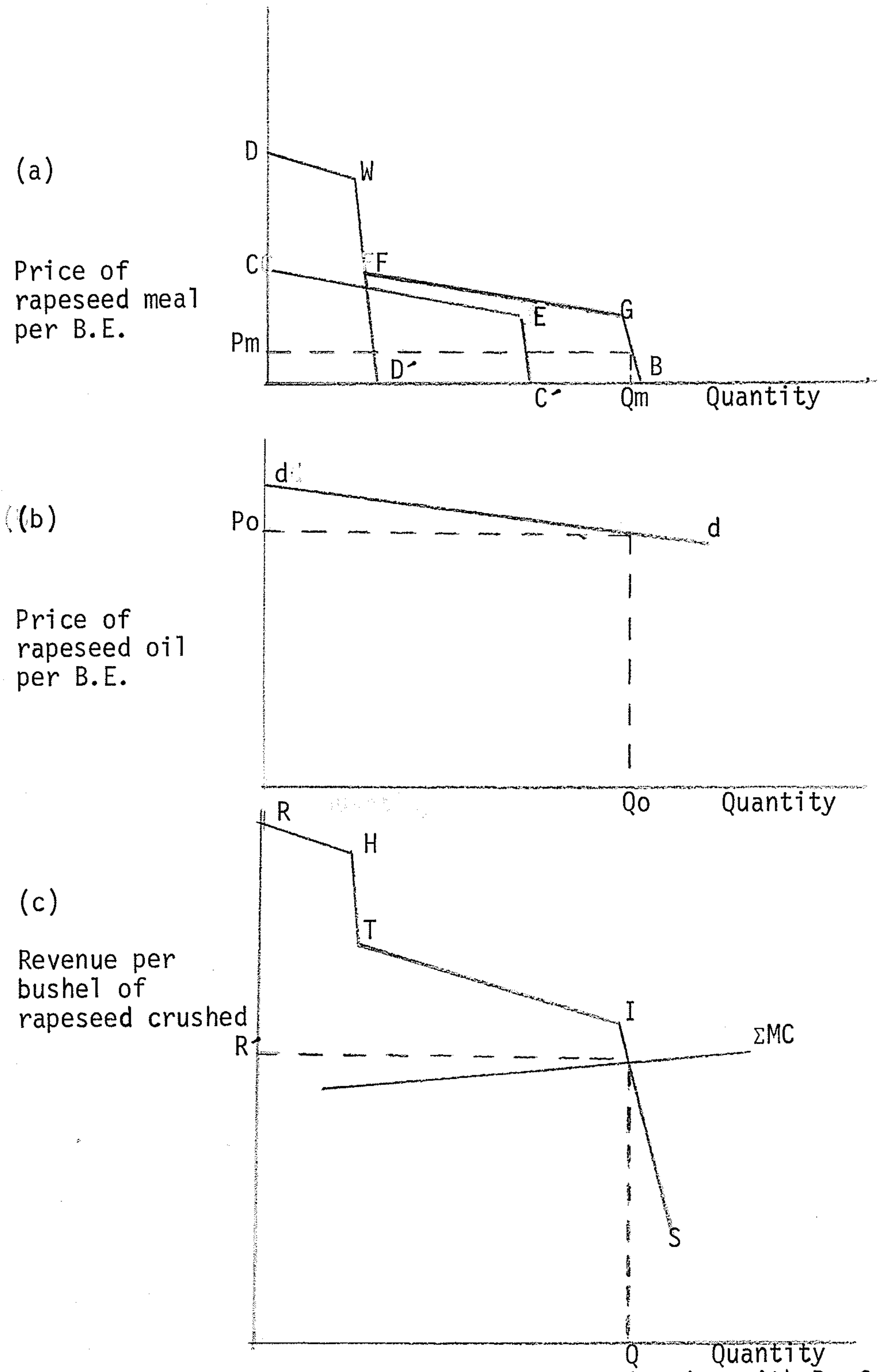


Figure 3.7: Output Determination with Perfect Competition

brought about by either an upward shift in the average revenue per bushel curve (see figure 3.7) on a downward shift in the marginal cost curve as a result in the price of rapeseed, would increase the profit maximizing output. Output is determined at Q with revenue per bushel determined at R. The net prices per bushel equivalent of rapeseed oil and meal f.o.b. the crushing plants are determined at Po and Pm respectively.

Another alternative is to use a cartel model to analyse the industry's behaviour; that is, to assume that the firms within the industry recognize their interdependence and as a result collude to some extent, even tacitly, with respect to pricing of the product. It would then be acceptable to analyse the industry as if it were a single firm. To do this, it is necessary to derive the marginal revenue per bushel function. This can be done first by horizontally summing the marginal revenue curves for meal in both Eastern and Western Canada. The resulting meal marginal revenue is then summed vertically with the marginal revenue curve for rapeseed oil to produce the marginal revenue per bushel function for both oil and meal. Output is determined where the horizontal summation of the firms' marginal crushing cost curves intersect the marginal revenue per bushel function. Output determination under these conditions is illustrated in figures 3.8 and 3.9. Panel (a) of figure 3.7 contains the demand for rapeseed meal in Western Canada (ABC), and in Eastern Canada (DEF), the marginal revenue curve for rapeseed meal in Western Canada (AVG) and in Eastern Canada (DWH), and the horizontal summation of the two rapeseed meal marginal revenue curves (AWIJK). Panel (b) of figure 3.8 contains the demand for rapeseed oil (RS) and

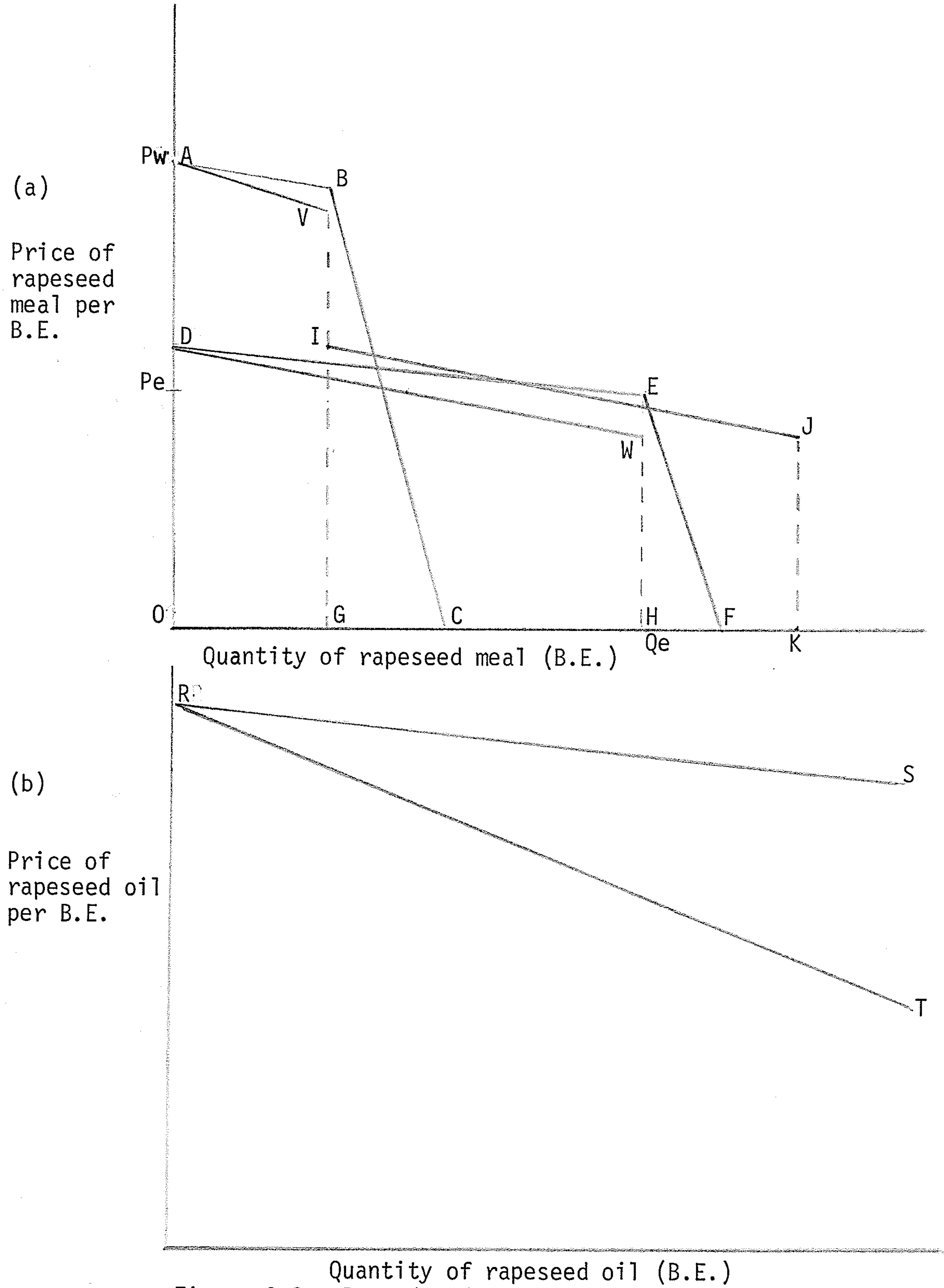


Figure 3.8: Demand and Marginal Revenue Curves for Rapeseed Meal and Rapeseed Oil

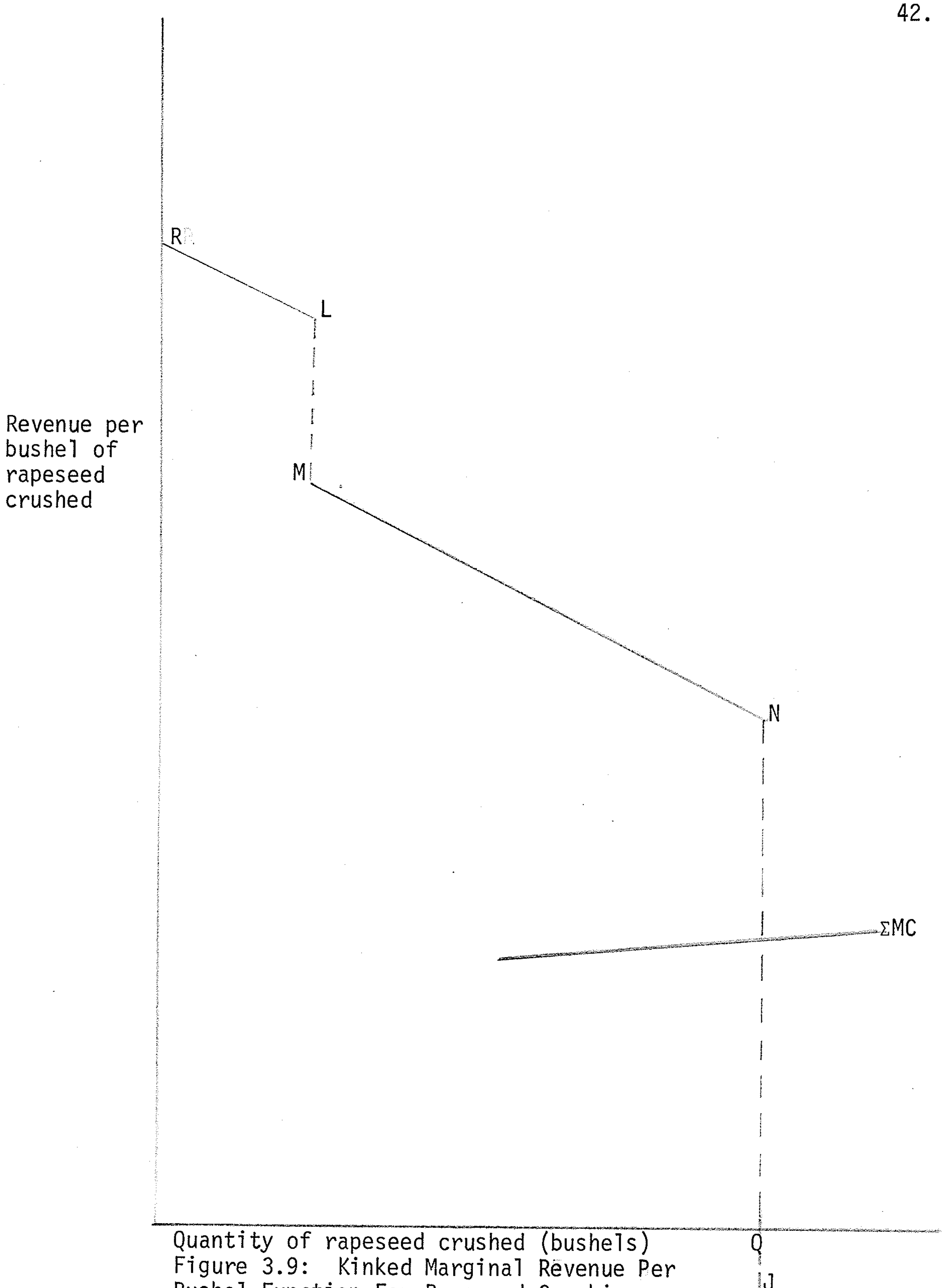


Figure 3.9: Kinked Marginal Revenue Per Bushel Function For Rapeseed Crushing

the marginal revenue for rapeseed oil (RT). Figure 3.9 contains the vertical summation of the marginal revenue curve for oil and for meal to form the marginal revenue per bushel curve. It also contains the horizontal summation of the marginal crushing cost curves for the various plants (MC). Output is determined at Q where the marginal cost curve intersects with the marginal revenue per bushel function. To find the prices for each product, the output Q (which can be interpreted as bushels of rapeseed or as bushel equivalents of rapeseed oil and meal) is found on the quantity axis of panels (a) and (b) of figure 3.8. The price of oil per bushel equivalent corresponding to an output of Q bushel equivalents of oil is Po. In the case of rapeseed meal to maximize profit the industry would attempt to sell meal in each market until the marginal revenues are equal to both markets. This occurs for both markets where the marginal revenue curve for that market is discontinuous. To maximize profit, the industry would sell OQw (see figure 3.8) in the Western market and OQe in the Eastern market. The price in the Western market would be OPw while the price in Eastern Canada would be OPe.

Two conclusions emerge from the analysis using the cartel model. First of all, with a cartel market structure, it is unlikely that the net return from meal sold in each market should be the same. Since the difference in the net returns received from meal sales in each market are due to transportation costs, arbitrage cannot eliminate these differences. As can be seen in figure 3.8, the net return will be lower for meal sold in Eastern Canada than for meal sold in Western Canada, but since Eastern and Western Canada both comprise one oil market, the net return from oil sales is independent of the destination of the oil.

Secondly, as long as the summation of the marginal crushing costs intersects the marginal revenue per bushel curve where the latter is discontinuous, or output of the crushing industry will not be responsive to fluctuations in the crushing margin. As can be seen in figure 8, an upward shift in the average revenue per bushel function or a downward shift in the summation of marginal costs curve will not change the quantity at which the intersection of marginal revenue and marginal cost occurs.

On the basis of the conclusions of the two models, it is possible to determine which model is most suitable for analysis of this industry. The perfectly competitive model implied that prices for both rapeseed oil and meal would be higher in Eastern Canada than in Western Canada and that net returns from sales of oil and meal would not depend on destination. It also implied that quantity of rapeseed crushed would be highly correlated with the size of the crushing margin. The cartel model, on the other hand, predicted that net returns from sales of meal would be lower for sales of meal to Eastern Canada, that net returns from oil sales would be the same whether the oil was sold to buyers in Western or Eastern Canada, and that output would not be responsive to fluctuations in the crushing margin.

In actual fact, net return from sales of meal does depend upon the destination of the meal while net returns from sales of rapeseed oil do not depend upon destination. In addition, the correlation between output and the crushing margin is very low. From 1967 to 1970, the correlation between output and the crushing margin of the same month was .264 while the correlation between output and the crushing margin of the preceding month was .279. The low correlation between output and the crushing margin as well as the fact that net returns for meal do vary according to destination would lead to the conclusion that the cartel model is the more appropriate model for this analysis.

The low correlation between output (quantity of rapeseed crushed in Canada) and the crushing margin indicated that the marginal revenue curve intersects the marginal revenue curve where the latter is discontinuous. This means that if the quantity at which this discontinuity occurs is increased, (that is, if the discontinuity is shifted to the right) the quantity of rapeseed crushed will increase by the same amount. The discontinuity in the marginal revenue per bushel is caused by the kink in the demand function for rapeseed meal (in either Eastern Canada, Western Canada or both) would shift to the right the discontinuity in the marginal revenue/bushel function and would increase output by the same amount. This is illustrated in figure 3.10, but for only one market in order to keep the diagrams clear. Initially the demand curve for rapeseed meal (panel a) is ABC while the marginal revenue curve for rapeseed meal is ADE. The demand and marginal revenue curves for rapeseed oil are dd and dr respectively. The marginal revenue per bushel function (panel c) is abe. Output is determined at Q_o. Now let the demand curve for rapeseed meal shift to AB´F. This shifts the rapeseed meal marginal revenue curve from ADE to AGH and the marginal revene per bushel function for rapeseed from abe to afg. Output is increased to Q_1.

On the other hand, a shift to the right in the demand curve for rapeseed oil will have no effect upon the quantity of rapeseed crushed. It will increase the crushing margin and consequently profits but since a shift in the demand curve for rapeseed oil will not affect the location of the discontinuity in the marginal revenue per bushel function, such a shift will not affect the quantity of rapeseed crushed or the output of rapeseed oil and meal.

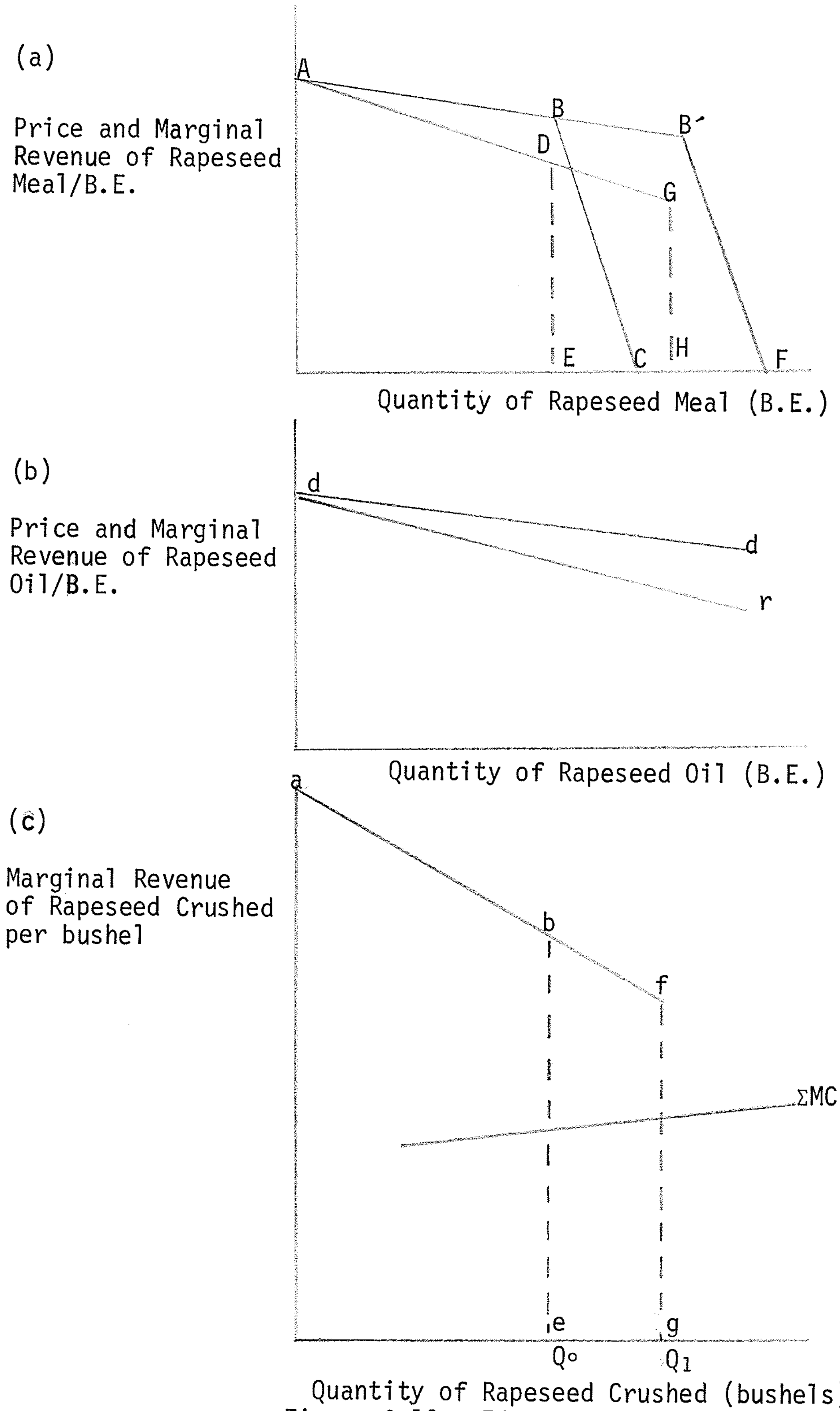


Figure 3.10: Effect of an Increase in Demand for Rapeseed Meal upon Quantity of Rapeseed Crushed

In terms of the analysis at hand, this means that it is sufficient to investigate the effect upon the demand curves for rapeseed meal in order to analyse the impact of new rapeseed varieties which yield a rapeseed meal of improved quality.

CHAPTER IV

DEMAND ESTIMATING TECHNIQUE

(A) COMPARISON OF REGRESSION AND LINEAR PROGRAMMING APPROACHES

There are essentially two approaches which can be used to investigate the characteristics of a demand function. The choice between the two depends in part upon the nature of the demand function and in part upon the type of information which is being sought.

The first of these two approaches is what might be called an aggregate approach. It utilizes market price and quantity data in order to determine the characteristics of demand for a particular commodity. Regression analysis is generally used in such analyses. Although this approach is widely used and is useful for deriving certain types of information, it does have a number of short-comings.

Firstly, since regression analysis is generally used to estimate aggregate relationships, this approach is most useful when the functions being dealt with either are, or can be approximated by, smooth curves. However, the demand for rapeseed meal as it was developed in the preceding chapter, is kinked. Regression analysis would tend to "average over" this kink and produce results which would not accurately describe the demand for rapeseed meal.

Secondly, estimation of the demand function for rapeseed meal using the aggregate approach would require data including market prices and quantities sold at those prices. At present, the only available data is in the form of average net prices received by the various rapeseed crushing plants. These prices are not market prices since transportation costs have already been deducted. To neglect this fact might not be a serious error for meal which is sold in Western Canada, but for meal sold in Eastern Canada to neglect the transportation cost would seriously distort the analysis. Since the proportion of meal sold in each market varies from month to month, it is not possible to adjust the average net prices by a constant in order that they might more closely approximate market prices. In order to adjust net prices, data revealing the distribution of meal sales in each time period would be required. At present, such data is not available.

Thirdly, regression analysis requires a time period over which the structure of the industry has been stable. If such is not the case, it becomes very difficult to derive coefficients which have any real meaning. Over the past number of years, the rapeseed crushing industry has experienced a period of rapid growth. During the period, the quality of both rapeseed oil and rapeseed meal has been improved. At the same time extensive promotional efforts coupled with research concerning the use of these products has made potential users more receptive to these products. Thus in view of the changes which have occured with the industry the possibility of obtaining coefficients of any value seems quite remote.

Finally, the aggregate approach deals primarily with price and quantity relationships. Using this approach it is difficult if not impossible to incorporate into the analysis the actual quality characteristics of the product in order to determine their impact upon demand. Since the purpose of this analysis is to measure the impact of changes in quality characteristics, the aggregate approach would not appear to be appropriate for this analysis.

The second approach to demand estimation hinges upon the fact that the market demand for any commodity is simply the summation of the demand for that commodity by each demand unit. For example, the market demand for oranges is simply the summation of the demand for oranges by each individual person or household. For purposes of this analysis, it is useful to regard the demand unit as a hundred weight of ration or protein supplement. (The choice of a hundred weight as demand unit is arbitrary. It could as easily have been a ton or a pound of feed). The demand for rapeseed meal by any ration or supplement is then the demand for rapeseed meal by a hundred weight of that ration, multiplied by the output (in hundred weights) of that ration. The market demand for rapeseed meal can then be derived by summing the demands for rapeseed meal for each ration produced.

From an economic standpoint, the optimum rate of production (whether the product is meat, milk or eggs), and hence the optimum rate of nutrient intake is a function of the prices of both the output and the feed inputs. This would mean that the amount of protein or energy included in the ration would have to be treated as an economic variable, not a constant. As a rule, however, animal scientists deal with maximum or minimum nutrient levels rather than optimal levels. As a result, accurate knowledge of the production function is often not available. Furthermore, even if such information were available, the fact that physical production conditions vary from farm to farm would make calculation of optimal nutrient levels difficult. Finally, rations whose nutrient contents fluctuated according to economic conditions would probably prove confusing to livestock feeders. For these reasons, nutrient content of rations do not as a rule vary in response to changes in economic conditions but as a general rule can be regarded as constants.[1] The objective of the livestock feeder can thus be reduced to one of minimizing the cost of formulating a ration whose nutrient requirements can be regarded as constants.

Since linear programming is now used by several feed manufacturers for least-cost formulation of rations and protein supplements, it is useful to examine its usefulness with respect to demand estimations. To be solved using a linear program, a problem must possess the following characteristics:

(1) Linearity (Additivity) - All relations among variables both in the objective function and in the constraints must be linear or must closely approximate linearity. In terms of this analysis, a linear objective function means that the cost of formulating a ration is simply the sum of the costs of each ingredient plus, perhaps, a constant cost for mixing. This implies that the cost of formulation is independent of the number of ingredients used in the ration. While it is possible that a ration utilizing many ingredients might require more thorough mixing, this additional cost would not likely be large enough to render a linear approximation seriously inaccurate.

Linearity with respect to the constraints implies that the activities are linearily independent of each other. In terms of this analysis this means for each ingredient, the amount of any nutrients/pound contributed to the ration is independent of the amounts of other ingredients used in the ration. For example, the amount of protein

---

[1]Having gone this far, it is important not to overstate the case. To a limited extent, ruminant rations are varied in response to changes in economic conditions. Rates of gain for cattle are sometimes adjusted by limiting intake or lowering the energy content of the ration in order to have the marketing date coincide with a period of high price. Because of their limited application, however, such exceptions do not invalidate the rule discussed above.

contributed by a pound of soybean meal is independent of the amount of rapeseed meal used in the ration. Such a requirement does not allow for an interaction among ingredients within the ration. In general, this requirement can be said to be met.

(2) Multiplicativity - With respect to the objective function this multiplicativity requires that the price of each ingredient be a constant independent of the amount of that ingredient which is used. If prices are a function of the quantity used, it may be possible to approximate an upward sloping supply schedule by subdividing each activity into several sub-activities and by giving each activity a separate cost. Generally, however, feed manufacturers face constant prices so that the requirement is satisfied.

With respect to the constraints, multiplicativity requires that the nutrient content of a unit of ingredient is a constant, independent of the amount of that ingredient which is used. For example, if one unit of soybean meal provides one half unit of protein then two units of soybean meal will provide one unit of protein.

(3) Divisibility - this means that the model is not restricted to whole units of any activities. For this analysis, this simply requires that any fraction of a pound of any ingredient may be used in order to formulate the least cost ration. While a problem could conceivably arise concerning the ability of equipment to measure very small amounts of any ingredient, this problem, if it occurs, is generally circumvented through the use of premixes which plants without sensitive equipment will buy and into which ingredients used in very small quantities have already been mixed.

(4) Finiteness - this requirement simply means that there are a

finite number of activities or ingredients which may be used and a finite number of nutrients which are required. This requirement is met since each feed manufacturer has access to only a limited number of ingredients.

The diet problem can be expressed in matrix algebra as,

Minimize: $Z = (C_1 \ldots\ldots C_n)\ (X_1 \ldots\ldots X_n)'$

Subject to:

$$\begin{bmatrix} A_{11} \ldots\ldots\ldots\ldots A_{1n} \\ A_{m1} \ldots\ldots\ldots\ldots A_{mn} \\ -A_{m+1\ 1} \ldots\ldots\ldots -A_{m+1\ n} \end{bmatrix} \begin{bmatrix} X_1 \\ \vdots \\ X_n \end{bmatrix} \geq \begin{bmatrix} b_1 \\ \vdots \\ b_m \\ -b_{m+1} \end{bmatrix}$$

where Ci is the price per unit of the i^{th} ingredient and where Xi is the number of units of the i^{th} ingredient used in the ration. bj is the minimum required level for the j^{th} nutrient and Aij is the contribution by the i^{th} ingredient of the j^{th} nutrient. Thus, in the "A" matrix there is a row of elements which contains the protein content of all of the ingredients, a row which contains the energy content of the ingredients and so on. As can be seen, there are n ingredients and m required nutrients. b_{m+1} is the maximum weight of all of the ingredients included in the ration. Since conceptually this is a maximum rather than a minimum restraint, b_{m+1} and its corresponding row in the "A" matrix are multiplied by -1 to produce a greater than restraint. Since each unit of ingredient contributes one unit to the weight of the ration, and since each element in the m+1 row was multiplied by -1 to convert it to a greater than restraint, each element in that row is equal to -1.

The procedure for deriving a demand curve for rapeseed meal involves three steps. The first of these is to derive a demand curve for a hundred weight of each ration or supplement. The quantities of rapeseed meal demanded at each price are then multiplied by the total output of that ration to provide a demand curve for that ration. The final step is the summation of the demand curves for each ration in order to derive a total demand curve for rapeseed meal. This procedure must be followed for each different quality of rapeseed meal which is to be considered. Linear programming would appear to have potential use for such a problem. A demand schedule is merely an expression relating quantity demanded and price. Such a schedule is merely an expression relating quantity demanded and price. Such a schedule could be derived for a hundred weight of each ration by solving for the least cost formulation of a ration using an ascending or descending series of prices. Such a procedure is called parametric programming. Using this procedure, and starting from an initial price for the ingredient for which the demand curve is desired, the least cost formulation of the ration is solved for at price intervals predetermined by the operator. In this way a demand schedule for a hundred weight of ration or supplement can be simulated. It can be readily seen that a demand schedule so derived is a function of the characteristics of the rapeseed meal. It is a relatively simple procedure to change the characteristics of the rapeseed meal by adjusting the appropriate coefficients in the "A" matrix and then to derive a new demand schedule. The impact of the quality change is the difference between the two demand schedules. With currently used rapeseed meal, there is an upper limit on the amount of rapeseed meal which can be used per hundred weight of ration. To calculate the effect of the glucosinolates one would first derive the demand curve including in the "A" matrix of the linear program, the appropriate upper limit on rapeseed meal use. Then after removing this upper limit from the "A" matrix, the demand curve would again be derived. In actual practice, solving the program with an upper limit on rapeseed meal use is not necessary. Since we are interested only in the amounts of rapeseed meal used, to derive a demand curve for meal where the upper limit is in force and to replace all quantities which exceed the maximum allowable level of rapeseed by quantities equal to that maximum allowable level. For example if the maximum level or rapeseed meal was eight pounds per hundred weight and the least cost ration included ten pounds of rapeseed meal, on the demand curve for current meal types, ten would be replaced by eight. In this case, the impact of removing the toxic compounds from the meal and in doing so removing the upper limit on meal use would be two pounds per hundred weight.

It is important to note that use of this second method of estimating the demand for rapeseed meal requires the assumption that the actual output of complete feeds and protein supplements is not responsive to changes in the price of rapeseed meal. This assumption is implicit in this method since the output by which each quantity on the demand curve for a hundred weight of each ration (or supplement) is multiplied in order to derive the total demand function for that ration is treated as a constant. This assumption is not unrealistic since the cost of rapeseed meal generally constitutes only a small part (less than 15%) of total ration cost. Thus a 1.0% change in the price of rapeseed would result in a .15X change in the quantity of complete feeds. Because of the fixed nature of capital invested in housing and operating equipment, the price elasticity of complete feeds should be quite low. This would result in a very low reponsiveness of total ouput of complete feeds to the price of rapeseed meal.

(B) USE OF REPRESENTATIVE RATIONS

(1) REASONS FOR USE OF REPRESENTATIVE RATIONS

The various feed manufacturers produce a very large number of protein supplements and complete rations. To analyse separately each one would not only be extremely costly but would also involve unnecessary duplication, since many of the products marketed by different firms are similar in nutrient content. It is, therefore, desireable to select rations which are adequately representative of the total number of different complete feeds and supplements produced.

The concept of a representative ration which is used here is similar in nature to the representative firms concept which has been used to some extent in estimating supply response. The procedure used is to break down the total output of complete feeds and supplements into several groups which are reasonably homogeneous within, and at the same time reasonably distinct from the other groups. The process of selection of homogeneous groups is aided somewhat by the fact that although there are a large number of rations and supplements produced, many of these are used during the period when the animal is young and when its feed consumption rate is relatively small. As a result, a relatively small volume of those feeds is actually consumed. Furthermore rapeseed meal is used mostly in rations for the more mature animals. This makes it possible to focus upon these rations and supplements.

(2) SELECTION OF REPRESENTATIVE RATIONS

Ideally, it is not necessary to have separate representative rations for each class of livestock. There is no reason why a ration could not be representative of both broiler and turkey rations for example. However, since output data for the feed manufacturing industry is broken down according to livestock class, the representative rations used in this study will also be selected upon this basis. Table VIII presents the 1969-1970 average output of the various complete feeds and supplements by the Canadian feed manufacturing industry. From this table, it is possible to select the types of rations and which are representative of the largest proportion of total output. By selecting only feed types of which production exceeded one hundred thousand tons, the number of types is reduced from eleven of both supplements and complete feeds to six supplements and five complete feeds.

TABLE VIII

AVERAGE OUTPUT FOR 1969-1970 OF COMPLETE FEEDS AND COMPLETE FEED EQUIVALENTS OF PROTEIN SUPPLEMENTS (tons)

Livestock Type	Supplements	Complete Feed
Calf	22,616	41,088
Beef	1,149,961	67,732
Dairy	1,075,437	280,025
Swine	1,858,520	368,556
Chick starter	47,686	51,490
Broiler	297,756	519,872
Grower, Layer	732,918	486,370
Fattening & Finishing	13,535	18,543
Turkey	118,841	269,115
Other Poultry	6,468	20,858
Miscellaneous	2,416	22,132
Total	5,324,652	2,145,830

Source: Statistics Canada, Manufacturing and Primary Industries Branch, Shipments of Prepared Stock and Poultry Feeds, Catalogue No. 32-004, Ottawa, Canada, The Queen's Printer, Vol. 24, No. 12.

The remaining feed types encompass 89.7% of complete feeds, 98.2% of supplements and 95.8% of total output of both supplements and complete feeds. With the exception of beef and dairy supplements and the turkey complete feed, a single representative ration was constructed for each of the feed types whose output exceeded 100,000 tons. Beef and dairy supplements, were considered similar enough to be estimated using a single representative ration. On the other hand turkey rations showed sufficient variations to require two representative rations. Table II contains the required nutrient levels of the representative rations for non-ruminant livestock - that is, swine and poultry.

It will be noted that the list of nutrient requirements does not included vitamins or minerals except for calcium and phosphorus. The reason for this is that these nutrients are generally supplied by vitamin-mineral pre-mixes. For this reason, the required levels of minerals and vitamins do not significantly affect the least cost combination of protein and energy feeds. Because of the requirement of pre-mix to fill the need for these vitamins and minerals, the upper limit on the weight restraint is 98.0 lbs. per cwt. of feed. This in effect leaves room for two pounds of vitamin-mineral pre-mix per hundred weight of feed. Calcium and phosphorus are exceptions. Since these minerals are required in relatively large amounts, and since some common feedstuffs contain significant amounts of them, the requirements for these minerals are included in the specification of the representative rations in Table IX.

In order to show the degree to which the representative rations actually do represent the total feed intake, it is necessary to examine the feed intake pattern for each livestock class. The nutrient requirements for broiler chickens can be broken down into two groups according to

TABLE IX

REQUIRED NUTRIENT LEVELS FOR REPRESENTATIVE RATIONS (LBS./CWT.)

	Broiler	Layer	Turkey A	Turkey B	Swine
Protein (L)	20	15	21	16	15
Energy (Kcal) (L)	140,000	130,000	137,000	144,000	123,000
Weight (L)	95	95	95	95	95
Weight (U)	98	98	98	98	98
Argenine (L)	1.20	.80	1.30	1.00	.20
Lysine (L)	1.10	.5	1.20	.90	.70
Methionine (L)	.40	.28	.40	.31	.30
Methionine + Cystine	.75	.53	.70	.52	.50
Phenylalanine	.70	--	.80	.60	.35
Tryptophan (L)	.20	.11	.20	.15	.13
Calcium (L)	.80	2.75	.75	.75	.65
Calcium (U)	.95	2.95	.85	.85	.80
Phosphorus (L)	.40	.60	.70	.70	.40
Fat (L)	2.0	1.5	2.0	2.0	1.5
Fat (U)	8.0	8.0	8.0	8.0	8.0

L - indicates a lower limit. U - indicates an upper limit.

TABLE XI

RECOMMENDED NUTRIENT REQUIREMENTS FOR GROWING AND FINISHING TURKEYS

	I	II	III	IV
Age - Male Female	8-12 8-11	12-16 11-14	16-20 14-17	20-24 17-20
Metabolizable energy	133,200	137,300	140,700	144,100
Protein	22	19	16.500	14
Argenine	1.30	1.10	1.00	0.80
Isoleusine	.85	.75	.70	.55
Methionine	.40	.35	.31	.26
Methionine + Cystine	.70	.58	.52	.43
Phenylalanine	.80	.67	.60	.50
Tryptophan	.20	.17	.15	.13
Calcium	.80	.80	.80	.80
Phosphorus	.70	.70	.70	.70

Source: Subcommittee on Poultry Nutrition, Committee on Animal Nutrition, Agricultural Board, National Research Council, Nutrient Requirements of Domestic Animals, Number 1, Nutrient Requirements of Poultry, (6th ed., rev. ed.), National Academy of Sciences, 1971.

TABLE XII

PROTEIN LEVELS RECOMMENDED BY LOCAL FEED MANUFACTURING FIRMS

Age (weeks)		Protein Content
Male	Female	
8-14	8-12	21
14-18	12-16	18
18-21	16-19	16
21-24	19-21	14

for a higher protein ration during early stages of growth. Based upon both the requirements in Table XI and the program just listed, turkey rations A and B were chosen to represent turkey rations in general. These rations were formulated first by dividing the growth period into two sections. The first section encompasses rations I and II while the second encompasses rations III and IV. In order to bring the requirements of Table IX closer into line with actual feeding practice as exhibited by the feeding program above, the feeding period of the first section was extended to eighteen weeks for males and sixteen weeks for females. Representative rations, A and B, represent sections one and two respectively. It will be noticed that the representative ration in each section conforms quite closely to the highest minimum requirements in that section. Thus, the representative ration could be fed to the birds for the entire feeding period encompassed by each particular section. Based upon the estimates of the feed manufacturer whose program was utilized, and assuming equal numbers of male and female birds, turkey ration "A" is representative of 57.8% of turkey feeds while ration "B" is representative of 42.2%.

The nutrient requirements for swine are listed in Table XIII. As can be seen, the rations fed to swine from .45 lbs. to market weight and to breeding swine are quite similar in nature. The chief difference lies in the lack of minimum levels for many of the amino acids from 77 lbs. to market weight and the higher energy required for animals weighing from 45 to 77 lbs. and for breeding swine. As was the case with the turkey rations, adequate protein is essential both for adequate growth but also to produce a lean carcass which will grade well. For this reason the energy level of the representative ration was lowered by about 5%. The result of this would be that the animal would consume more feed and as a result ensure an adequate intake of protein.

Table XIV shows the feed consumption pattern of swine from birth to market weight. Notice that the share of total feed consumed by the hog from a weight of 75 pounds to market weight is 603 pounds or 67% of total feed consumption. In addition, 213 of the 268 lbs. shown to be consumed by the hog from birth to 35 lbs. is actually that hog's share of the feed consumption of the breeding herd. As has been seen, the breeding herd ration is similar to that for growing and finishing a hog. When this portion of the total feed consumption is added, the total feed represented by this ration is 817 lbs. or 81% of total feed consumption.

Formulation of rations is somewhat simpler for ruminants than for non-ruminants. Because of the micro-organisms which live within the stomach of the ruminant, and which are capable of transforming crude protein into the correct amino acid balance, balancing the amino acid content of the ration is not important. The crucial aspect is to supply

TABLE XIII

NUTRIENT REQUIREMENTS FOR GROWING, FINISHING AND BREEDING SWINE/100 LBS. OF RATION

Weight (lbs.)	11-22	23-44	45-77	77-220	Bred Sows and Gilts
Metabolizable energy (Kcal)	146,400	146,400	138,000	129,600	138,000
Crude Protein (lb.)	22	18	16	15	14
Calcium (lb.)	.80	.65	.65	.50	.75
Phosphorus (lb.)	.60	.50	.50	.40	.50
Argenine (lb.)	-----		.20	-----	-----
Isoleusine (lb.)	.76		.50	.35	.43
Methionine (lb.)	.48		.30	-----	.21
Methionine + Cystine (lb.)	.12		.50	------	.35
Phenylalanine (lb.)	-----		.35	------	.36
Tryptophan (lb.)	.18		.13	.09	.08
Lysine (lb.)	1.20		.70	.50	.49

Source: Manitoba Department of Agriculture, Guide To Practical Swine Rations, (by S.C. Stothers and J.C. Brown), Winnipeg, Canada, The Queen's Printer, 1971.

TABLE XIV

CUMULATIVE FEED CONSUMPTION BY MARKET HOGS

Weight	Feed Consumption
35	268*
50	319
75	406
100	496
125	590
150	688
175	790
200	897
225	1009

Source: Manitoba Department of Agriculture, Hog Manual, Winnipeg, Canada, The Queen's Printer, 1971.

sufficient crude protein. In addition, the rumen micro-organisms are capable of converting a limited amount of non-protein nitrogen into the amino acids which are essential for growth and maintenance of the animal. Because of this it is possible to satisfy part of the animal's protein requirements by including limited amounts of non-protein nitrogen such as urea into the ration.

The representative ration for dairy cattle is a concentrate ration. This means that it is designed to be fed in conjunction with forage. The actual requirements of the concentrate depend to some extent upon the quality of forage being fed. The lower the quality of the forage, the higher will be the required protein and energy content of the concentrate feed. Since the quality of forage will vary, it is difficult if not impossible to accurately formulate a concentrate which will just meet the requirements of the animal. For this reason the nutrient requirements used in the representative ration are approximate and probably include a safety margin.

Table XV lists the nutrient requirements of the dairy representative ration. This ration is designed to be fed in conjunction with a good quality forage. The amount fed of this ration will depend upon the milk production level of each cow.

TABLE XV

REQUIRED NUTRIENT LEVELS FOR DAIRY CONCENTRATE/CWT.

Protein (lb.)	14.0
D E (kcal)	140,000
Ca (lb.)	.4
P (lb.)	.6

In addition to complete rations, feed manufacturers also produce a large number of protein supplements. These supplements are sold to livestock feeders to be mixed generally with cereal grains to produce a ration which is adequate for the particular livestock being fed. Protein supplements vary widely in concentrations. Supplements which have very high protein content allow the farmer to utilize less supplement and more of cereal grains which are often home grown. Such supplements also reduce the cost of transporting supplement to the feeding site. On the other hand, higher protein supplements usually cost more per pound of protein. This is so since such supplements require the use of high protein ingredients such as meat meal or fish meal whose cost per pound of protein is usually higher than such feedstuffs as rapeseed or soybean meal.

Two procedures can be used to estimate the demand curves for protein supplements. The first is the direct method. Using this method, the nutrient requirements of each supplement would be specified and the least cost combination of inputs would be solved for using a series of rapeseed meal prices in the same way as was done for the rations. This method is appropriate if all of the required nutrient levels of each supplement are known. However, in most cases the amino acid levels contained in the supplement are not disclosed.

The other procedure is to utilize the recommendations of the manufacturer of the supplement concerning the combination of the supplement with cereal grains to form a complete ration. Naturally, when supplement is combined at recommended rates with cereal grains, the resulting ration must meet the minimum nutrient requirements of the class of animal for which the mixture is designed. Thus, by introducing a restraint into each linear program specifying as minimum amounts of cereal grains, the amount recommended to be mixed with the supplement, a demand curve for the supplement can be simulated. It should be pointed out that this demand curve is not for a hundred weight of supplement but is a demand curve for X pounds of supplement where X is the number of pounds of supplement mixed per 100 lbs. of feed. However, since output of supplements is expressed in complete-feed equivalents, it is unnecessary to construct a demand curve for a hundred-weight of each supplement.

This second procedure was followed when dealing with the demand for rapeseed meal by non ruminant supplements. The demand curves for the non ruminant supplements listed in Table XVI were estimated in this manner.

In the case of the ruminants, since rations vary widely according

TABLE XVI

RECOMMENDED RATES OF MIXING SUPPLEMENT
WITH CEREAL GRAINS PER CWT. OF RATION

	Turkey Grower	Broiler Finisher	Poultry Layer	Hog Grower
	(37)*	(39)*	(40)*	(40)*
Supplement	13.7	30	13.7	12.5
Wheat		70		
Oats				27.5
Wheat or barley	83.3			
Wheat, oats or barley			83.3	
Wheat, wheat shorts or barley				60

* - minimum protein level of the supplement used.

to the desired rate of gain, the indirect method is not practical. However, as was discussed earlier, for ruminants, amino acid balance is not important. Many feed manufacturers provide supplements which are recommended for use in both dairy and beef rations. Because of this, it was felt that one representative supplement was adequate for both dairy and beef cattle rations. The supplement used is of medium protein content. The nutrient levels required for this supplement are listed below in Table XVII.

TABLE XVII

REQUIRED NUTRIENT LEVELS FOR DAIRY-BEEF REPRESENTATIVE SUPPLEMENT

Weight (L)	90.0
Weight (U)	93.0
Fat (L)	3.0
Fat (U)	10.0
Protein (L)	35.0
Fibre (U)	10.0
Urea (U)	4.0

In programming the rations and protein supplement discussed above fifteen ingredients were allowed to enter the ration. While these ingredients by no means exhaust the number of potential ingredients which feed formulations do use, it was felt that these ingredients were adequately representative for this analysis. The ingredients used are listed in Table XVIII along with their nutrient composition. It should be noted that urea was allowed into only ruminant rations. While it contains no protein as such it contains 42% nitrogen which can be used by ruminants to produce protein. Since protein is approximately six percent nitrogen, the crude protein equivalent of urea is 262%. Urea, however, cannot exceed 1% of the total ration weight. The ingredient prices listed in Table XVIII are averages for 1971 calculated from monthly prices obtained from local feed manufacturers.

In deriving the demand curves for rapeseed meal for each ration the price of rapeseed meal was varied from 2.0¢/lb. to 4.0¢/lb. or until rapeseed was eliminated from the least-cost formulation. The price was stated at 2.0¢ rather than at 0.0¢ since it was felt that the crushers

Table XVIII

Cost and Nutritive Composition of Ingredients

	Cost Cents/lb	C.P. %	M.E. Kcal/lb.	Fibre %	Ca %	P %	Fat %	Argenine %	Isoleusine %	Lysine %	Methionine %	Methionine + Cystine %	Phyenylalanine %	Tryptophan %
Alfalfa, Dehydrated	2.7	17	620	24.0	1.4	.22	2.0	0.7	0.9	1.1	0.2	0.5	0.8	0.3
Barley	1.5	11	1280	5.0	.06	.42	1.3	0.5	0.5	0.4	0.2	0.38	0.62	0.1
Fish Meal	11.8	55	1350	1.0	3.0	2.0	7.0	3.8	4.4	7.3	2.7	3.1	2.6	.9
Ground Limestone	0.9	0.0	0.0	0.0	38.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lysine	98.0	100	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100	0.0	0.0	0.0	0.0
Meat Meal	5.4	55	920	2.4	7.5	4.0	0.3	3.9	1.9	3.8	0.8	1.46	1.90	0.3
Methionine	74	100	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100	100	0.0	0.0
Oats	1.5	11	1190	0.0	0.1	0.3	0.2	0.5	0.7	0.4	0.3	0.3	0.45	0.2
Rapeseed Meal	d	36	1091a	9.3	0.66	1.0	0.44	2.0	1.40	2.34	0.7	1.13	1.46	0.44
			800b											
			1227c											
Soybean Meal	4.7	45	1184a	6.0	0.32	0.6	0.5	3.0	2.1	6.4	0.6	1.18	2.16	0.5
			1022b											
			1307c											
Tallow	7.8	0.0	3800	0.0	0.0	0.0	100	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tri-calcium phosphate	4.5	0.0	0.0	0.0	31.0	18.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Urea	3.25	262	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wheat	1.9	13	1500	3.0	.05	0.47	1.5	0.7	0.7	0.4	0.2	0.37	0.78	0.14
Wheat Shorts	2.7	17	1200	3.9	.1	0.4	4.0	0.8	0.8	0.7	0.3	0.50	0.78	0.20

a) in cattle rations b) in poultry rations c) in swine rations d) variable would not offer rapeseed meal for less than half the price of soybean meal (4.7¢/lb.). The price of rapeseed meal was varied by increments of .2¢/lb. ($4/ton).

CHAPTER V

ANALYTICAL RESULTS

This chapter presents the results of the analysis, the procedure for which was outlined in Chapter IV. In general, the results of the estimation conform to what was expected. In order to simplify the discussion of the results, it is convenient to number each of the meal improvements which were analysed and to briefly describe the changes involved in each. The demands for meals possessing these improvements will be compared to the demand for currently produced meal which will be referred to as standard meal:

(1) Improvement I consists of the removal of the toxic glucosinolates from rapeseed meal.

(2) Improvement II involves increasing of the protein content of rapeseed meal from 36% to 40%.

(3) Improvement III consists of increasing the metabolizable energy content of rapeseed meal by 12.5%.

(4) Improvement IV combining improvement I with improvement II, involves the removal of the glucosinolates as well as increasing the protein content of the meal.

(5) Improvement V is a combination of improvements I and II, involving both removal of the glucosinolates from, and increasing the energy content of rapeseed meal.

(6) Improvement VI combines improvements I, II and III, and involves increasing both the protein and energy content of the rapeseed meal, as well as the removal of the glucosinolates.

The demand curves which were estimated for the seven types of rapeseed meal are shown in figure 5.1. Conforming to the theoretical demand curve derived in Chapter III, all but one of the demand curves is sharply kinked. As discussed in Chapter IV, it is the location of the kink in the demand curve for rapeseed meal which determines the output of rapeseed meal and consequently the quantity of rapeseed crushed in Canada. The location of this kink also determines the price of the rapeseed meal. Consequently, in determining the impact upon the output of rapeseed meal, of a particular quality change, the comparison will be made between the quantity demanded at the kink in the demand curve for that type of rapeseed meal and the quantity demanded at the kink in the demand curve for standard meal, regardless of whether the kinks occur at the same price. Listed in Table XIX are the quantities demanded of each type of rapeseed meal at prices ranging from 2.0 to 4.4 cents per pound. The location of the kink for each demand schedule is indicated by an asterisk. It is these quantities which will be compared in assessing the impact of each of the quality changes.

As shown in Table XIX, all of the quality changes shifted the demand curve for rapeseed meal to the right. Improvement I shifted the kink in the demand curve to the right by 25%, while meals II and III shifted the kink to the right by 7% and 1% respectively. Improvement VI moved the kink in the demand curve to the right by 32%. It is more difficult to estimate the impact of the quality changes embodied in meal V. It can be seen that the demand curve for meal V is not sharply kinked. Its form, in fact, approaches linearity. Consequently, the marginal revenue curve associated with this demand curve would not be discontinuous, and as a result, without a detailed analysis of crushing costs, it is not possible to determine what the price of the meal would be or what quantity of meal would be sold. It is, however, possible to provide some insight into what outcomes are probable.

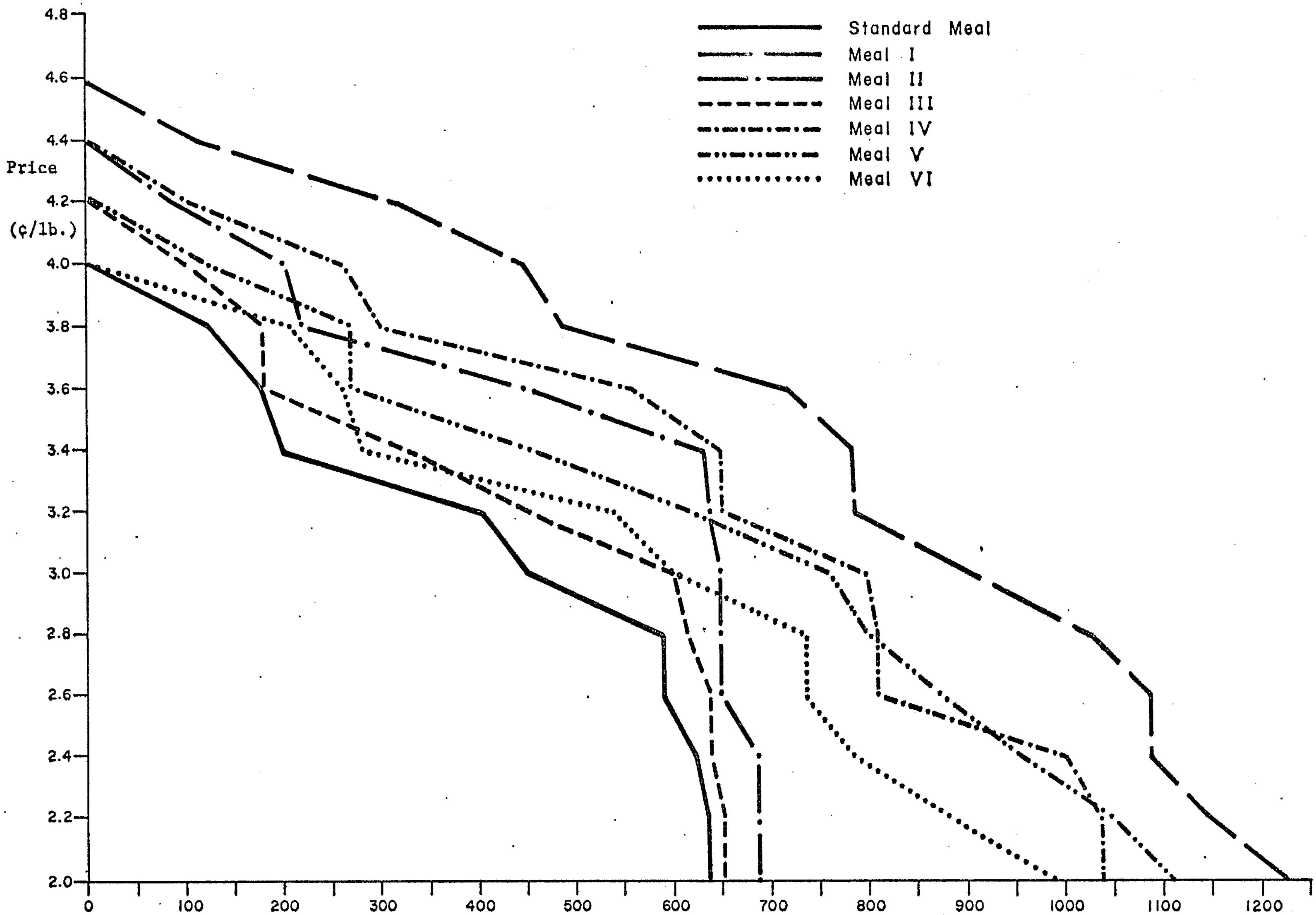


Figure 5.1: Estimated Demand Curves for Seven Types of Rapeseed Meal

TABLE XIX

Demand Schedules for Seven Types of Rapeseed Meal

Quantity (000 lbs.)

Price ¢/lb.	Standard Meal	Meal I (a)	Meal II	Meal III	Meal IV	Meal V	Meal VI
2.0	634,454	992,205	686,198	654,288	1,038,065	1,116,924	1,230,152
2.2	634,454	885,612	686,198	654,288	1,038,065	1,068,174	1,143,331
2.4	621,201	783,737	686,198	637,911	1,004,031	956,618	1,089,298
2.6	591,739	739,511	648,986	637,911	798,832	875,303	1,089,298
2.8	591,739*	739,511*	648,986	629,512	795,832	803,891	1,027,017
3.0	454,007	601,779	648,986	598,989*	783,431*	763,279	801,365
3.2	405,930	538,138	638,703	455,354	653,771	619,688	789,381
3.4	197,355	280,094	633,343*	330,468	648,411*	458,767	784,430*
3.6	179,498	262,237	448,671	180,776	557,758	266,373	719,029
3.8	129,305	207,956	217,061	180,776	286,121	266,373	486,020
4.0	-	-	204,337	101,211	260,480	120,953	446,120
4.2	-	-	86,239	-	103,326	-	318,270
4.4	-	-	-	-	-	-	116,209
4.6	-	-	-	-	-	-	-

(a) Meal I posseses improvement I as described on Page 1.

If the industry were to maintain its present policy of pricing rapeseed meal at 60% of the price of soybean meal, (2.8¢/lb) the price of rapeseed meal would not be affected but the quantity sold would increase by 36%. If however the price of the meal were raised to 64% of the price of soybean meal (3.0¢/lb) the increase would be only 29% while an increase to 68% of the price of soybean meal (3.2¢/lb.) would cause an increase of only 5% in the quantity of rapeseed meal sold. In view of the marked reduction in the quantity demanded which is associated with increasing the price from 3.0 to 3.2 cents per pound, it is unlikely that the price of the meal would be raised above 3.0 cents per pound.

Similarly, in the case of meal IV, there are two location on the demand curve where the curve is sharply kinked. The kinks occur at prices of 3.0 and 3.4 cents per pound. The output at which the industry operated would depend upon the size of the crushing margin. A large crushing margin would encourage crushing plants to lower the price of rapeseed meal in order to increase the volume of output. In such a case, output would expand by 32%. On the other hand, a narrow crushing margin would favor a higher rapeseed meal price with the resulting reduction in output; in which case the expansion in output resulting from the improvement of rapeseed meal quality would be only 10%.

Except for meals I and V, all of the quality improvements also shifted the kinks in the demand curves upward. As shown in Table XIX the kinks in the demand curves for meals II and VI occurs at 3.4 cents per pound, 0.6 cents per pound higher than for the standard meal. The demand curve for meal IV is kinked at 3.0 cents per pound, while meal IV is kinked at both 3.0 and 3.4 cents per pound. The price of the meal is determined by the location of the kink, thus the upward shifting of the kinks in the demand curves would have the result of increasing the revenues of the crushing plants while not affecting the output of the industry.

It must be stressed that the locations of the kinks, as discussed above, are not fixed. The price at which the kink occurs is determined by the price structure of feedstuffs in general and of high-protein feedstuffs in particular. A change in the structure of these prices will cause a vertical shift of the kink in the demand curve for rapeseed meal.

Although each quality change shifted the kink in the demand curve to the right, these shifts were neither uniform, nor universal among the rations and supplements examined. The following is a brief discussion of the impact of the quality changes upon the use of rapeseed in the individual rations and supplements. The comparison will be based upon the rapeseed meal prices listed above. The price used for meal V is 3.0 cents per pound.

Table XX shows the quantity of rapeseed meal used in each of the rations and supplements at the prices which were predicted to accompany the respective quality changes. None of the quality changes increased the quantity of rapeseed meal used in broiler rations. The use of meal I was the same as that of standard meal. All of the rest of the meal types resulted in reductions ranging from 0.17 to 1.19 pounds per hundred-weight of broiler ration. It is noteworthy, however, that except for meal III, increasing the protein content of the rapeseed meal resulted in more protein being supplied by rapeseed meal even though less rapeseed meal was used. In the case of the

TABLE XX

Quantities of Rapeseed Meal Used in Livestock Rations and Supplements
(pounds/CWT)

Price (cents/lb.)	2.8	2.8	3.4	3.0	3.0 (3.4)	3.0	3.4
Meal Type	Standard Meal	Meal I	Meal II	Meal III	Meal IV	Meal V	Meal VI
Broiler Ration	14.28	14.28	13.09	14.11	13.09	14.11	12.75
Broiler Supplement	7.12	7.12	13.09	8.41	13.09	8.41	12.75
Layer Ration	5.00	7.76	5.00	5.00	7.94	9.39	9.66
Layer Supplement	2.58	2.58	3.00	2.50	3.00	2.50	2.89
Turkey Grower Ration	5.74	5.74	6.97	7.30	(6.97) 16.80	7.30	16.19
Turkey Finisher Ration	2.28	2.28	0.00	1.33	(0.00) 2.36	1.33	0.74
Turkey Supplement	0.23	0.23	0.00	0.22	(0.00) 0.26	0.22	0.26
Hog Ration	8.00	17.32	8.00	8.00	14.96	18.01	15.42
Hog Supplement	3.33	3.33	3.80	3.19	3.80	3.19	3.62
Dairy Ration	2.35	2.35	2.04	2.46	2.04	2.46	2.13
Cattle Supplement	5.0	6.62	5.0	5.0	5.7	6.62	5.7

broiler supplement however, all of the meal types, except meal I, resulted in increased use of rapeseed meal. The increases, as shown in Table XX ranged from 0.0 for meal I to 5.97 for meals II and IV.

Because of the relatively low upper limit imposed on the use of rapeseed meal in layer rations resulting from its glucosinolate content, removal of the glucosinolates (Meal I) increased the quantity of rapeseed used in the layer ration from 5.00 to 7.76 pounds per hundred-weight. However, because use of standard meal reached the upper limit resulting from the content of glucosinolates, addition of protein or energy (meals II and III respectively) had no effect upon the amount of rapeseed meal used in the layer ration. However, when the addition of protein or energy was combined with removal of the glucosinolates, (meals IV and V respectively) use of rapeseed meal increased to 7.94 and 9.39 pounds respectively while addition of both protein and energy (meal VI) increased meal use to 9.66 pounds per hundred-weight of ration. None of the quality changes greatly affected the use of rapeseed meal in the layer supplement. Energy, however, appeared to be the key to increased use in layer rations. Additions of energy (meals III and VI respectively) increased in the use of rapeseed meal from 2.58 to 3.00 pounds per hundred-weight of complete feed equivalent of layer supplement.

As shown in Table XX, while none of the quality changes had a significant effect upon either the turkey supplement or the turkey finisher, they did have a marked impact upon the quantity of rapeseed meal used in the turkey grower ration. The largest impact was made by improvements IV and VI. The actual impact made by improvement IV depends upon the price charged for the meal. As was discussed previously, there are two prices which are most plausible. At 3.0¢/lb, the impact of improvement IV is to increase use of rapeseed meal from 5.74 to 16.80 pounds per hundred-weight while at a price of 3.4¢/lb, the increase is only to 6.97 pounds per hundred-weight of ration. Improvement VI increased the use of rapeseed meal to 16.19 pounds per hundred-weight of ration.

With the hog ration, meals I and V had the greatest impact in increasing meal usage. Removal of glucosinolates alone more than doubled use of rapeseed meal from 8.00 to 17.32 pounds per hundred-weight. The addition of energy to glucosinolate - free rapeseed resulted in a further increase in usage of .69 pounds while increases in the protein content actually decreased use of rapeseed meal. In the hog supplement, none of the quality changes significantly affected rapeseed meal use. Meals II and IV both increased usage by 15% from 3.33 to 3.80 pounds per hundred-weight.

Energy appears to be the factor most important in increasing rapeseed meal usage in dairy rations. However, none of the quality improvements greatly affected use of rapeseed meal use. Meals III and VI both increased use of rapeseed meal from 2.35 to 2.46 pounds per hundred-weight. Removal of the glucosinolates was the factor which most increased use of rapeseed meal in the cattle supplement. Meal I increased meal use from 33.3 to 44.1 pounds per hundred-weight of actual supplement. Since it was estimated that the supplement would comprise about 15% of the ration, on a complete feed equivalent basis, the increase was from 5.0 to 6.62 pounds per hundred-weight. There was no energy requirement for the cattle supplement. However, there was an upper limit of 10% crude fibre. A decrease in the fibre content of 1% was found to be associated with an increase of 1.72% in the energy content. Thus an increase in the energy content of 12.5% would be associated with a reduction in fibre content of 7.26%. This would reduce the fibre content from 9.3% to 8.6%. However, when the supplement was formulated using the low energy, (high fibre) rapeseed meal, the fibre constraint was found not to be binding. Thus decreasing the fibre content of the rapeseed meal would not affect the use of rapeseed meal in the cattle supplement. Increasing the protein content actually decreased the use of rapeseed meal.

Summary

All of the quality changes which were considered shifted the demand for rapeseed meal to the right. Removal of the glucosinolates resulted in an increase of 25% in the quantity of rapeseed meal demanded at the kink in the demand curve. Addition of protein and energy increased the quantity demanded by 7% and 1% respectively. If the addition of protein was combined with the removal of the glucosinolates, the quantity demanded was increased by 32% or 10% depending upon the price charged for the meal. The addition of both energy and protein to glucosinolate-free rapeseed also shifted the demand to the right by 32% at the kink. The most probable price for high energy, glucosinolate-free rapeseed is 3.0¢/lb. At this price, the quantity demanded increased by 26% for that type of meal. The quality changes were also found to affect the pricing of rapeseed meal. The price of meal I remained the same while the prices of meals II, III, and VI rose to 3.4, 3.0, and 3.4 cents per pound respectively. Although prediction of the price for meal VI was more difficult, it was felt that a price of

3.0 cents per pound was the price most likely to be charged for it. In the case of meal IV two meal prices were plausible. These prices were 3.0 and 3.4¢ per pound. The decision as to which price to use would depend, at least in part, upon the size of the overall Crushing Margin.

CHAPTER VI

CONCLUSIONS

This chapter presents the conclusions which result from the analysis of the previous chapters. Since the objective of the study was to investigate the impact of selected quality changes in rapeseed meal upon the demand for that product and subsequently upon the quantity of rapeseed crushed in Canada, the discussion will focus upon the implications of the demand analysis which has been performed. Also discussed will be recommendations for study of alternative methods of expanding the demand for rapeseed meal as well as a discussion of the weaknesses of this analysis and means whereby these weaknesses might be corrected.

(A) IMPLICATIONS OF THE DEMAND ANALYSIS

On the basis of the results of Chapter V, it would appear that of the quality changes considered, the highest priority should be accorded to the development of glucosinolate-free rapeseed meal. Such a development would expand the demand for rapeseed meal more than any other of the quality changes analysed. On the other hand, increasing the protein and/or energy content of rapeseed meal without removing the glucosinolate would result in only marginal increases in demand. Rapeseed varieties whose glucosinolate content is low enough to no longer pose a problem may be ready for commercial production in about five to eight years time.[1] In addition there has

[1] R.K. Downey, "Market-Oriented Rapeseed Breeding", Rapeseed Association of Canada Proceedings of the Fifth Annual Meeting, March 6-7, 1972, Saskatoon, Saskatchewan, P. 71

been some research done on the feasability of removing the two compounds from standard rapeseed varieties by chemical means. If it is feasible, the latter method would be a valuable development, at least in the interval until the improved rapeseed varieties have been developed. However achieved, removal of the glucosinolates from the rapeseed meal would appear to have the largest payoff in terms of increased demand.

While removal of the glucosinolates from the rapeseed meal reduced the sharpness of the kink in the demand curve, the kink is not completely removed, and hence the revenue per bushel function is still kinked and the marginal revenue curve is still discontinuous. This means that output of rapeseed meal and rapeseed oil will increase by the full amount by which the demand curve is shifted to the right; thus, the removal of the glucosinolates from rapeseed meal would increase rapeseed meal output by 25%. The impact of each of the quality changes in shown in Table XXI.

TABLE XXI

IMPACT OF IMPROVED RAPESEED MEAL
UPON MEAL OUTPUT

Improvement	I	II	III	IV	V	VI
% increase in Output	25	7	1	32* 10**	29	32

* low price assumption (3.0¢/lb.)

** high price assumption (3.4¢/lb.)

It is of interest to express the impact of each of the quality changes in terms of their effect upon farm income because of increased domestic crushing. As was discussed previously in Chapter I, the most likely crop to be replaced if rapeseed acreage were increased would, at the present time, be barley. On the basis of the acreage per acre returns from barley and rapeseed for the crop years 1964/65 to 1969/70, replacing one acre of barley with an acre of rapeseed would increase farm income by $5.52. In the 1970/71 crop year, the quantity of rapeseed crushed in Canada was 8.575 million bushels. Assuming an average yield of 18 bushels per acre, this represents 476 thousand acres of rapeseed. Table XXII shows the changes in farm income resulting increased domestic rapeseed crushing in turn caused by changes in the quality of rapeseed meal.

TABLE XXII

ESTIMATED IMPACT OF RAPESEED MEAL IMPROVEMENTS UPON FARM INCOME IN 1969/70

Improvement Number	Increased Demand for Rapeseed (1000 acres)	Increased Farm Income (1000 dollars)
I	119.0	656.9
II	33.3	183.8
III	5.0	27.6
IV	152.3*	840.7
	47.6*	262.8
V	138.0	761.8
VI	152.3	840.7

* low price assumption
** High price assumption

It should be borne in mind that while this analysis focuses upon the domestic market for rapeseed, the improvements considered would also be instrumental in further stimulating the export demand for both rapeseed and rapeseed meal. Thus in any benefit-cost study, the total cost of achieving these quality changes should not be compared to the benefits accruing in the domestic market along, but to the benefits accruing in both the domestic and export markets for rapeseed.

It might be thought that an alternative way of expanding the output of the rapeseed crushing industry would be to increase the number of firms in the industry in an attempt to reduce the effect of the oligopoly structure. However, as can be seen by referring to figure 5.1, lowering the price of standard rapeseed meal would have only a marginal effect upon the quantity demanded. Thus, while the entry of new firms might reduce the price of the rapeseed meal, their effect upon total output would be small.

(B) WEAKNESSES OF THIS ANALYSIS

The weakness which is most apparent in this analysis is its treatment of Canada as a single geographic region. Because the two markets for rapeseed meal are so widely separated geographically, prices of feed ingredients can differ substantially between them. Under such circumstances, it would be desireable to estimate the impacts of each quality change in each market separately using prices prevailing in that market. The reason this was not done was that it was felt that the impact of different ingredient price would be felt in the price at which the kink occurred not at the quantity at which it occurred. Since this study focuses on the impact of quality changes on output, it is the location of the kink along the quantity areas which is most important.

A second and more serious weakness is the disaggregative way in which the demand curves for each ratio model was estimated. An improved method would have been to integrate all of the ration models into one larger linear program. By doing this one would be able to impose market restrictions upon the estimation process, restrictions which are difficult to impose when the demand curve for each of the rations is estimated separately. An example of such a market restriction would be an upper limit on the total quantity of meat meal. Since the supply of meat meal is fixed any given time, so to is its usage. By improsing an upper limit on the total use of meat meal in all rations one could (1) ensure that total meat meal use did not exceed its supply and (2) force meat meal to be used in the rations where its value was greatest. Aggregation of all of the ration models into a single linear program would greatly increase the complexity of the program. It is, however, possible that the increased benefits of such a model would be sufficient to justify its complexity.

(C) SUGGESTIONS FOR FURTHER STUDY

Of the rations analysed, it appears that the ones into which rapeseed is not easily introduced are those rations having high energy requirements. There is some indication that it would be economic to reduce the energy content of some of these rations. The result would be that the animal would consume more feed to achieve the same daily intake. This would raise feed conversion ratios and might even reduce the rate of gain. However, in doing so, feed costs might be reduced sufficiently to increase overall profitability. Many of the feed formulations are designed in Eastern Canada or in the United States where corn and soybean meal are readily available. However, in Western Canada, use of these formulations required the importation of soybean meal from the United States while Western Canada exports rapeseed meal. There has been some interest shown in the use of lower energy rations by both researchers and producers. This possibility should be pursued since it holds potential for further expansion of rapeseed meal use, especially in Western Canada.

BIBLIOGRAPHY

American Soybean Association. Soybean Digest--Blue Book Issue. Hudson, Iowa: The Association, 1972.

Coral Incorporated. A Study of the Japan Market for Rapeseed. Winnipeg, Manitoba: Rapeseed Association of Canada, 1968.

Heady, Earl O., and Earl Candler. Linear Programming Methods. Ames, Iowa: Iowa State University Press, 1958.

Horst, James. Compound Feeds in the United Kingdom--The Effect of Support Policies on Use of Ingredients. U.S. Economic Research Service. Washington, D.C.: Government Printing Office, 1972.

Houck, J. P. Demand and Price Analysis of the U.S. Soybean Market. Technical Bulletin 244. St. Paul, Minnesota: Agricultural Experiment Station, University of Minnesota, 1963.

---------, and J. S. Mann. Domestic and Foreign Demand for U.S. Soybeans and Soybean Products. Technical Bulletin 256. St. Paul, Minnesota: Agricultural Experiment Station, University of Minnesota, 1961.

Manitoba Department of Agriculture. Hog Guide. Winnipeg, Manitoba: The Queen's Printer, 1971.

Moore, Charles V., and Trimble R. Hedges. "A Method for Estimating Demand for Irrigation Water," Agricultural Economics Research, October, 1963, pp. 131-135.

National Research Council. Agricultural Board. Committee on Animal Nutrition. Nutrient Requirements of Domestic Animals. No. 1, Nutrient Requirements of Poultry. Rev. 6th ed. Washington, D.C.: National Academy of Sciences, 1971.

Rapeseed Association of Canada. Canadian Rapeseed Meal in Poultry and Animal Feeding. Winnipeg, Manitoba: The Association, 1972.

---------. Proceedings of the Fifth Annual Meeting. Winnipeg, Manitoba: The Association, 1972.

---------. Proceedings of the Inter-National Conference on Science, Technology and Marketing of Rapeseed Products. Winnipeg, Manitoba: The Association, 1970.

Statistics Canada (formerly Dominion Bureau of Statistics). Agricultural Division. Apparent Per Capita Consumption of Food in Canada. Cat. No. 32-006. Ottawa, Ontario: The Queen's Printer.

---------. ---------. Coarse Grains Quarterly. Cat. No. 22-051. Ottawa, Ontario: The Queen's Printer.

Statistics Canada (formerly Dominion Bureau of Statistics). Agricultural Division. Farm Cash Receipts. Cat. No. 61-001. Ottawa, Ontario: The Queen's Printer.

---------. ---------. Quarterly Bulletin of Agricultural Statistics. Cat. No. 21-003. Ottawa, Ontario: The Queen's Printer.

---------. External Trade Division. Trade of Canada, Exports. Cat. No. 65-202. Ottawa, Ontario: The Queen's Printer.

---------. ---------. Trade of Canada, Imports. Cat. No. 65-007. Ottawa, Ontario: The Queen's Printer.

---------. Industry Division. Monthly Review of Canadian Fisheries Statistics. Cat. No. 24-002. Ottawa, Ontario: The Queen's Printer.

---------. Manufacturing and Primary Industry Division. Oils and Fats. Cat. No. 32-226. Ottawa, Ontario: The Queen's Printer.

---------. ---------. Shipments of Prepared Stock and Poultry Feeds. Cat. No. 32-004. Ottawa, Ontario: The Queen's Printer.

Stothers, S. C., and J. C. Brown. Guide to Practical Swine Rations. Manitoba Department of Agriculture. Winnipeg, Manitoba: The Queen's Printer, 1971.

Tangri, Om P., and E. W. Tyrchniewicz. "The Removal of the Crow's Nest Pass Rates on Grain and Grain Products Moving into Eastern Canada for Domestic Consumption: Implications for Industrial Development in the Prairie Provinces, Especially Manitoba." Winnipeg, Manitoba: Manitoba Department of Industry and Commerce, 1972.

Vandenborre, R. J. "Demand Analysis of the Markets for Soybean Oil and Soybean Meal," Journal of Farm Economics, 45:920-933, November, 1963.