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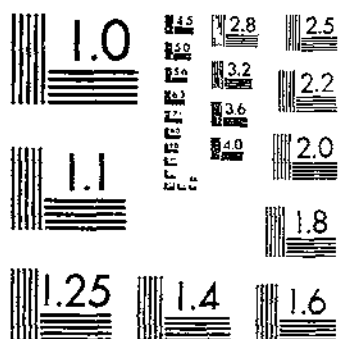
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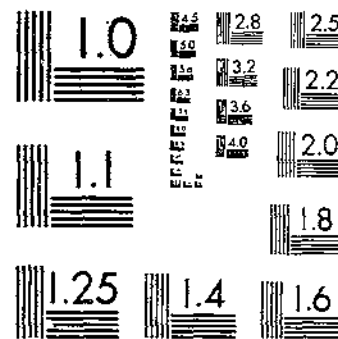
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An Econometric Analysis of Canadian Grains and Oilseeds

John Spriggs

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ABSTRACT

Changes in the U.S. wheat price have little effect on the export supply of wheat in Canada, but a significant effect on the export supply of Canadian barley. Thus, an increase in the price of U.S. wheat relative to the price of U.S. barley could substantially reduce Canadian barley exports. This study examines these and other domestic supply and demand relationships for wheat, barley, and rapeseed in Canada and develops models for these commodities for use by U.S. policymakers in estimating the supply response of Canadian grains and oilseeds to changes in market conditions. Other experiments performed on the models show that: 1) U.S. soybean meal and oil prices have little effect on the export supply of Canadian rapeseed, and 2) a \$10-per-metric-ton increase in the statutory rate would result in a decline in wheat exports of 1.6 million metric tons the first year and 0.8 million metric tons and less in later years.

Key words: Canada, wheat, barley, oilseed, rapeseed, exports, feed grains, grain exports

PREFACE

This publication is one of a series of foreign market studies by the International Economics Division (IED), Economic Research Service (ERS) (formerly the Economics and Statistics Service), U.S. Department of Agriculture, focusing on countries that are major markets for U.S. agricultural exports and on countries whose farm exports compete with U.S. farm exports. The studies provide a systematic and consistent basis for evaluating agricultural policies in these countries and projecting agricultural trade.

Objectives of the studies:

- (1) Identify and, to the extent possible, quantify factors within each country which affect, or may affect, changes in its agricultural trade, especially trade with the United States.
- (2) Improve the capability of the U.S. Department of Agriculture to project the volume and value of agricultural trade in the short and medium term.
- (3) Enable the U.S. Department of Agriculture to analyze and test fluctuations in agricultural trade in response to changing economic conditions and policy considerations.

The research for this publication was conducted by John Spriggs under a cooperative research agreement with ERS. The author thanks Lance McKinzie of Purdue University, and J. Larry Deaton and Mary Anne Normile of ERS for assistance.

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An Econometric Analysis of Canadian Grains and Oilseeds

John Spriggs*

INTRODUCTION

Canada ranks second only to the United States as a wheat exporter and fourth behind the United States, France, and Argentina as a coarse grains exporter (primarily barley). Canada is also growing in importance as an oilseeds exporter (rapeseed).

This study examines how supply and demand of wheat, barley, and rapeseed in Canada affect its exports of these commodities. Of particular interest is the effect of the particular marketing arrangements in Canada for these commodities.

PRODUCTION AND MARKETING

Wheat, barley, oats, and rapeseed are the principal crops produced in western Canada. Their area of production depends on rainfall and soil fertility conditions which vary significantly in the western Provinces. Oats have become a less important crop in recent years while rapeseed's importance has risen, particularly as a crop grown for export. The Canadian Wheat Board assumes a major role in the pricing and delivery of western wheat and barley, while rapeseed is marketed through the private market.

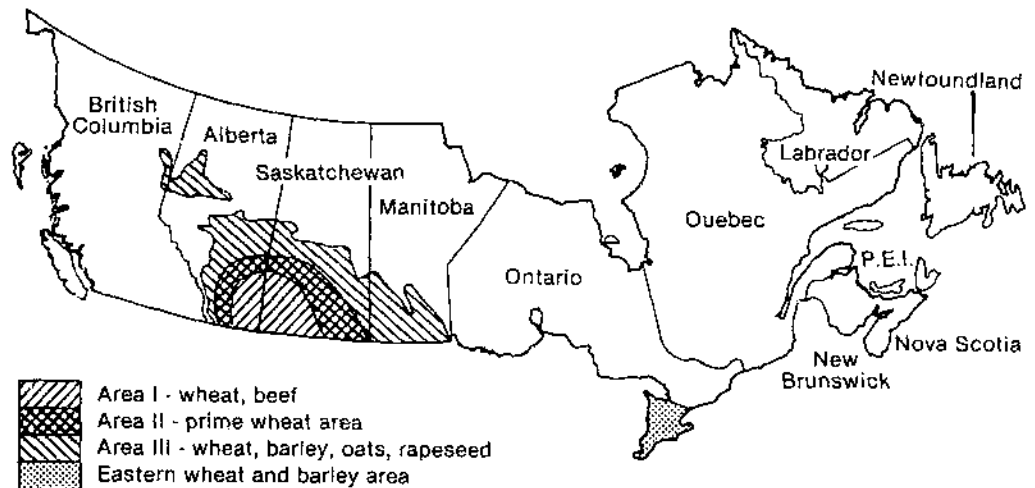
Production Patterns

Canada's principal field crop producing area lies in the Prairie Provinces of Alberta, Saskatchewan, and Manitoba (fig. 1). The major field crops include wheat, barley, oats, and rapeseed. The prairies account for over 95 percent of the country's wheat, barley, and rapeseed area and about 80 percent of the total area devoted to oats. The area is hampered in the north and northwest by the short growing season and by poor soil fertility, while to the northeast, field crop production is hampered by the high-lime soil around Lake Manitoba. One can distinguish three broad classifications of activity within the designated prairie crop area. In the first area, rainfall is low, averaging 12 to 15 inches per year; soil fertility is also low (see area I in fig. 1). The principal enterprise here

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Figure 1

Grain Areas of Canada



is wheat production, but extensive cattle grazing is important over much of the unimproved land. Wheat yields in this area fluctuate greatly, and even in good years average less than those in the other areas. Area II, which forms a belt around area I, is the prime wheat growing area. The soils are deeper and more fertile than in area I, and average annual rainfall is higher. Area III in turn forms a belt around area II (frequently called the parkbelt). Rainfall is still high in this belt (around 20 inches per year) and soils are more fertile. Wheat quality tapers off so that other crops, particularly barley, oats, and rapeseed, are important here. The enterprise structure is generally more diversified in area III than in the other areas.

In addition to the contiguous area of crop production, there is a small area of field crops in the Peace River Block on the Alberta-British Columbia border. The enterprise structure here is similar to that in the parkbelt. The principal growing area for these field crops in eastern Canada (area IV) is in southern Ontario (32, pp. 22-37). ^{1/}

^{1/} Underscored numbers in parentheses refer to literature listed in the References.

In terms of area sown, Canada's most important field crop is wheat, followed by barley, oats, and rapeseed, respectively. It is difficult to perceive any trend in wheat area during 1948-77 (fig. 2). Barley and rapeseed, on the other hand, appear to have trended up, while oats has trended down. The wheat area suffered substantially in 1970 when a 1-year government program (called LIFT for Lower Inventories For Tomorrow) was introduced to reduce wheat area.

Crop yields are generally more variable in the prairies than in the United States. Table 1 presents the coefficients of variation for the four crops over the 20 years to 1977. The coefficients are measured around the linear trend of yield over time.

Table 1--Coefficients of variation in crop yields, western Canada and the United States, 1957-77

Crop	:	:	:
	:	Canada	United States
	:	:	:
Wheat	:	0.15	0.08
Barley	:	.12	.09
Oats	:	.11	.08
Rapeseed	:	.10	--

-- = not applicable.

Crop yields have generally been trending upward as a result of improved varieties, increased fertilizer and herbicide utilization, and improved cultural and management practices. However, the rate of increase has been slow.

Wheat and barley are by far the most important export grains (fig. 3). Exports of rapeseed and oats are relatively minor. Oat exports were of some consequence during the early fifties, but no longer. Oats, a bulky grain, is relatively more expensive to transport abroad and hence is primarily used for domestic feed. Rapeseed, on the other hand, is an export-oriented crop which has only recently gained importance as an alternative enterprise to wheat and barley. It has the potential of becoming a major export grain in the future. Since this study focuses on Canada's major grains from an export standpoint, we shall concentrate on wheat, barley, and rapeseed.

Wheat and Barley Marketing

Wheat and barley are marketed primarily through the Canadian Wheat Board (CWB), established as a voluntary marketing body under the Canadian Wheat Board Act of 1935. Originally, producers could sell their grain on the open market or deliver

Figure 2

Land Use Patterns in Prairie Provinces

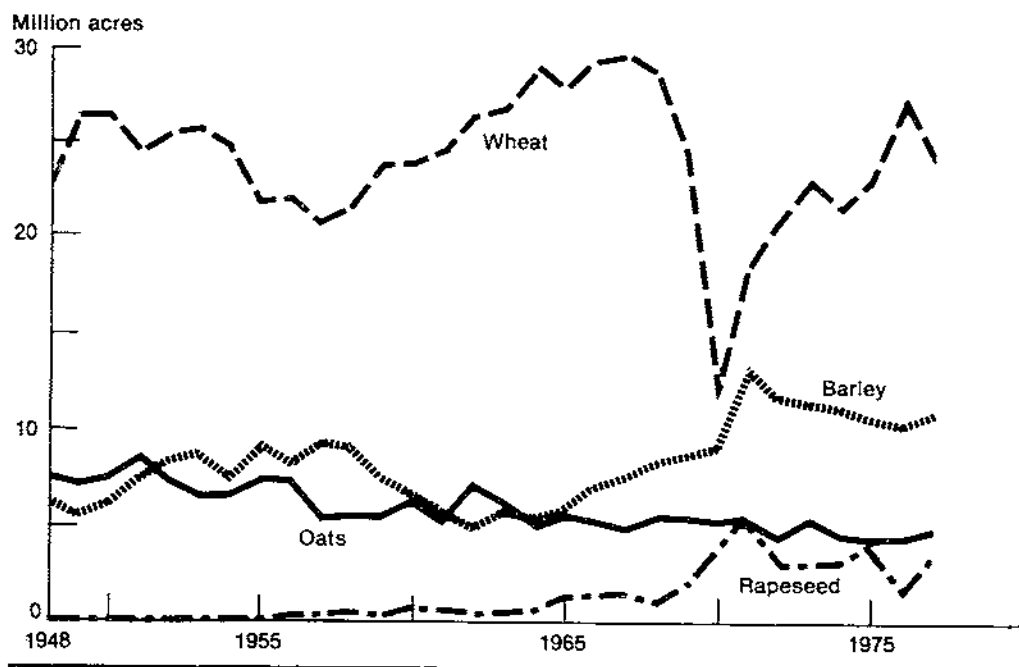
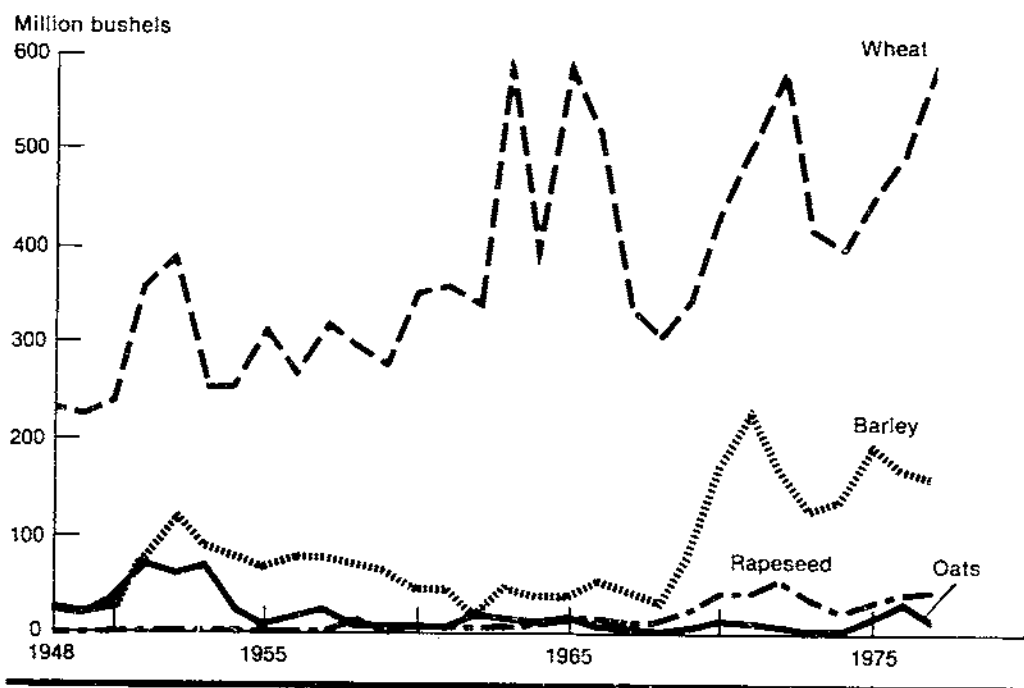


Figure 3

Canadian Exports of Major Grains



it to the CWB at a fixed initial price established and guaranteed by the Federal Government. As a wartime measure, the Federal Government in 1943 made the CWB sole marketer of wheat produced in a designated area of western Canada and destined for interprovincial or export trade. The designated area included the three Prairie Provinces (Manitoba, Saskatchewan, and Alberta) plus the Peace River area of British Columbia. The board's authority was extended in 1949 to prairie-grown barley and oats moving in interprovincial or export trade. The board also gained control of all transactions in grains exclusive of farm-to-farm and farm-to-feedlot sales. Thus, farm sales to elevators, flour mills, feed mills, feed warehouses, and seed cleaning mills were subject to the board's control. Producers' deliveries to these facilities were regulated by delivery quotas and prices were established by the CWB.

The quota and price restrictions on farm-to-feed mill (local) sales were lifted in 1960 as a result of pressure from feed mill operators and policing difficulties.

The CWB thus allowed feed grain sales to take place outside its jurisdiction on a farm-to-farm, farm-to-feedlot, or farm-to-feed mill basis provided the grain remained within the province where it was produced. Such sales are usually referred to as offboard sales and take place in what is known as the offboard market. Prices in this market are determined freely and sales are not subject to the delivery quota system. ^{2/}

The marketing arrangements for wheat and barley remained essentially unchanged until 1973, when the Federal Government permitted offboard sales to take place between the Prairie Provinces but not between western and eastern Canada. The following year, offboard sales were permitted between western and eastern Canada. Since eastern Canada is a feed grain deficit area, this policy change had a marked effect on the eastern Canadian feed grains market.

The policy change affected the eastern market through prevailing grain prices. Prior to 1973, when CWB was sole marketer of western wheat and barley in eastern Canada, asking prices were based on the cost of imported U.S. corn. In the years leading up to 1973, the eastern prices for wheat and barley exceeded those in western Canada because large surplus stocks in the prairies had depressed prices on the offboard market. Thus, eastern livestock producers found themselves at a feed-cost

^{2/} The market is not completely insulated from CWB control. The CWB controls access of offboard grain to rail and elevator facilities.

disadvantage to their western counterparts. In 1973/74, an interim policy designed to correct this problem involved basing the eastern feed grain prices on those in the western offboard market. This used the so-called monitored offboard price collected by the Agricultural Products Board. It was not very successful and was dropped the following year (26, p. 3).

Eastern livestock feeders could purchase grains in the offboard market or through the CWB in 1974/75. The CWB prices for 1974/75 and 1975/76 were based on the prices obtained at the Winnipeg Grain Exchange. Beginning in 1976/77, CWB prices were based on the price of U.S. corn entering Montreal (10, pp. 11-14). The CWB price to eastern feed users under the new domestic feed grains policy is a ceiling price. Merchants on the offboard market are free to sell at or below the CWB price but not above it.

Price Pooling

Producers in western Canada have the choice of selling on the offboard market or to the CWB. If they sell in the offboard market, they receive a full settlement for their grain when the sale is made. If they sell to the CWB, they are subject to price pooling and the delivery quota system.

All wheat and barley delivered to the CWB enters a pool. It is sold domestically or overseas by the board, and the producer receives a pooled price from these sales. Each producer receives the same basic price no matter when their grain is delivered during the crop year. The producer does not have to wait until all the grain is sold before receiving a return, and payment is usually made in two amounts. The first or initial payment is paid on delivery to a country elevator. The second or final payment is announced 6 to 12 months after the close of the marketing year. If sales have been better than anticipated, the CWB may make intermediate payments called adjustment and interim payments.

Delivery Quota System

Since producers receive the same price regardless of when grain is delivered, there is no price incentive to spread deliveries over the whole crop year. The CWB operates a delivery quota system to prevent clogging the grain distribution system at harvesttime.

The original intent of the quota system was to spread deliveries evenly over the crop year. Quotas have effectively restricted deliveries of grain in some years, however, and are thought to have had repercussions on subsequent production intentions.

Beginning in 1953/54, delivery quotas based on a producer's specified acreage were introduced. This system remained in effect until 1969/70. Specified acreage was defined as the

total area seeded to quota grains (wheat, oats, barley, and rye) plus land in summerfallow, eligible grasses, and forage crops. It was used as a basis for determining a producer's delivery entitlement. For example, the CWB could announce a 1-bushel quota shortly after harvest. This meant that producers could deliver a quantity not exceeding 1 bushel times their specified acreage. The total quantity could consist of one or a combination of the four quota grains. As elevator space became available during the crop year, further quantities were called forth with the general quota.

The general quota by itself did not give the CWB much control over the delivery of particular grains. If a ready market existed for barley but not for wheat, the general quota could not by itself restrict wheat deliveries and encourage barley deliveries. Supplementary quotas were utilized to permit added control over deliveries of particular grains. Under these quotas, the CWB could call forth specific grains not being delivered in sufficient quantities under the general quota. Supplementary quotas for the major quota grains (wheat, barley, and oats) were used in 10 of the 14 years they were in place. A third type of quota, the unit quota, allowed all producers to deliver a specific quantity of a quota grain at the beginning of the crop year. It was designed such that no matter which grain was delivered, the return per acre was approximately the same.

The combination of general, supplementary, and unit quotas was replaced in 1970 by separate quotas for each grain. This gave the CWB more direct control over deliveries. About the same time that the new delivery quota system was introduced, the CWB began a block shipping system in western Canada, dividing the prairie grain-producing area into 48 shipping blocks. This enabled more efficient handling and transportation of the grain, and freed terminal elevators of unwanted stocks which would be kept on farms or in primary elevators until needed.

Other Factors

Other factors affecting the marketing of wheat and barley include grain freight subsidies and government stabilization of the domestic milling price for wheat. There are two types of freight subsidy. The first involves grain destined for the export market, while the other involves grain destined for feed use in the east and British Columbia. The freight subsidy on export grain, known as the Crow's Nest Pass freight rates, permits grain to be railed from the prairies to Vancouver or Thunder Bay (export terminals) at only a fraction of the rates charged in the United States (29). The other freight subsidy is covered by the Feed Freight Assistance Policy. Prior to August 1976, the subsidy paid nearly the entire cost of feed grain transportation from Thunder Bay to eastern Canada or British Columbia. Following that date, the subsidy was substantially

reduced on feed grains moving into Ontario, western Quebec, or British Columbia. The subsidy on feed grains destined for the Maritime Provinces and eastern Quebec was unaffected.

Beginning in 1969, the Federal Government moved to stabilize the domestic milling price for wheat to support sagging producer prices. The domestic milling price was fixed at \$1.95 per bushel (No. 1 northern, basis Thunder Bay). It remained at this price until 1973 when the price was raised to \$3.25. Legislation has more recently been enacted to raise the price once more to a minimum of \$4 and a maximum of \$5 per bushel.

Rapeseed Marketing

Unlike wheat and barley, all rapeseed is marketed via the private market in which prices are freely determined. The rapeseed may be marketed directly from the producer to a domestic oilseed crusher or to a country elevator for subsequent export.

Approximately one-third of the total supply is destined for the domestic market (35 percent in 1976/77). It is crushed in one of nine plants and separated into its components, oil and meal. Rapeseed oil is then refined and used primarily in food products such as cooking oil, margarine, and salad oil. Rapeseed meal is used as a high protein supplement for livestock and poultry. Rapeseed is nearly a perfect substitute for soybeans in the production of food and feed items. Although its use is small compared with soybeans, its potential as an alternative source of oil and meal is promising.

Between 50 and 60 percent of the total rapeseed supply is exported (57 percent in 1976/77). The quantities moving into world trade necessarily use the same storage and transportation facilities as the major grains. Since rapeseed competes for these facilities, deliveries are subject to the general delivery quota system. Rapeseed quotas in recent years have been declared open prior to the crop year, so they have had no limiting effect on rapeseed production.

The major export market for Canadian rapeseed is Japan, which in 1976/77 accounted for 70 percent of total shipments; the other important market, the European Community (EC), took 20 percent that year. Other buyers include India and Bangladesh.

The rapeseed crushing industry has recently expanded in line with domestic use. Annual crushing capacity reached an estimated 0.88 million metric tons (mmt) in 1976. This is much less than total annual production (1.9 mmt in 1976/77), but there is in fact considerable excess capacity. Virtually all exports are in raw seed form. Exports of oil and meal are negligible. This limits the use of Canadian crushing plants to

rapeseed destined for the domestic market which amounted to 0.66 mmt in 1976/77. The reason for a lack of Canadian meal and oil exports is twofold. First, rapeseed destined for the export market is railed to an export position (Vancouver or Thunder Bay) at the subsidized Crow's Nest freight rate. This subsidized rate does not apply to rapeseed meal or oil. Perkins calculated the rail rate differential on a seed equivalent basis and found that it was cheaper to move rapeseed by \$21 to \$24 per metric ton (mt) than to move the oil and meal (39).

The second factor working against oil and meal exports is the import tariffs on rapeseed oil imposed by Japan and the EC. Japan imposes a tariff of 17,000 yen (\$85) per mt, while the EC imposes a 10-percent ad valorem duty. There are no duties on rapeseed meal entering Japan and the EC. But because rapeseed crushing results in a joint product, the duty on rapeseed oil suffices as a hindrance to expanded crushing in western Canada. Japan and the EC impose no duties on imports of the seed.

THE CONCEPTUAL FRAMEWORK

The basic approach to the conceptual models for wheat, barley, and rapeseed is similar. Functional relationships are established for domestic demands (food and industrial use, feed, and seed), carryover stocks, and production. Since all three grains heavily emphasize exports, it is necessary to specify how Canada confronts the world market for these grains. The conceptual models focus primarily on the role of prices in determining domestic demand, supply, and exports.

Wheat Supply and Demand

The supply of wheat equals production plus carryin stocks. Since the latter is identical to carryout stocks of the previous year, we will defer discussion of carryin until the discussion of demand for carryout stocks. Production equals area planted times yield. Area planted is a function largely of economic and technological variables which are subject to measurement. Yield, on the other hand, is largely a function of factors not easily measured. Hence, we will attempt to explain area planted and leave yield as an exogenous variable.

Wheat is produced almost entirely in the Prairie Provinces. Hence, national wheat production is expressed as a function of factors affecting production in the prairies. Eastern wheat production is not subject to the influence of the CWB, and may respond to factors different from those in the west. Since eastern wheat production is negligible, these factors will be ignored.

Western producers may either dispose of their grain through the CWB market or through the offboard market. The producers receive an initial and final payment through the CWB market,

while through the offboard market they receive full settlement on delivery.

Area planted to wheat is expressed as a function of the supply-inducing price of wheat and the supply-inducing prices of competing crops, barley and rapeseed. Clearly, there is no single definitive supply-inducing price since producers may respond in different ways to various prices. Using theory as well as observation, the researcher attempts to isolate one or two variables likely to be representative of the price to which rational producers are responding.

For example, in previous Canadian wheat supply studies, Capel used the March average CWB International Wheat Agreement price for No. 2 Northern wheat at Fort William, Schmitz used the latest final price received prior to seeding, Schmitz and Bawden used the average farm price of wheat lagged 1 year, and Meilke used initial and final payments as separate supply-inducing prices (17, 43, 44, 30).

Another candidate for the supply-inducing price is added in this study. This price is based on the microeconomic theory of firm profit maximization and is adapted from earlier work by Jolly and Abel (20). Their theory suggests that the expected offboard price for wheat will be the supply-inducing price whether quotas are binding or not. Hence, this study uses the expected offboard price to represent the supply-inducing price. 3/

Wheat is demanded for food and industrial use, feed, export, and seed. Carryover stocks are also held both on farms and in the licensed elevator system where almost all are CWB stocks.

Food and Industrial Use

Wheat for this end-use is marketed by the CWB to millers and processors at a price which until recently was set independently of market forces. Between 1969/70 and 1972/73, the price was set at \$1.955 per bushel. Thereafter, the price was set at \$3.25 per bushel until August 1979. Since the end of that period, the milling price has been the export price as long as the latter is between \$3.25 and \$5 per bushel.

Feed Use

Wheat for this end-use is marketed primarily through the offboard market. The CWB stands ready to supply wheat to this market if the offboard prices move above the price at which U.S. feeds (corn and soymeal) become competitive.

Carryout Stocks

Wheat is carried over in either private or CWB stocks. There is a very close relationship between CWB stocks and nonfarm

3/ See appendix for the theoretical justification for using the expected offboard price as the supply-inducing price.

stocks. Although it is possible to have a nonfarm private carryout, in most years this is a negligible factor (less than 5 percent of total nonfarm carryout stocks in every year since 1969/70 except 1972/73). Since data series are provided by Statistics Canada on farm and nonfarm carryout stocks of wheat but not CWB carryout stocks, we shall use the former series to represent private and CWB carryout, respectively. Nonfarm carryout is assumed to be determined exogenously in the model. It is regarded largely as a policy instrument of the CWB. However, it is possible that strikes or false export sales expectations will also influence the level of this variable. Onfarm carryout represents private carryout. This is expected to be a function of the expected offboard price.

Other Uses

Wheat required for seed use is specified as a proportion of the expected planted area in the next crop year. The export demand from the rest of the world for Canadian wheat is specified to be inversely related to the Canadian export price.

Provided that delivery quotas are not restrictive (that is, that farmers' expected delivery entitlement is greater than their expected wheat deliveries to the CWB), the offboard price which affects feed use, onfarm carryout, and seed use is assumed to be equalized with the export price. That is, the offboard price only differs from the export price by the cost of transportation to an export position and by the price differential due to quality differences. Ignoring such transportation costs and quality differentials, the wheat demand model may be represented as in figure 4. ^{4/}

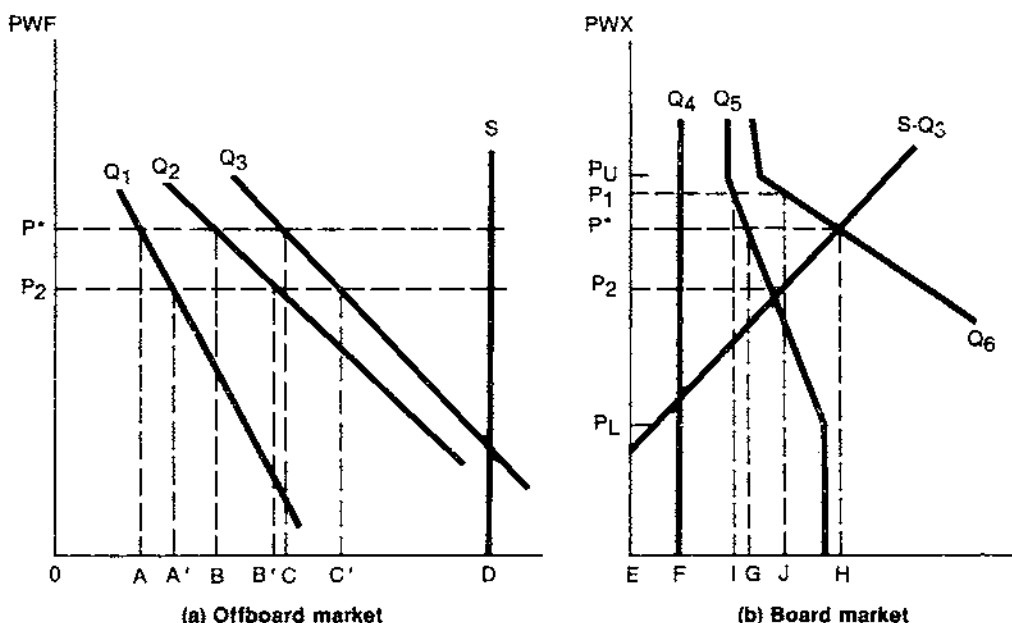
We begin with a given supply (S) in panel (a). S comprises production plus carryin (onfarm and nonfarm). In panel (a), QWDF, OFSW, and QWDO are horizontally summed to yield curve Q₃. Q₃ represents the sum of the demands which are related to the offboard price. In panel (b), curve S - Q₃ represents the excess supply from the offboard market. In addition, the demands for board grains NFSW, QWDH, and QWX are horizontally summed in panel (b) to yield curve Q₆. Note that the curve representing NFSW (Q₄) is vertical since NFSW is assumed to be determined by exogenous factors and in particular, CWB policy.

Also note that the curve representing QWDH is kinked to reflect the fact that the domestic milling price is the export price only within a certain price range, P_L to P_U in figure 4.

^{4/} Seed use is a function of the offboard price since this is assumed to affect the expected planted area in the following crop year.

Figure 4

Wheat Demand Model



PWF = Offboard price of wheat
 PWX = Canadian wheat board price of wheat
 Q₁ = QWDF (feed use)
 Q₂ = Q₁ + OFSW (onfarm carryout)
 Q₃ = Q₂ + QWDO (seed use)
 Q₄ = NFSW (nonfarm carryout)
 Q₅ = Q₄ + QWDH (food and industrial use)
 Q₆ = Q₅ + QWX (exports)

If quotas are not restrictive, the equilibrium price (P^*) and quantities allocated to each end-use are simultaneously determined in panel (b) at the intersection of Q_6 with $S - Q_3$.

Equilibrium levels of QWDF, OFSW, QWDO, NFSW, QWDH, and QWX are represented by OA, AB, BC, EF, FG, and GH, respectively.

If quotas are restrictive or if the CWB ceiling price on domestic feed wheat becomes effective, then the equilibrium offboard price is no longer equalized with the export price.

Quotas could be restrictive for one of the following reasons. The world free market price might be below some price level deemed minimally acceptable. Alternatively, if supplies were unusually large, restrictive quotas might be needed to prevent the large supply from clogging the nation's licensed storage and transportation facilities.

Suppose we want to maintain the world price above the free market level. This may come about as a result of some agreement by the major exporters--the United States, Canada, and Australia (46, p. 16). With respect to figure 4, suppose the maintained price is P_1 . Then the delivery quotas will permit deliveries of only EJ. At the higher world price, exports decrease to IJ, while QWDH decreases to FI. Since EJ is delivered, the remainder JH is to be distributed on the offboard market among feed and seed uses and onfarm carryout. Since the offboard market is assumed to operate freely, the quantities allocated to each end-use in this market increase. QWDF and OFSW increase to OA' and A'B' respectively, while QWDO decreases to B'C'. The offboard market price (P_2) is determined simultaneously with these quantities.

It is possible that the CWB is motivated to introduce restrictive quotas because of storage and transportation constraints rather than price considerations. The storage and transportation facilities may only be capable of handling EJ, while desired deliveries are EH. As before, the result is a higher world price (P_1) and lower domestic offboard price (P_2) than in a freely operating market.

Apart from the effect of quotas, the model should also allow for the impacts of corn-competitive pricing. This policy was introduced as an amendment to the new domestic feed grains policy in July 1976. Under this policy, the CWB agrees to offer feed grains for sale at a price consonant with the price of U.S. corn. The CWB price acts as a ceiling price for western feed grains supplied by the offboard market. So long as the offboard prices stay below the CWB corn-competitive prices, the market will be supplied by the offboard market. Should the offboard prices tend to move above the CWB price, then the CWB becomes a seller in the domestic feed grains market (10).

The impact of corn-competitive pricing may be analyzed with respect to the wheat demand model in figure 4. Suppose we are initially at the nonquota-restrictive equilibrium represented at price P^* . Now suppose the corn price drops relative to the wheat price so that the CWB's corn competitive price is only P_2 . Then the CWB will still take delivery of EH. However, it will return part of this (JH) to the feed grain market. By returning this amount to the domestic feed market, the CWB will bring the domestic feed wheat price down to P_2 . At the same time, however, only IJ will be exported as opposed to GH previously, while the world price would rise from P^* to P_1 . In the case of wheat, the magnitude of this effect on the export market is likely to be fairly small. This is because total quantity fed is small relative to exports. The effect should be more significant in the case of barley.

The conceptual model is summarized in equation form. The equations assume nonrestrictive quotas and no effect from the corn-competitive pricing policy. Following are the necessary adjustments to the model required to handle the cases of restrictive quotas and corn-competitive pricing. With regard to notation, the symbol ":" means "is a function of." The overlined variables are treated as exogenous to the model. The variables with negative (positive) subscripts are lagged (lead) variables.

Behavioral Relations--Conceptual Wheat Model Equations

(1) Planted area

$$AW: PWF_{-1}, \overline{X1}, e_1$$

(2) Food and industrial demand

$$QWDH: PWH, \overline{X2}, e_2$$

(3) Feed use

$$QWDF: PWF, \overline{X3}, e_3$$

(4) Export demand

$$QWX: PWX, \overline{X4}, e_4$$

(5) Onfarm carryout

$$OFSW: PWF, \overline{X5}, e_5$$

(6) Offboard price

$$PWF: PWX, \overline{X6}, e_6 \text{ (offboard price)}$$

Identities:

(7) Seed requirements

$$QWDO = 0.0905 \cdot AW_{+1}$$

(8) Production

$$QW = AW \cdot \overline{YW}$$

(9) Exports

$$QWX = QW + OFSW_{-1} + NFSW_{-1} - QWDH - QWDF - QWDO - OFSW - \overline{NFSW}$$

(10) Canadian mill price of wheat

$$\begin{aligned} PWH &= PWX \text{ if } P_L \leq PWX \leq P_U \\ &= P_L \text{ if } PWX < P_L \\ &= P_U \text{ if } PWX > P_U \end{aligned}$$

e1....e7 = random disturbance terms,

NFSW = nonfarm wheat carryout,

P_L = lower bound on milling price, wheat,

P_U = upper bound on milling price, wheat,

PWH = CWB price for Canadian millers and processors,

PWX = wheat, export price quotations,

X1....X6 = vectors of exogenous variables, as follows:

X1 = prices of competing enterprises, wheat quotas, technological change,

X2 = income, population,

X3 = domestic feed grain prices, domestic livestock prices, livestock numbers,

X4 = income and population in major wheat consuming countries, production plus beginning wheat stocks in other major producing countries,

X5 = other variables representing the transactions and speculative demands for onfarm stocks,

X6 = quota restrictiveness variable,

YW = wheat yield.

One behavioral equation not yet discussed is the price relation (equation 6). This equation relates the offboard price to the export price when quotas are not restrictive (that is, the prices are equalized). With regard to the estimation of this equation, it is necessary (because of the paucity of observations on PWF) to use an historical period that is not

free of the effects of quotas. To take account of this, a quota restrictiveness variable (X_6) is included in the equation.

Simple adjustments can be made to this basic model to incorporate restrictive quotas and corn-competitive pricing. The first case involves restricted quotas where the export price is being supported at some minimum acceptable level. Here, PWX is exogenously determined and equation (6) is deleted. The offboard price (PWF) will remain endogenous. The second case involves restrictive quotas due to storage and transportation constraints. This case may be incorporated through the deletion of equation (6) and the addition of an identity to apply

when the throughput capacity (\bar{Q}) is reached. Thus, we have

$$\bar{Q} = QWX + QWDH \quad (8A)$$

The third case involves corn-competitive pricing. Here PWF is exogenously determined and again equation (6) is deleted. The export price (PWX) will remain endogenous.

Barley Supply and Demand

The supply of barley is modeled in the same way as for wheat. Production is separated into its components, area and yield. An equation is estimated for area planted while yield is treated as exogenous.

Like wheat, almost all of Canada's barley is grown in the Prairie Provinces. Hence, national barley area will be expressed as a function of factors affecting area planted in the prairies.

Western producers may dispose of their grain through the CWB or through the offboard market. As outlined in the case of wheat, the supply-inducing price of barley is theoretically the same as the offboard price.

Barley is primarily used as a feed grain. Over the 15 years to 1977, barley fed domestically averaged 42 percent of the total disposition of the Canadian crop. This is followed by carryout stocks (30 percent), exports (22 percent), food and industrial use (3 percent), and seed (3 percent).

The conceptual model for barley is the same as that developed for wheat except in the treatment of export demand and carryout stocks. Canada is assumed to face a perfectly elastic export demand curve for barley. Although Canada is a large exporter of barley, it is reasonable to believe that the export price of barley is determined in the larger world market for feed grains. Carryout stocks of barley are not separated into onfarm

and nonfarm stocks. This is because a sizeable proportion of nonfarm stocks of barley are also non-CWB stocks (20 percent on average for the 9 years, 1969/70 to 1977/78).

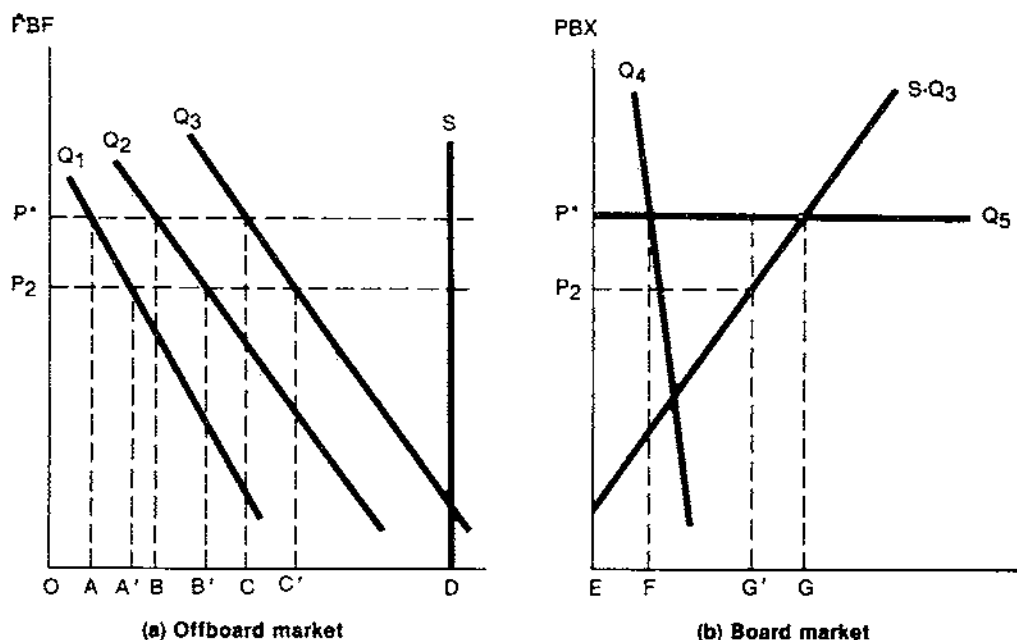
In the wheat model, the separation was made on the basis of nonfarm carryout being a good representation of CWB stocks and onfarm carryout being a good representation of private carryout.

In the case of barley, onfarm carryout and nonfarm carryout are not likely to accurately reflect nonboard and board stocks, respectively.

The barley demand model (fig. 5) begins with a given supply (S) in panel (a). In panel (a), $QBDF$, $TSKB$, and $QBDO$ are horizontally summed to yield curve Q_3 . Q_3 represents the sum of the demands which are related to the offboard price. $TSKB$ is included in panel (a) because the private carryout component of this variable is hypothesized to be related to the offboard price. $TSKB$ also contains a CWB carryout component. Hence, to this extent, panel (a) incorporates not just the

Figure 5

Barley Demand Model



PBF = Offboard price of barley

PBX = Canadian wheat board price of barley

Q_1 = $QBDF$ (feed use)

Q_2 = Q_1 + $TSKB$ (carryout)

Q_3 = Q_2 + $QBDF$ (seed use)

Q_4 = $QBDF$ (food and industrial use)

offboard market but also CWB carryout. In panel (b), curve Q_4 represents the domestic barley demand for food and industrial use while the horizontal line Q_5 represents the export demand curve. Under the assumption of no restrictive quotas, the equilibrium price is P^* . The offboard price is equalized with the export price. Equilibrium levels of QBDF, TSKB, QBDO, QBDH, and QBX (exports) are represented by OA, AB, BC, EF, and FG, respectively.

If quotas are restrictive, then the equilibrium offboard price is no longer equalized with the export price. Suppose unusually large grain supplies are endangering the efficient transportation and handling of the grain. The CWB may decide to prevent such problems by restrictive quotas. In terms of figure 5, deliveries may be restricted to EG' . (Deliveries also include the change in CWB barley stocks, but let us assume this is 0.) This forces an amount $G'G$ onto the domestic offboard market depressing the offboard price to P_2 . At the lower offboard price, quantities allocated in the offboard market to feed (QBDF) and carryout (TSKB) increase to OA' and $A'B'$, respectively, while seed use (QBDO) declines to $B'C'$.

The conceptual barley model is summarized in equation form. The equations assume nonrestrictive quotas. Following that are the necessary adjustments to the model required to handle the case of restrictive quotas.

Behavioral Relations-- Conceptual Barley Model Equations

(1) Planted area

$$AB: PBF_{-1}, \overline{X1}, e1$$

(2) Food and industrial demand

$$QBDH: PBX, \overline{X2}, e2$$

(3) Feed use

$$QBDF: PBF, \overline{X3}, e3$$

(4) Total carryout

$$TSKB: PBF, \overline{X4}, e4$$

(5) Offboard price

$$PBF: PBX, \overline{X5}, e5$$

Identities:

(6) Seed requirements
 $QBDO = 0.089 \cdot AB_{+1}$

(7) Production

$$QB = AB \cdot \overline{YB}$$

(8) Exports
 $QBX = QB + TSKB_{-1} - QBDH - QBDF - QBDO - TSKB$

e1....e6 = random disturbance terms,
PBX = barley, CWB export price quotations,
X1....X6 = vectors of exogenous variables, as follows:
X1 = prices of competing enterprises, technological
change, production costs,
X2 = income, population,
X3 = other domestic feed grain prices, domestic
livestock prices, and livestock numbers,
X4 = other variables representing the transactions
and speculative demands for barley stocks,
X5 = quota restrictiveness variable,
YB = barley yield.

The model may be adjusted to handle the case of restrictive
quotas by deleting equation (5) and adding an identity to

represent throughput capacity (\bar{Q}) where $\bar{Q} = QBX + QBDH$.

Rapeseed Supply
and Demand

Rapeseed supply is modeled in a manner similar to wheat and
barley. The rapeseed demand model includes demand for rapeseed
oil and rapeseed meal. Since rapeseed is not marketed by the
CWB, board pricing policies are not analyzed.

In the rapeseed model, production is separated into its
components, area and yield. An equation is estimated for area
planted while yield is treated as exogenous. Like wheat, almost
all of Canada's rapeseed is grown in the Prairie Provinces. It
is a competing enterprise of wheat and barley, particularly in
the parkbelt of western Canada. Rapeseed, however, is not
marketed through the CWB. It is sold instead through the open
market. Since rapeseed moves through the same transportation
and storage facilities as the board grains, deliveries to the
primary elevator are controlled by quotas. It is possible that
in some years these quotas will be restrictive and so result in
a depressed rapeseed price. This does not appear to have

occurred in the past. Since rapeseed is not marketed through the board, there is also, of course, only a nonboard price for producers. The Winnipeg cash price for No. 1 Canadian rapeseed is used as the supply-inducing price.

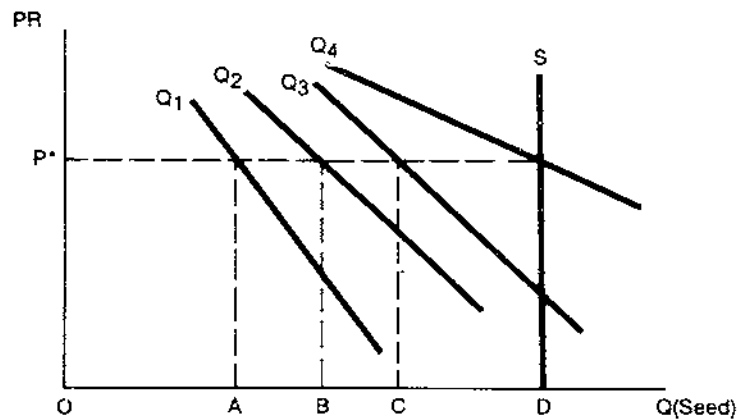
Rapeseed, when crushed, yields two joint products: oil (40 percent) and meal (58 percent). The remaining 2 percent is moisture loss. The rapeseed oil is highly substitutable with soybean and other vegetable oils used primarily for human consumption in margarine, shortening, and salad oils. There has been some dissatisfaction with the oil in past years due to a high erucic acid content (an undesirable nutritional characteristic). A national program was started in 1971 to introduce low erucic acid varieties of rapeseed. By 1976, these varieties accounted for 98 percent of total seeded area in the prairies (40). Rapeseed meal is highly substitutable with soybean meal, though it sells at a lower price primarily because of its lower protein content. Perkins suggests that another reason for rapeseed meal's price discount is its glucosinolate content which causes digestive upsets in animals (38). This has led to the development of "double low" varieties of rapeseed, low in both erucic acid and glucosinolates.

Rapeseed is crushed in Canada primarily for domestic oil and meal use. Most exports are as seed. This is partly due to the transportation cost advantage enjoyed by the seed moving to export terminals. The seed moves at the statutory Crow rate while the meal and oil must move at the higher compensatory rate. Another factor encouraging seed exports vis-a-vis meal and oil exports is the import tariff levied on rapeseed oil by the major importers, Japan and the EC (19).

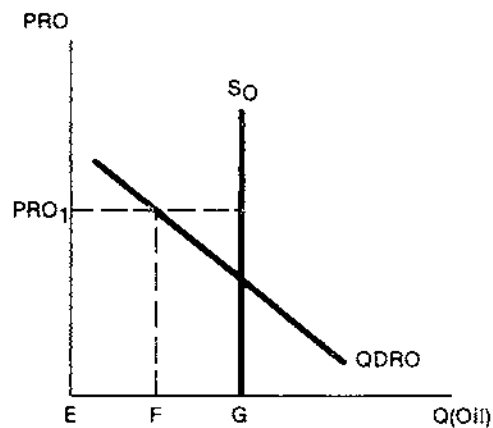
The conceptual model of the Canadian rapeseed industry is presented in figure 6. In figure 6(a), rapeseed crushed (INDR), rapeseed carryout (TSKR), rapeseed for seed requirements (QRDO), and rapeseed exports (QRX) are represented as inverse relations to the price of rapeseed (PR). They are horizontally summed to form an aggregate demand curve (Q_4). The equilibrium price (P^*) is determined where curve Q_4 intersects with the given rapeseed supply (S). At equilibrium, the quantities allocated to INDR, TSKR, QRDO, and QRX are OA, AB, BC, and CD, respectively.

Quantity OA is crushed to yield a fixed proportion of oil [curve S_O in panel (b)] and a fixed proportion of meal [curve S_M in panel (c)]. For geometric convenience, the horizontal axes of panels (b) and (c) are assumed to be adjusted by the fixed proportionality of the respective joint products to the raw seed.

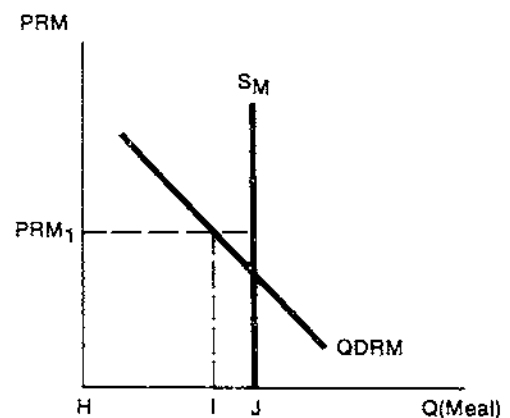
Figure 6

Rapeseed Demand Model

(a) Rapeseed market



(b) Rapeseed oil market



(c) Rapeseed meal market

PRO = Rapeseed oil price
 PRM = Rapeseed meal price
 Q_1 = INDR (domestic crush demand)

$Q_2 = Q_1 + \text{TSKR (carryout)}$
 $Q_3 = Q_2 + \text{QRDO (seed use)}$
 $Q_4 = Q_3 + \text{QRX (exports)}$

In panel (b), the demand for rapeseed oil in Canada (QDRO) is represented as an inverse relation to the price of rapeseed oil (PRO). Given the price of rapeseed oil (assumed exogenous due to the strong influence of U.S. soybean oil prices), quantity EF is consumed in Canada while the residual FG is exported.

In panel (c), the demand for rapemeal in Canada (QDRM) is represented as an inverse relation to the price of rapeseed meal (PRM). Given the price of rapeseed meal (again, assumed exogenous), quantity HI is consumed in Canada while IJ is exported.

The conceptual rapeseed model is summarized in equation form. The equations assume nonrestrictive quotas.

Behavioral Relations--Conceptual Rapeseed Model Equations

- (1) Planted area

$$AR: PRX_{-1}, \overline{X1}, e1$$

- (2) Crush demand

$$INDR: PRX, \overline{PRO}, \overline{PRM}, \overline{X2}, e2$$

- (3) Export demand for rapeseed

$$QRX: PRX, \overline{X3}, e3$$

- (4) Rapeseed carryout

$$TSKR: PRX, \overline{X4}, e4$$

- (5) Rapeseed oil demand

$$QDRO: \overline{PRO}, \overline{X5}, e5$$

- (6) Rapeseed meal demand

$$QDRM: \overline{PRM}, \overline{X6}, e6$$

Identities:

- (7) Seed requirements

$$QRDO = .0073 \cdot AR_{+1}$$

- (8) Rapeseed production

$$QR = AK \cdot \overline{YR}$$

- (9) Rapeseed oil production

$$QRO = .398 \cdot INDR$$

- (10) Rapeseed meal production

$$QRM = .575 \cdot INDR$$

- (11) Rapeseed exports

$$QRX = QR + TSKR_{-1} - INDR - QRDO - TSKR$$

- (12) Rapeseed oil exports

$$QROX = QRO - QDRO$$

- (13) Rapeseed meal exports

$$QRMX = QRM - QDRM$$

e1....e6 = random disturbance terms
PRM = rapeseed meal price
PRO = rapeseed oil price
PRX = rapeseed price

X1....X6 = vectors of exogenous variables, as follows:
X1 = prices of competing enterprises, technological change, production costs,
X2 = crush capacity,
X3 = income, population, and livestock prices and production in major oilseed consuming countries, production plus beginning stocks in other major oilseed producing countries,
X4 = variables representing the transactions and speculative demands for rapeseed carryout,
X5 = prices of competing edible oils, income and population,
X6 = prices of competing protein meals, livestock prices and products,

YR = rapeseed yield.

MODEL ESTIMATION

Each submodel for wheat, barley, and rapeseed is run separately to obtain coefficient estimates. Direct and cross-price elasticities are calculated and performance statistics are reported. Parameter and elasticity estimates are compared with those reported in the literature.

Wheat

Five behavioral equations are estimated by ordinary least squares for the wheat model. These correspond to equations (1) through (6) of the conceptual model but exclude equation (4), which concerns the export demand equation (see page 28).

A number of different specifications of the export demand equation (4) were tried, including separate equations to represent regional export demands (by less-developed countries, socialist countries, and advanced capitalist countries). The export demand equation(s) fit poorly, however, and had a large impact on the model. This led to problems of convergence in historical simulations of the model. Furthermore, there were conceptual problems with the equation(s). From 1960 to present, Canada's posture in the world wheat market has changed a number of times. Such changes cause movements in the shape of the export demand curve facing Canada. Hence, it would seem inappropriate to represent the whole period by a single linear price relation. In the early sixties, Canada appeared to be a price leader in a duopolistic world wheat market, with the United States as a price follower. This posture has been

explained by McCalla (27). Canada was in the dominant position in part because it was the major wheat exporter to the nonconcessional market. U.S. commercial exports averaged only 60 percent of Canadian export sales for the period 1960/61 through 1964/65. During the next 5 years, the ratio of U.S. to Canadian commercial export sales increased slightly to 70 percent. Unlike the early sixties, however, this period was characterized by what McCalla calls an unstable oligopoly:

The year 1965 began auspiciously with the first major price war in a decade. While the sharp fall in prices was triggered by a Canadian cargo to Mainland China, the Australians had been shading prices for some months previously. The United States reacted sharply and cut prices continually until July 1965. Prices tended to stabilize at this new lower level until increased sales by Canada and Australia to Mainland China, and particularly, the Soviet Union, and sharply increased U.S. shipments to India, substantially reduced stocks. Prices rose to even higher levels than pre-1965 in mid-1966 and remained high until mid-1967. Then prices trended downward as major exporters jockeyed for market shares in the year of grace between the end of the International Wheat Agreement in June 1967 and the beginning of the International Grains Agreement (IGA) in July 1968. Prices stabilized in the latter half of 1968 as members sought to abide by the minimums of the IGA. But in early 1969, first the French and then the Canadians broke prices below minimum. This led finally to the action of the United States to cut prices sharply in July and August 1969 which dropped the level of all wheat prices by October 1969 to their lowest levels in the past 15 years (27).

When Canada, the United States, and Australia were adhering to the minimum pricing provisions of the IGA, they appeared to be behaving as triopolists in a cartel-like arrangement. This posture suggested that the world price was supported above a competitive equilibrium level and that the export sales were made on a market-shares basis (6).

In more recent years, particularly since 1972, U.S. commercial wheat exports have expanded relative to Canada's wheat exports. Over the 5 years 1972/73 to 1976/77, Canada's exports amounted to less than 60 percent of U.S. commercial exports. Hence, the relative export positions were reversed from that of the early sixties. During the seventies, Canada behaved not as a price leader, but as a price follower. This remains the situation today. The change in foreign buyer preferences contributes to this structural change in Canada's posture in the world wheat market. During the sixties, Canada's hard red spring wheat had

a special place in world markets because of its superior milling quality. The CWB increased its price-setting power to the extent that Canada could offer a differentiated product. With changes in foreign breadmaking technologies, the special status of Canadian wheat has considerably diminished.

Because of the difficulty with specifying the export demand curve, the wheat simulation model will assume that world price is exogenous and that exports are obtained as a residual. The assumption of an exogenous world price may have been unacceptable during the early sixties, when Canada was the price-setter. During the seventies, when Canada was a price follower, this assumption may have been more palatable. The five estimated equations appear in table 2.

The variables used in the equations are:

AW = area planted to wheat, Canada (hectares),
 CPI = consumer price index, Canada (1971/72 = 100),
 D70 = 0-1 variable, equals 1 in 1970/71, 0 otherwise
 OFSW = ending onfarm stocks, wheat, Canada (mt),
 PBF = offboard price, barley (dollars/mt),

PBFA = $PBF \cdot (YB + YB_{-1} + YB_{-2})/3$,
 PHOG = price index, 100 hogs, Calgary, calendar year average
 (cents/100 lbs.)
 POP = population, Canada, June 30 (thousands),
 PR = price of 1 CW rapeseed on Winnipeg (dollars/mt),
 PRA = $PR \cdot (YR + YR_{-1} + YR_{-2})/3$,

PWF = offboard price of wheat (dollars/mt)
 PWFA = $PWF \cdot (YW + YW_{-1} + YW_{-2})/3$,
 PWH = Canadian mill price of 1 CWRs, Thunder Bay (dollars/mt),
 PWIP = CWB initial payment for wheat (dollars/mt),
 PWX = CWB export selling quotation of 1 CWRs, Thunder Bay,
 (dollars/mt),

QW = wheat production in Canada (mt),
 QWDF = wheat for feed use, Canada (mt),
 QWDH = wheat for human use and industrial use, Canada (mt),
 STRUCT = structural change variable, equals 1 in 1968/69,
 equals 0.5 in 1969/70, 0 otherwise,

Y = personal expenditure on consumer goods and services,
 Canada (million dollars),
 YB = barley yield (mt/ha.),
 YR = rapeseed yield (mt/ha.),
 YW = wheat yield (mt/ha.),
 Z = quota restrictiveness variable, equals deliveries to
 CWB in a crop year divided by farm supply (production
 plus beginning onfarm stocks).

Table 2--Estimated equations for the Canadian wheat model

(1) Planted area

AW:	PWFA ₋₁	PBFA ₋₁	PRA ₋₁	D70	STRUCT	CONSTANT
	40,265.	-19,905.	-8,411.1	-3,331,314.	2,906,748.	8,314,574
t:	1.93	-0.93	-1.23	-4.61		6.16
e:	.43	-.22	-.13			

$$\bar{R}^2 = .912 \quad \text{D.W.} = 2.75 \quad N = 14(1964/65 - 1977/78)$$

(2) Food and industrial use

QWDH:	PWH/CPI	Y/CPI	POP	CONSTANT
	-603.92	3,949.6	40.885	748,340.
t:	-1.26	1.81	3.60	
e:	-.03	.10	.47	

$$\bar{R}^2 = .926 \quad \text{D.W.} = 2.32 \quad N = 31(1947/48 - 1977/78)$$

(3) Feed use

QWDF:	PWF/PHOG	PBF	QWDF ₋₁	CONSTANT
	-61,313,146.	4,724.8	0.66371	1,475,011.
t:	-4.49	2.40	6.12	
e(SR):	-.60	.14		
e(LR):	-1.78	.42		

$$\bar{R}^2 = .839 \quad \frac{1}{m} = -1.46 \quad N = 15(1963/64 - 1977/78)$$

(4) Onfarm carryout

OFSW:	PWIP/PWF	QW	OFSW ₋₁	CONSTANT
	14,029,382	0.53437	0.34971	-22,928,996.
t:	2.93	3.23	1.30	
e(SR):	3.07	1.59		
e(LR):	4.72	2.45		

$$\bar{R}^2 = .791 \quad \frac{1}{m} = -.72 \quad N = 15(1963/64 - 1977/78)$$

(5) Offboard price

PWF:	PWX	PWX ₋₁	Z	CONSTANT
	0.42501	0.26797	24.308	-19.241
t:	6.43	4.45	1.41	
e:	.66	.23		

$$\bar{R}^2 = .959 \quad \text{D.W.} = 2.45 \quad N = 15(1963/64 - 1977/78)$$

t = t-statistic.

e = elasticity evaluated at observation means.

1/ The m-statistic corresponds to Durbin's second test for determining the absence of serial correlation when some of the regressors are lagged dependent variables. Spencer found in a Monte Carlo analysis that this test was generally more reliable in detecting the absence of serial correlation than Durbin's first test (involving the h-statistic) when the sample size is small. For both equations, we conclude that serial correlation is not present at the 5-percent significance level.

Equation (1) represents area planted to wheat. Explanatory variables include lagged prices for wheat, barley, and rapeseed, a dummy variable for 1970/71, and a structural change variable. With respect to the alternative crop prices, we use offboard prices for wheat and barley and the Winnipeg cash price for rapeseed. It is hypothesized that producers respond to expected crop yield as well as expected price (22). A 3-year moving average of past crop yield was used to represent expected yield. This was multiplied by price to give an expected return per hectare, which is entered in the equation as the explanatory price variable. The 0-1 variable for 1970/71 represents the effect of the Federal Government's LIFT program for that year. The structural change variable attempts to account for a change in prairie producer orientation from a single crop enterprise (wheat) in the sixties to a more diversified cropping pattern in the seventies (wheat, barley, and rapeseed).

Equation (2) represents the domestic demand for human and industrial use. The price elasticity (-0.03) is very small, but this is not uncommon for a commodity which in its final form (bread) has few good substitutes. The income elasticity is also small and positive (0.10), which is reasonable because bread may be classified as a necessity.

Equation (3) represents the feed demand for wheat. It could be argued that eastern feeders over much of the historical period were responding to a different wheat price (CWB determined price) than western feeders (the offboard price). Hence, one should have separate feed equations for eastern and western Canada. This is not attempted for two reasons. First, there is little data separating aggregate quantities of wheat fed into separate eastern and western components. ^{5/} Second, wheat for feed as a proportion of total supplies is not very large (7-percent average for 1967/68 to 1976/77). Hence, specification errors in this equation should not have too serious an effect on the estimated disposition of wheat, and in particular, on exports. Apart from the offboard price of wheat, the explanatory variables include the offboard price of barley (a competing feed grain), the price of hogs (for which wheat is

^{5/} One possibility is to use grain shipments to the east under the feed freight assistance program as an estimate of quantities fed in eastern Canada. Estimated quantities fed in the west are then calculated by subtracting these grain shipments from total grain fed. One problem with this, of course, is that it ignores eastern-produced wheat for feed.

an input), and the lagged dependent variable. The lagged dependent variable allows for only partial adjustment in amounts fed each year to a change in prices. This gives rise to shortrun and longrun elasticities which appear in the equation as $e(SR)$ and $e(LR)$, respectively.

Equation (4) represents the onfarm carryout of wheat. It is specified as a function of the ratio of initial payment to the offboard price, quantity of wheat produced, and onfarm carryin. The price ratio attempts to capture the speculative demand. If the offboard price is low relative to the initial payment which producers receive, it is suggested that producers will tend to increase their stock levels in anticipation of higher offboard prices in the future. If, on the other hand, the offboard price is high relative to the initial payment, it is suggested that producers will reduce stock levels in anticipation of a decrease in the future offboard price. The wheat production variable in this equation reflects the transactions demand for holding stocks while the lagged dependent variable reflects the partial adjustment in onfarm carryout each year to changes in the relative prices.

Equation (5) represents the offboard price. The explanatory variables include the current and lagged export price quotations for wheat plus a quota restrictiveness variable (Z). Z corresponds to the quota restrictiveness variable used by Meilke (30).

Barley

Five behavioral equations were estimated for barley by ordinary least squares since the model is econometrically recursive (table 3).

In equation (1), area planted to barley is expressed as a function of the lagged offboard prices for barley and wheat, a linear trend, and a dummy variable for 1971. As for wheat, the prices are adjusted by a 3-year moving average of crop yield. The direct- and cross-price elasticities (with respect to wheat) of 0.34 and -0.56, respectively, are plausible. Meilke obtained shortrun direct and cross-price elasticities (with respect to wheat) of 0.70 and -0.84, respectively (30). Missiaen and Coffing developed two alternative equations for barley area with estimated direct price elasticities of 0.66 and 0.29 (32). Bjarnason, combining all feed grains, estimated a shortrun direct price elasticity of supply of 0.45 (7). The trend variable in equation (1) represents technological change while the dummy variable represents farmer response in 1971 to the unusually large increase in summerfallow area the previous year. This large increase in summer fallow area resulted from the LIFT program initiated by the Government that year.

Table 3--Estimated equations for the Canadian barley model

(1) Planted area

AB:	PBFA ₋₁	PWFA ₋₁	D71	T	CONSTANT
	12,410.	-20,744.	1,149,233.	277,648.	-14,762,465.
t:	1.28	-2.05	3.42	8.32	
e:	.34	-.56			

$$\overline{R}^2 = .914 \quad D.W. = 1.92 \quad N = 14(1964/65 - 1977/78)$$

(2) Food and industrial demand

QBDH:	PBX/CPI	Y/CPI	POP	CONSTANT
	-191,499.	3,224.4	3.7858	164,166.
t:	-0.69	2.46	0.56	
e:	-.05	.37	.20	

$$\overline{R}^2 = .896 \quad D.W. = 1.75 \quad N = 29(1948/49 \text{ to } 1976/77)$$

(3) Feed use

QBDF:	PBF	PWF	HOGS	T	CONSTANT
	-47,812.	30,552.	665.12	277,924.	-17,985,996.
t:	-1.22	.91	3.79	6.05	
e:	-.55	.42	.85		

$$\overline{R}^2 = .918 \quad D.W. = 2.37 \quad N = 14 (1963/64 - 1976/77)$$

(4) Total carryout

TSKB:	PBF	PWF	QBS	D6869	D7576	CONSTANT
	-83,563.	83,262.	0.21097	1,348,491.	-1,843,765.	148,746.
t:	-2.77	3.19	7.51	4.99	-5.47	
e:	-1.33	1.61	.70			

$$\overline{R}^2 = .889 \quad D.W. = 2.20 \quad N = 15(1963/64 - 1977/78)$$

(5) Offboard price

PBF:	PBX	Z	CONSTANT
	0.66002	17.114	-13.238
t:	21.1	1.67	
e:	1.04		

$$\overline{R}^2 = .978 \quad D.W. = 1.38 \quad N = 15(1963/64 - 1977/78)$$

The variables in the equations are:

AB = area planted to barley, Canada (ha.),
CPI = consumer price index, Canada (1971/72 = 100),
D6869 = 0-1 variable, equals 1 in 1968/69 and 1969/70, 0 otherwise,
D71 = 0-1 variable, equals 1 in 1971/72, 0 otherwise,
D7576 = 0-1 variable, equals 1 in 1975/76 and 1976/77, 0 otherwise,
HOGS = hog number on farms, June 1 (thousands),
PBF = offboard price of barley, (dollars/mt),
PBFA = $PBF \cdot (YB + YB_{-1} + YB_{-2})/3$,
PBX = CWB selling quotation, 3 CW 6 row barley, Thunder Bay (dollars/mt),
POP = population, Canada, June 30 (thousands),
PWF = offboard price of wheat (dollars/mt),
PWFA = $PWF \cdot (YW + YW_{-1} + YW_{-2})/3$,
PWX = CWB export selling quotation, 1 CWRS, Thunder Bay (dollars/mt),
QBDF = barley for feed use, Canada (mt),
QBDH = barley for food and industrial use, Canada (mt),
QB = barley production, Canada (mt),
QBS = $QB + TSKB_{-1}$,
T = linear trend (1950/51 = 50),
TSKB = total carryout stocks of barley, Canada (mt),
Y = personal expenditure on consumer goods and services, Canada, (million dollars),
YB = barley yield (mt/ha.),
YW = wheat yield (mt/ha.),
Z = quota restrictiveness variable (wheat marketings divided by the farm supply of wheat).

The dependent variable in equation (2) is barley demanded for food and industrial use. The most important explanatory variable appears to be income [deflated by the Consumer Price Index (CPI)] with a t-value of 2.46. Price and population had t-values of less than 1, but since the coefficients have the expected sign, they are also included.

Barley demanded for feed use in equation (3) is expressed as a function of the offboard prices of barley and wheat, hog numbers, and a linear trend. The price elasticities in this equation are plausible.

LaForge estimated a direct price elasticity of demand for barley fed on the prairies at -0.33.

In equation (4), total stocks of barley are expressed as a function of the offboard prices of barley and wheat, barley production, and two dummy variables. An attempt was made to estimate separate stocks demand equations for onfarm and nonfarm stocks in a way similar to wheat. However, the resulting estimated equations were less than satisfactory in terms of their explanatory power. The problem may be explained largely by the sizeable proportion of nonfarm stocks which are also nonboard stocks. In the demand equation for onfarm stocks, we attempt to capture the factors affecting offboard stocks, while in the demand equation for nonfarm stocks, we attempt to capture the factors affecting board stocks. This may have been reasonable in the case of wheat where the CWB accounted for nearly 100 percent of nonfarm carryout stocks. In the case of barley, however, the CWB accounts for only about 80 percent of nonfarm stocks, but varies from year to year. Hence, onfarm stocks and nonfarm stocks are not likely to accurately reflect nonboard and board stocks, respectively.

In the total stocks demand equation, the price of wheat is included since wheat competes for the same storage space as barley. It is theorized, other things being equal, that the higher the price of wheat, the smaller will be the speculative demand for holding barley stocks. Barley production is included as an explanatory variable to represent the transactions demand for holding stocks. A dummy variable was introduced for 1968/69 and 1969/70 to reflect the abnormally large onfarm carryout in these years. The large carryout is likely due in large part to the heavy supplies of grain, particularly wheat, in these years. This put a strain on the elevator system and resulted in personal quotas advancing slowly through the crop year. A dummy variable was also introduced for 1975/76 and 1976/77 to reflect the unusually heavy export sales of barley in these years.

Equation (5) represents the price relation between the offboard price and the export price of barley.

Rapeseed

The equations for the rapeseed model have been estimated by ordinary least squares (table 4). ^{6/}

^{6/} This may lead to simultaneous equations bias in the coefficients. However, because of the limited number of observations during the time rapeseed has been a significant crop in Canada (since 1967) it is doubtful that a consistent method of observation will cause much change in the coefficients. Further, it was decided that given the time constraint on this study, bigger gains could be made in improving the model specification rather than the estimation method. Refinements in the method of estimation are left for later research when time and more observations (degrees of freedom) are available.

Area planted to rapeseed in equation (1) is expressed as a function of the lagged price of rapeseed, the lagged offboard price of wheat, and a dummy variable for 1971 to account for the lagged effect of the Government's LIFT program. The LIFT program had a positive effect on rapeseed acreage because it generated an unusually large area of summerfallow in 1970 for cropping the following year. A structural change variable is also included to account for the growth of the marketing infrastructure for rapeseed which occurred with the formation of the Rapeseed Association of Canada, as well as the technical know-how for producing rapeseed as conditions at that time encouraged farmers to move away from a wheat monoculture to a more diversified cropping pattern that included rapeseed.

The direct price elasticity evaluated at the observation mean is 1.21. This compares with a shortrun elasticity of 1.176 from a study by Uhm (53). The elasticity of rapeseed supply with respect to the price of wheat is -1.01 compared to Uhm's corresponding shortrun elasticity of -1.141. These elasticities are high relative to those obtained for the other crops (wheat and barley). However, this is not too surprising since rapeseed is still grown on a relatively small area. Hence, what would be modest supply responses to relative grain price changes at the whole farm level may translate into large supply responses for rapeseed.

Rapeseed crush demand in equation (2), is expressed as a function of the ratio of the price of rapeseed to the value of rapeseed equivalent of soybean oil and meal (VRES). This latter variable is a proxy for the value of rapeseed oil and rapeseed meal. The variable is derived from

$$VRES^* = \alpha \cdot USPO + \beta \cdot USPSM \cdot 0.7$$

where α and β are, respectively, the yield of rapeseed oil and rapeseed meal, while USPO and USPSM are, respectively, the U.S. (Decatur) prices for soybean oil and soybean meal expressed in Canadian dollars. USPSM is multiplied by 0.7 in the above equation to represent the price discount for rapeseed meal relative to soybean meal. This is primarily because of the lower protein content of rapeseed meal (34 percent versus 44 percent), but is also partly due to the lower acceptability of rapeseed meal as a livestock ration (39). Given $\alpha = 0.40$ and $\beta = 0.58$, then $VRES^* = 0.4 (USPO + USPSM)$. Taking the proportion (0.4) over to the left hand side, we have approximately $VRES = USPO + USPSM$, where $VRES = VRES^*/0.4$. We use this approximate relation in the equation.

The estimated price elasticity at observation means is -1.18. There are no other known studies that have estimated such an

Table 4--Estimated equations for the Canadian rapeseed model

(1) Planted area

AR:	PRA ₋₁	PWFA ₋₁	D71	STRUCT	CONSTANT
	8,393.4	-10,205.	678,515.	-602612.	1,062,653.
t:	6.28	-6.40	4.91	-6.27	
e:	1.21	-1.01			

$$\overline{R}^2 = .950 \quad D.W. = 1.89 \quad N = 13(1965/66 - 1977/78)$$

(2) Crush demand

INDRP:	PR/VRES	T	D76/77	CONSTANT
	-973,595.	38,073.	187,793.	-2,101,350.
t:	-10.5	23.8	16.6	
e:	-1.18			

$$\overline{R}^2 = .996 \quad D.W. = 1.81 \quad N = 11(1967/68 - 1977/78)$$

(3) Rapeseed oil demand

RPDOC:	PROP	USPSO	Y/CPI	CONSTANT
	-12,663.	3,194.6	4,807.9	-160,458.
t:	-1.87	1.12	5.36	
e:	-.91	.59	2.95	

$$\overline{R}^2 = .801 \quad D.W. = 1.63 \quad N = 11(1967/68 - 1977/78)$$

(4) Rapeseed meal demand

RPDMC:	PRMP	USPSM	T	CONSTANT
	-1,437.3	660.73	13,122.	-815,705.
t:	-1.36	2.33	3.34	
e:	-.49	.60		

$$\overline{R}^2 = .871 \quad D.W. = 2.00 \quad N = 11(1967/68 - 1977/78)$$

(5) Export demand for rapeseed

XRPTC:	PR	VRES	HOGNEC	T	CONSTANT
	-6,111.8	1,720.1	65.333	45,807.	-6,618,666.
t:	-3.27	2.24	3.70	1.41	
e:	-1.52	1.11			

$$\overline{R}^2 = .852 \quad D.W. = 3.11 \quad N = 11(1967/68 - 1977/78)$$

(6) Rapeseed carryout

TSKR:	(PR-PR ₋₁)	QR	TSKR ₋₁	CONSTANT
	-2,985.3	0.32794	0.28858	-66,299.
t:	-3.28	5.68	2.15	
e:	1/ -1.12	1.11	.27	

$$\overline{R}^2 = .792 \quad D.W. = 1.71 \quad N = 18(1960/61 - 1977/78)$$

^{1/} The imputed direct price elasticity at the observation means is -1.83.

The variables in the equations are:

AR = area planted to rapeseed, Canada (ha.),
CPI = consumer price index, Canada (1971/72 = 100),
D71 = 0-1 variable, equals 1 in 1971/72, 0 otherwise,
D7677 = 0-1 variable, equals 1 in 1976/77 and 1977/78, 0 otherwise,
HOGNEC = hog numbers, European Community, Dec. 31 (thousand head),
INDRP = rapeseed crushed, Canada (mt),
PR = price of 1 Can. rapeseed, Winnipeg (dollars/mt),
PRA = $PR \cdot (YR + YR_{-1} + YR_{-2})/3$,
PRMP = proxy variable for price of rapeseed meal (see text for details),
PROP = proxy variable for price of rapeseed oil (see text for details),
PWFA = $PWF \cdot (YW + YW_{-1} + YW_{-2})/3$,
PWF = offboard price, wheat (dollars/mt),
QR = rapeseed production, Canada (mt),
RPDMC = rapeseed meal demand, Canada (mt),
RPDOC = rapeseed oil demand, Canada (mt),
STRUCT = structural change variable, equals 1 in 1968/69, equals 0.5 in 1969/70, 0 otherwise,
T = linear trend (1950/51 = 50),
TSKR = rapeseed ending stocks, Canada (mt),
USPSM = U.S. (Decatur) annual average price of soybean meal expressed in Canadian dollars (dollars/short ton),
USPSO = U.S. (Decatur) annual average price of soybean oil expressed in Canadian dollars (dollars/short ton) (cents/lb.),
VRES = value of rapeseed equivalent of soybean oil and soybean meal (see text for details),
XRPTC = rapeseed exports, Canada (mt),
Y = personal expenditure on consumer goods and services, Canada (million dollars),
YR = rapeseed yield, Canada (mt/ha.),
YW = wheat yield, Canada (mt/ha.).

equation, so that direct comparisons are not possible. There has been a recent U.S. study, however, in which an equation for soybean crushing demand has been estimated. Meyers and Hacklander reporting on USDA's soybean model obtained an input (soybeans) price elasticity of -1.25 and an output (value of soybean meal and oil) price elasticity of -1.09 (31).

It is also hypothesized that the rapeseed crushing demand is a positive function of the capital invested in crushing facilities. This is represented by a linear trend and a dummy variable from 1976/77 on. The dummy variable represents the recent rapid expansion in crushing facilities.

Rapeseed oil demand in equation (3) is expressed as a function of a proxy variable representing the price of rapeseed oil, the U.S. (Decatur) price of soybean oil in Canadian dollars, and real income. The proxy variable for rapeseed oil was made necessary through the lack of data on Canadian rapeseed oil prices. The proxy variable (PROP) was derived from

$$\text{PROP} = (\text{PR}/\text{VRES}) \cdot \text{USPSO}$$

where the right-hand side variables are as previously defined. Thus, PROP is the U.S. price of soybean oil weighted by the price relative (PR/VRES) which attempts to reflect price discounts or premiums for rapeseed oil with respect to soybean oil. The explanatory variables in equation (3) have expected sign. The elasticity on PROP is -0.91 at the observation means. By way of comparison, a previous study estimated an equation for Canadian rapeseed oil demand using quarterly data on Canadian rapeseed oil and soybean oil prices (1968-IV to 1975-I) (19). The data series on rapeseed oil prices was discontinued in 1975. The estimated direct price elasticity for their equation (calculated at observation means) is -1.05. This is roughly the same as the corresponding elasticity (-0.91) in this study.

The estimated elasticity of rapeseed oil demand with respect to a change in the U.S. soybean oil price is 0.59 in this study. This is quite close to the estimated cross-price elasticity of 0.55 from the Furtan and others study (19).

In equation (4), rapeseed meal demand is expressed as a function of a proxy variable representing the Canadian price of rapeseed meal, the U.S. (Decatur) price of soybean meal, and a linear trend.

The proxy variable for rapeseed meal price (PRMP) is similar to that used in equation (3) for the rapeseed oil price. The only difference is that USPSM replaces USPSO. Thus,

$$\text{PRMP} = (\text{PR}/\text{VRES}) \cdot \text{USPSM}$$

where the right-hand side variables are as previously defined.

The estimated elasticity with respect to PRMP is -0.49, while the elasticity with respect to the U.S. soybean meal price is 0.60. Again, these may be compared with elasticities estimated from the Furtan and others study (19). In that study, an equation was estimated explaining Canadian rapeseed meal demand using annual data, 1967-75. Explanatory variables included in their equation were the Canadian rapeseed meal price, Canadian soybean meal price, and Canadian cattle numbers. The data series on rapeseed meal price was discontinued in 1975.

Also in that study, the estimated elasticity (at observation means) with respect to rapeseed meal price was -0.68, while the estimated elasticity with respect to soybean meal price was 0.85. Thus, both the Furtan and this study obtained cross-price elasticities which were greater in absolute value than the own-price elasticities, although the elasticities obtained in the Furtan study are a little higher than those in this study.

In equation (5), the rapeseed export demand is specified as a function of factors influencing imports in the major foreign consuming regions of Canadian rapeseed. Export demand is negatively related to the price of rapeseed and positively related to the price of other oilseeds (as represented by the VRES variable). Other explanatory variables include hog numbers in the EC and a linear trend. Hog numbers in the EC are included in an attempt to explain the variability in rapeseed imports into the EC. While Japan is a larger importer of Canadian rapeseed, the year-to-year variability (about a linear trend) is much less than in the EC. The trend is a catchall variable that accounts for the positive effects of population and income growth as well as the increasing acceptability of rapeseed abroad as a source of edible oils and protein meal. ^{7/}

Rapeseed carryout stocks in equation (6) are expressed as a function of the change in rapeseed price and lagged stocks. These variables reflect the speculative motive for holding stocks (21, p. 70). Rapeseed production is also included to reflect the transactions motive for holding stocks (21, p. 65).

THE SIMULATION MODEL

The three submodels for wheat, barley, and rapeseed were simulated simultaneously over the historical period 1967/68 to 1977/78. Interactions between the submodels were thus permitted. Price interactions existed in the supply response equations, the feed demand equations, and the carryout stocks equations. A number of historical simulations were made. In the first simulation, all equations were turned on and the model was permitted to feed on itself. That is, solved rather than actual values for lagged endogenous variables were used in the simulation. The equations for estimating the offboard prices of wheat and barley (see tables 2 and 3) were also included. Over

^{7/} The direct estimation of an export demand curve has been challenged on economic grounds as leading to biased coefficients. The solution appears to be to estimate a disaggregate model of the world market for rapeseed. This is beyond the scope of the present study.

the historical simulation period, the actual values for the quota restrictiveness variable (Z) are used. ^{8/}

The model performance over the historical period was analyzed by the two performance measures (table 5). These measures both relate to the model's predictive ability. The first measure calculated for each endogenous variable is the root mean square error divided by the observation mean. The second measure is Theil's U2 statistic:

$$U2 = \sqrt{(A_t - P_t)^2 / (A_t - A_{t-1})^2}$$

where:

A_t = actual value, time t

P_t = predicted value, time t.

This statistic compares how the model predicts with a naive (no-change) prediction for each endogenous variable. If this statistic is smaller than 1, then the model on average predicts better than the naive prediction. If the statistic is 0, the model predicts perfectly for the historical period.

Analyzing the performance of the model with respect to the wheat variables, it appears that QWX (exports) and OFSW (onfarm carryout) are of some concern (table 5). On the basis of the first performance measure, the model does a poorer job in predicting these two variables (and in particular OFSW) than any of the other wheat variables. On the basis of the second performance measure, the model does little better than a naive model in predicting exports ($U2 = 0.95$). Since wheat exports are treated as a residual in the wheat supply-utilization identity, the export predictions contain the net effect of errors made in predicting the other variables included in that identity. In particular, many of the errors in the export prediction are due to errors in the prediction of onfarm carryout. In the historical simulation of wheat exports, 3 years stand out as having the largest error, 1969/70, 1974/75, and 1977/78. In 1969/70, exports were overestimated by 4 mmt. For the same year, onfarm carryout was underestimated by 3.5 mmt.

^{8/} This differs somewhat from the estimation of offboard prices in the forecast simulations. In the forecast simulation analysis, the variable Z is replaced by the value (0.725) which represents the average value of Z in the presence of no quota restrictions. A test is made on whether the solution value for exports exceeds the predetermined constraint. If it does, the model is re-solved with exports at the constraint level and offboard prices solved as suggested in the theoretical model.

Table 5--Performance statistics of the model,
historical period 1967/68 to 1977/78

Variable	RMSE/Y	U2
Wheat:		
AW (area)	0.08	0.35
QW (production)	.09	.27
QWDH (food use)	.03	.63
QWDF (feed use)	.08	.57
QWX (exports)	.21	.95
OFSW (onfarm carryout)	.29	.53
QWDO (seed use)	.10	.42
PFW (offboard price)	.10	.31
Barley:		
AB (area)	.08	.54
QB (production)	.09	.47
QBDH (food use)	.07	.89
QBDF (feed use)	.09	.78
QBX (exports)	.40	1.07
TSKB (carryout)	.19	.69
QBDO (seed use)	.11	.83
PBF (offboard price)	.08	.23
Rapeseed:		
AR (area)	.22	.42
QR (production)	.25	.47
INDRP (crushed)	.13	.48
QRPX (exports)	.19	.53
TSKRP (carryout)	.71	.60
QRPO (seed use)	.27	.54
RPDO (oil produced)	.15	.51
RPDOC (oil use)	.12	.47
XRPO (oil exports)	.79	.87
RPDM (meal produced)	.13	.47
RPDMC (meal use)	.11	.54
XRPM (meal exports)	.74	.71
PR (rapeseed price)	.11	.35

This underestimate was primarily due to the error in the estimate of the offboard price that year. Since offboard price enters the OFSW equation in a hyperbolic way, onfarm carryout is very sensitive to changes in price when the latter is low. Onfarm carryout in 1974/75 was predicted to fall by 3 mmt when, in fact, it fell by only 0.6 mmt. It is suggested that dock

strikes, which were especially a problem in 1974, may have been a significant factor in preventing any further decline in OFSW. This miscalculation in OFSW translated into a sizeable overestimate of wheat exports. Exports in 1977 were underestimated by 3.5 mmt. This was primarily due to an underestimate of acreage that year.

With regard to the barley variables, the model performed least well in predicting exports. In fact, the Theil U2-statistic is greater than 1, indicating that on average the model performed worse than a naive no-change prediction. The problem is largely due to the sensitivity of the model to errors in the estimation of the offboard prices of wheat and barley. When the offboard prices are treated exogenously, the performance measures for XBTC are greatly improved to 0.18 and 0.49, respectively.

With respect to the rapeseed variables, the model generally performs well in predicting the endogenous variables. The least satisfactory results are for oil and meal exports, but even here the model performs better than the naive prediction model. The relatively poor results for the oil and meal exports are not too surprising since these variables are determined as residuals in the model.

The first simulation experiment is to obtain estimates of the impact and longrun elasticities of Canadian exports of wheat, barley, and rapeseed with respect to a change in U.S. prices of wheat, barley, and soybean oil and meal. For this experiment, additional price relations were added to the model, relating the Canadian export prices of wheat and barley, respectively, to the U.S. farm prices of wheat and barley. U.S. prices of soybean oil and meal are already incorporated in the rapeseed submodel.

The estimated price relations are as follows:

(1) Canadian export price, wheat (Can. dollars/mt.)

PWX:	USPW1	CONSTANT
	46.721	7.5906
t:	24.0	
e:	.92	

$\overline{R}^2 = .963$ D.W. = 1.91 N = 23(1955/56 to 1977/78)

(2) Canadian export price, barley (Can. dollars/mt.)

PBX:	USPB1	CONSTANT
	63.816	-5.1298
t:	35.9	
e:	1.07	

$$\overline{R}^2 = .983$$

$$D.W. = 2.02$$

$$N = 23(1955/56 \text{ to } 1977/78)$$

Variables in the equations

$$USPW1 = (PWUS - EXSUB) \cdot EXRT$$

USPW = U.S. season average price of wheat (U.S. dollars/bu.)

EXSUB = U.S. wheat subsidy (U.S. dollars/bu.)

EXRT = U.S.-Canadian exchange rate (Can. dollars/U.S. dollars)

$$USPB1 = USPB \cdot EXRT$$

USPB = U.S. season average price of barley (U.S. dollars/bu.)

The elasticities are estimated over the simulation period beginning in 1977. Thus, impact elasticities are estimated by increasing a particular exogenous variable by 1 percent in 1977 and observing the percentage changes in the endogenous variables (over their 1977 actual values) in the same period. The longrun elasticities are estimated by increasing a particular exogenous variable by 1 percent in 1977, maintaining that change for 10 years, and observing the percentage changes in the endogenous variables at the end of the 10-year period. During the 10-year simulation period, all exogenous variables other than the one under consideration are held constant.

Selected impact elasticities are of particular interest to the United States since they estimate the effect of a percentage change in U.S. grain prices on Canadian grain exports (table 6).

The impact elasticities measure the effect on Canadian exports via the demand side. The effects via the supply side are assumed to be felt only after some lag.

The model suggests that the export supply of wheat from Canada is inelastic with respect to changes in the U.S. wheat price,

Table 6--Selected impact elasticities, Canadian exports

Effect of 1-percent change in:		Canadian exports of		
		Wheat	Barley	Rapeseed
U.S. wheat price	:	0.74	-1.51	0
U.S. barley price	:	0	2.86	0
U.S. soybean meal price	:	0	0	0.06
U.S. soybean oil price	:	0	0	.18
Exchange rate (Can. dollars/ U.S. dollars)	:	.75	1.35	.25

while the export supply of barley is elastic. The export supply of rapeseed is found to be inelastic with respect to changes in the U.S. prices of soybean meal and soybean oil. The only significant cross-price effect is that of wheat price on barley exports. A higher U.S. wheat price is expected to result in a greater quantity of barley being required for domestic feed use. This results in less barley available for export. A 1-percent change in the exchange rate is equivalent (in this model) to a 1-percent change in all U.S. grain and oilseed prices. Hence, the exchange rate elasticity equals the sum of the price elasticities for a given export commodity. For wheat and barley, the exchange rate elasticity is estimated to be inelastic while for barley it is elastic.

The longrun elasticities measure the effect on Canadian exports of a change in U.S. prices after all supply-demand interactions are assumed to have taken place (table 7). The model suggest that the export supply of wheat from Canada is inelastic in the long run (0.82), but is more elastic than in the short run (0.74). The export supply elasticity for barley is still elastic but slightly less than in the short run. This may seem a little surprising at first glance, but the reason is as follows. In the short run, barley exports increase primarily as a result of decreased carryout and decreased feed use. In subsequent years, exports also increase because of a production response, while carryout and feed use are down by about the same amount as in the first year. Hence, there is still a negative effect in the long run on feed use of barley but there is little change in carryout. The longrun elasticity of export supply is made up largely of the positive production and negative feed use components while the shortrun elasticity is made up largely of the negative stock change and negative feed use components. It turns out that the negative shortrun stock change component is

Table 7--Selected longrun elasticities, Canadian exports

Effect of 1-percent change in:	:	Canadian exports of		
		Wheat	Barley	Rapeseed
	:	:	:	:
U.S. wheat price	:	0.82	-2.86	-0.57
U.S. barley price	:	-.56	2.70	0
U.S. soybean meal price	:	-.02	0	.20
U.S. soybean oil price	:	-.07	0	.59
Exchange rate (Can. dollars/ U.S. dollars)	:	.18	-.15	.22
	:			

slightly larger than the positive longrun production component. Hence, the longrun elasticity is slightly less than the shortrun elasticity.

The export supply of Canadian rapeseed is found in the long run to be inelastic with respect to changes in the prices of U.S. soybean meal and U.S. soybean oil.

There are some large cross-price elasticities present in the long run. In particular, an increase in the U.S. wheat price is estimated to have a substantial effect on Canadian barley and rapeseed exports.

The longrun effects of a change in the exchange rate are estimated to be far more modest than in the short run. In fact, the model predicts that the longrun effect of a change in the exchange rate on barley exports is negative. This is in large part because the barley area response equation includes the price of wheat with a higher cross-price elasticity of supply than the direct (barley) price elasticity of supply. This result is less than satisfactory, as one usually expects the direct elasticity to exceed any cross-elasticity, and the equation may deserve further scrutiny.

The above elasticity estimates assume no export constraint is present. Such a constraint, however, is specifically incorporated in the theoretical analysis. An export constraint was assumed to result in a divergence between the export and domestic (offboard) prices for grains with consequent effects on domestic consumption and supply response. It is not very meaningful to estimate elasticities allowing for such an export constraint, since the elasticities would then be conditional on the variable levels involved. Moreover, it would be erroneous to use such elasticity estimates as the basis for predicting what would happen to Canadian grain exports given larger price increments than 1-percent.

Experiment 1

In 1977/78, Canada's export of wheat and flour amounted to 16 mmt, a near record for Canada. In only 3 previous years have exports of the same magnitude been recorded--1963/64, 1965/66, and 1972/73. There was considerable sentiment that Canada could have exported more in 1977/78, except that the transportation system could not physically handle any more grain exports. The CWB was forced to defer 2 mmt of export grain to the 1978/79 marketing year.

The purpose of this experiment is twofold:

(1) To assess what would have happened to exports and the Canadian wheat economy in the absence of the export constraint, and

(2) Given that exports were constrained, to assess the effects of alternative CWB strategies for dealing with the constraint on the Canadian wheat economy.

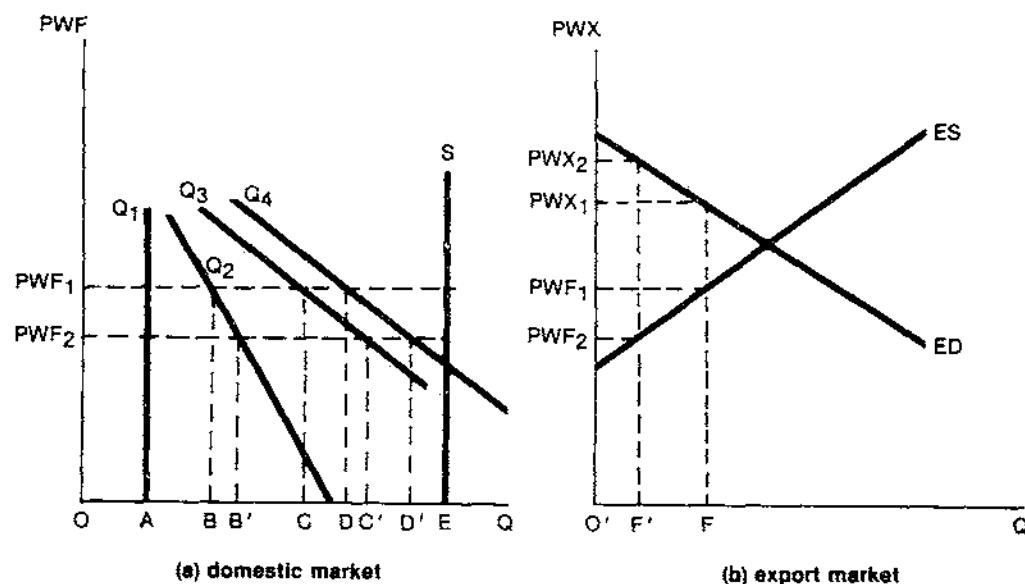
There are any number of possible strategies for handling the excess supplies of export wheat with respect to the second purpose. Only three possible strategies are considered and compared with the actual strategy used. The first strategy is to keep the excess supplies at the farm level, either accumulating as onfarm stocks or being marketed on the offboard market. This is accomplished by restrictive delivery quotas. The second strategy is to put the excess supplies in CWB stocks. This is accomplished through delivery entitlements sufficient to make the quotas nonrestrictive. The third strategy is the same as strategy 1, except that an attempt is also made to neutralize the depressing effects on the domestic market by raising the initial payment to producers.

The conceptual model of wheat demand in 1977/78 (see fig. 7) is basically the same as that developed earlier in the conceptual framework (fig. 4) except that QWDH (food and industrial use) and NFSW (nonfarm carryout) have been moved to panel (a) from panel (b). Also, note that in 1977/78, wheat for food and industrial use (QWDH) is assumed not to respond to world prices. It has been argued that the domestic milling price can be explained by world wheat prices, but this approach is not followed here (23). We assume that NFSW is a variable under the control of the CWB. By adjusting the delivery quotas during the marketing year, it is assumed the CWB can obtain any desired level of NFSW. While NFSW does include some offboard stocks as well as board stocks, in fact the former has generally amounted to less than 5 percent of the total. This assumption may not be valid in some cases where obstacles such as strikes prevent the desired level of NFSW from being attained. Such obstacles do not render this variable any more price-responsive. However, they do add a new dimension to the factors affecting nonfarm carryout and delivery quotas. Assuming a basis difference equal to $(PWX_1 - PWF_1)$ to allow for transportation and quality differences, we may obtain the market equilibrium described in the following. Export price is PWX_1 , offboard price is PWF_1 , the quantity of wheat for food use plus ending nonfarm stocks is OA, wheat for feed use is AB, ending onfarm stocks is BC, seed requirements are CD, and exports are O'F.

It has been suggested that in 1977/78, exports were constrained so that actual exports fell short of $O'F$ (say $O'F'$). The necessary adjustments on the domestic market may be accomplished in a number of ways as the alternative strategies suggest. Figure 7 shows how the domestic market adjusts if strategy 1 is followed. That is, wheat for feed use expands from AB to AB' , onfarm carryout expands from BC to BC' , and seed requirements decline from CD to $C'D'$. The offboard price declines from PWF_1 to PWF_2 . The world price of wheat in the export market rises to PWX_2 from PWX_1 . One further hypothesized effect of this strategy is on planting intentions, though this is not shown in figure 7.

Figure 7

Graphical Demand Model for Canadian Wheat, 1977/78



PWF = Offboard price of wheat

PWX = Canadian wheat board price of wheat

Q_1 = $QWDH$ (food and industrial use) + $NFSW$
(nonfarm carryover)

Q_2 = $Q_1 + QWDF$ (feed use)

Q_3 = $Q_2 + OFSW$ (onfarm carryout)

Q_4 = $Q_3 + QWDO$ (seed use)

S = $QWPTC$ (production) + $OFSW_{-1}$ + $NFSW_{-1}$

ES = $S - Q_4$ (export supply)

ED = QWX (export demand)

It was theorized that planting intentions are based on the expected offboard price. Assuming that expected prices are a function of past prices, the lower offboard price should have a depressing effect on planting intentions in subsequent crop years. The second strategy would be to accumulate all the extra supplies (F'F) as nonfarm stocks. This would cause a parallel shift to the right in curve Q_4 by the amount F'F. Consequently, curve ES would shift to the left in a parallel way by the same amount. The resulting equilibrium achieves the original offboard price, PWF_1 . In addition, exports will be O'F' and the export price will be PWX_2 . ^{9/}

A third strategy might combine the first strategy with a measure to offset the expected supply depressing effects. Such a measure is the initial payment. It is suggested that an increase in the initial payment will encourage producers to retain more of their grain (in excess of expected delivery entitlements) as onfarm stocks rather than dispose of it on the offboard market. This will be the case if producers expect the higher initial payment to persist into the new crop year so that they may take advantage of it with their old-crop wheat.

There were problems in the estimation of an export demand equation which resulted in that equation being excluded from the model. For purposes of this experiment, it was decided to synthesize an export demand curve. This was accomplished by using an assumed elasticity of export demand and passing a linear curve through the observed 1977/78 price-quantity point with the assumed elasticity occurring at that point. Thus, for 1977/78, the export demand curve was passed through the actual export price of \$137.20 and actual exports of 16 mmt. This price and quantity correspond to PWX_2 and O'F' in figure 7 (b).

The estimated demand curves QWDF, OFSW, and QWDO were also adjusted by add factors so that they passed through the actual offboard price (\$85) and quantities (1.838, 5.28, and 0.96 mmt, respectively) for 1977/78. The add factors allowed for the effects of explanatory variables in 1977/78 that are included in the disturbance terms of the estimated equations. With respect to figure 7(a), the price corresponds to PWF_2 while the quantities correspond, respectively, to AB', B'C', and C'D'.

^{9/} Note that the model, by construction, treats the first strategy as having a supply-depressing effect while it treats the second strategy as not having a supply depressing effect. The assumed absence of a supply-depressing effect of the second strategy may be open to question. It is possible that larger CWB stocks will still send signals to the producers to lower plantings in the subsequent crop year.

To obtain the effects of the apparent export constraint in 1977/78, it is first necessary to estimate prices and disposition of the crop in the absence of the constraint. To accomplish this one must estimate the offboard price relation that would prevail in the absence of this constraint and the desired level of nonfarm carryout. The offboard price relation is based on equation 5 in table 1, where Z takes on the value 0.73. This is the average value for Z during the years when constraints on the domestic market are judged absent. The years so selected were 1963/64 through 1965/66 and 1972/73 through 1975/76. The level of desired nonfarm carryout was estimated as the average level during the seventies when quotas were deemed to be nonrestrictive (1972/73 to 1975/76). However, 1973/74 was excluded because a rail strike and a work slowdown by Vancouver grain handlers enlarged nonfarm carryout considerably in that year. The resulting average desired nonfarm carryout was 6.5 mmt.

The estimated shortrun effects of removing the export constraint are presented in table 8, under three alternative assumptions about the export demand elasticity.

The largest increase in exports (1.57 mmt) occurred when the export demand curve was the most elastic. This increase is not large when compared with other figures publicized on lost sales. It has been suggested that wheat exports could have gone as high as 20 mmt, or about 4 mmt, above the actual level (7). Part of this difference could be made up if a lower figure for nonfarm carryout were assumed. In recent years, the lowest carryout has been 6.17 mmt in 1976/77. With this level of carryout, the model would predict an export level of around 18 mmt. Apart from this there is a possibility that the model is misspecified. One possible area of misspecification is in not allowing sufficient price responsiveness in the feed and onfarm carryout equations. However, the elasticities (for 1977/78) of -0.54 and -3.45, respectively, do not look unreasonably low. A more likely candidate for misspecification is the estimated price relationship between the offboard price and the export price. There are a number of factors affecting the offboard price of wheat which are not included in the relation, such as the effect of changing domestic feed grain policies and changes in the quality of the crop from year to year (10). While the relation has good explanatory power as measured by the coefficient of determination ($R^2 = .959$), the relation did not do particularly well in the recent years of high and volatile prices. The estimates for 1974/75 and 1976/77 were approximately two standard deviations (about \$13.50) from the actual values in these years.

Table 8--Shortrun effects of removing the constraint on Canadian wheat exports, 1977/78

Item	:No export constraint and export demand elasticity of--			
	: Actual	: -0.5	: -1.0	: -10.0
	:	:	:	:
	<u>Million metric tons</u>			
Production plus carryin	: 33.17	33.17	33.17	33.17
Use:	:			
Food	: 1.98	1.98	1.98	1.98
Seed	: .96	.96	.97	.99
Feed	: 1.84	1.83	1.82	1.78
Exports	: 16.00	16.68	16.97	17.57
Onfarm carryout	: 5.28	5.22	4.93	4.35
Nonfarm carryout	: 7.11	6.50	6.50	6.50
	:			
	<u>Dollars/metric ton</u>			
Export price	: 137.20	125.69	128.97	135.85
Offboard price	: 85.00	85.29	86.67	89.60
	:			
	<u>Million hectares</u>			
Δ Area planted _{t+1}	: --	.02	.13	.36

-- = not applicable.

The other possible explanation for the difference between the model's result and the potential export figure of 20 mmt is that the latter is an overestimate. It would require onfarm carryout to decline to about 2 mmt. This is quite possible and, in fact, was achieved from 1973/74 through 1975/76. However, in those years, the offboard price was at record levels of around \$120 per mt. Such a price is unlikely in 1977/78 given that the export price is only \$137.20, about \$50 less than the average for 1973/74 through 1975/76.

Let us now compare the effects of the three alternative strategies on the domestic market. The three strategies are:

- (1) The CWB forces the domestic market to absorb the entire excess of wheat supplies. By excess, we mean the difference between what was exported and what would have been exported had there been no export constraint.
- (2) The CWB allows the entire excess of wheat supplies to accumulate as nonfarm stocks. Since this strategy assumes

that the entire difference between unconstrained and constrained exports enters nonfarm carryout, these results for the domestic market will be the same either if the strategy is applied to a constrained export situation or if exports are unconstrained. Hence, the results achieved with this strategy will be identical to those presented in table 8 except that exports will be lower (at 16 mmt) and nonfarm carryout will be higher. In table 8, the results of strategy 2 are presented for the case in which the export demand elasticity is assumed to be -10.0.

(3) The CWB adopts strategy 1 but also raises the initial payment so as to neutralize the supply-depressing effects on the domestic market of the first strategy.

These are by no means the only strategies one could consider; however, they are examples of how the model may be used to assist policy decisionmaking. The results of the three strategies are shown in table 9 along with the actual strategy for comparison.

Strategies 1 and 2 are polar strategies. The first assumes that the entire effect of the export constraint is felt on the domestic market while the second strategy assumes that there are no repercussions of the export constraint on the domestic market. The analysis suggests that the range of effect on subsequent planted area is about 0.57 million ha. Compared to the actual strategy, strategy 1 is estimated to result in a lower planted area to wheat the following year by 0.21 million ha. (2 percent) while strategy 2 was estimated to raise it by 0.36 million ha. (3 percent).

The third strategy is similar to strategy 1 except that the initial payment is raised to offset the depressing effect of the first strategy on the offboard price. Raising the initial payment to \$113.90 per mt resulted in the offboard price rising to its actual level of \$85. In addition, onfarm carryout and wheat demand for seed use increase slightly above the levels estimated by strategy 1. Feed use of wheat declines slightly from the strategy 1 level.

Experiment 2

The model in this experiment is simulated into the future, 1978/79 to 1982/83, and an export constraint on wheat is imposed each year. We revert to the original model in which no export demand equation is specified. The model is used to obtain baseline forecasts and then to observe the effects on the endogenous variables of imposing an export constraint. The assumptions for the exogenous variables used in the baseline forecasts appear in table 10. Most variables are assumed

Table 9--Alternative strategies for handling the apparent constraint on Canadian wheat exports, 1977/78

Item	:	Actual	Strategy		
			1	2	3
	:				
	:		<u>Million metric tons</u>		
	:				
Production plus	:				
carryin	:	33.17	33.17	33.17	33.17
	:				
Use:	:				
Food	:	1.98	1.98	1.98	1.98
Seed	:	.96	.94	.99	.96
Feed	:	1.84	1.87	1.78	1.84
Exports	:	16.00	16.00	16.00	16.00
Onfarm carryout	:	5.28	5.87	4.34	5.89
Nonfarm carryout	:	7.11	6.50	8.07	6.50
	:				
	:		<u>Dollars/metric ton</u>		
	:				
Export price	:	137.20	137.20	137.20	137.20
Offboard price	:	85.00	82.31	89.60	85.00
Initial payment	:	110.23	110.23	110.23	113.90
	:				
	:		<u>Million hectares</u>		
	:				
Δ Planted area _{t+1}	:	--	-.21	+36	--

-- = not applicable.

constant over the forecast interval. The exceptions include the aggregate variables (CPI, income, and population) which are assumed to increase at a given percent per year, the linear trend variable, and yields. Yields were fitted to a linear trend over the historical period (1947/48 to 1977/78) and then extrapolated according to this trend in the years 1979/80 to 1982/83. For 1978/79, actual yields were used.

The baseline projections, 1978/79 to 1982/83, appear in table 11. For 1978/79, the projections (P) are compared in this table with the actual values (A). In the case of wheat, projected exports in 1978/79 were substantially above actual exports, despite the considerable underestimate of production in this year. This may be explained by a severe export constraint in this year owing to a series of obstacles in the handling and transportation of grain (15, pp. 2-3). The model projections do not reflect these problems.

Imposing a wheat export constraint in 1978/79 equal to actual exports and setting production at the actual level produced the results in table 12. In this situation the projected offboard price declined in 1978/79 to \$82.90. This is below the actual price (\$90), but closer to it than the original (no export constraint) projected price (\$104.90). Predictably, the projected carryout for 1978/79 increased substantially (to 15.7 mmt) and projected exports for 1979/80 increased to 15.1 mmt

Using the wheat model with production and exports in 1978/79 set to the actual levels, the first simulation experiment investigates the effects of an export constraint due to handling and transportation limitations. In 1977/78, such a constraint has been cited as the reason why exports did not exceed 16 mmt (16). In 1978/79, this constraint is cited again (15, pp. 2-3) as the reason exports did not exceed 13.1 mmt. The first simulation experiment analyzes the effects on supply and distribution of wheat under the assumption that exports will not exceed 15 mmt in any year of the forecast interval 1979/80 to 1982/83. Given the presently estimated model and exogenous variable assumptions, this constraint is binding in years 1979/80, 1981/82, and 1982/83 (table 13). The results in this table represent the change in solution values (from table 12) resulting from the export constraint.

It was expected that during the years of the export constraint, the offboard price would decline, domestic feed use would increase, and in subsequent years, acreage planted and production would decline. These expected results are borne out in the table. However, the magnitude of changes in supply and disposition and the offboard price are quite modest, since in this experiment the export constraint is not very restrictive in any year.

Crow's Nest Pass Freight Rate

A particular transportation problem faced by the CWB is a lack of investment on the part of railroads in capital needed for moving grain. Investment is lacking especially in the hopper cars needed to haul the grain, but there are also problems of insufficient rail capacity through the mountains to the west. In large part, the problem is due to the statutory rate at which grain moves to the export terminal. All prairie grain destined for export is railed at a concessional rate known as the Crow's Nest Pass Rate. This rate has caused much controversy in its long history. The rate charged today is the same as it was when the agreement was signed in 1923. With rising railway costs, producers are currently paying less than one-third the actual cost of transporting the grain.

Table 10--Exogenous variable assumptions in the prediction interval,
1978/79 to 1982/83 for the baseline predictions

Variable and description	Unit	1978/79	1979/80	1980/81	1981/82	1982/83
CPI (Consumer Price Index)	8-percent growth/yr.	--	--	--	--	--
EXRT (Exchange rate)	Can.dol./U.S. dol.	1.14	1.14	1.14	1.14	1.14
FEEDRP (Rape-seed fed)	1,000 mt	99.0	99.0	99.0	99.0	99.0
HOGNEC (EC hog numbers)	Million head	74.2	74.2	74.2	74.2	74.2
HOGNTC (Can. hog numbers)	Million head	7.1	7.1	7.1	7.1	7.1
NFSW (nonfarm wheat carryout)	mmt	6.83	6.83	6.83	6.83	6.83
PHOG (hog price)	dol./cwt.	53.0	53.0	53.0	53.0	53.0
POP (Population millions)	1.2-percent growth/yr.	--	--	--	--	--
T (Linear trend)		78.0	79.0	80.0	81.0	82.0
USPB (U.S. barley price)	U.S. dol./bu.	1.90	1.90	1.90	1.90	1.90
USPSM (U.S. soybean oil price)	U.S. dol./short-ton	185.0	185.0	185.0	185.0	185.0
USPSO (U.S. soybean oil price)	U.S. dol./pound	27.0	27.0	27.0	27.0	27.0
USPW (U.S. wheat price)	U.S. dol./bu.	2.94	2.94	2.94	2.94	2.94
Y (Pers. cons. exp.)	10-percent growth/yr.	--	--	--	--	--
(Mil./dol.)						
YBTC (Barley yield)	mt/ha	2.42	2.36	2.40	2.44	2.47
YRPTC (Rape-seed yield)	mt/ha	1.20	1.13	1.14	1.16	1.17
YWTC (Wheat yield)	mt/ha	1.96	1.86	1.88	1.90	1.92

-- = not applicable.

Table 11--Baseline projections

Item	1978/79		Crop year			
	Projected	Actual	1979/80	1980/81	1981/82	1982/83
<u>Million metric tons</u>						
Wheat:						
Area planted (million ha.)	9.0	10.6	9.4	9.7	9.7	9.5
Production	17.7	21.1	17.5	18.3	18.5	18.2
Domestic use	5.0	5.2	4.9	4.8	4.8	4.7
Exports	15.5	13.1	12.1	12.9	13.4	13.5
Carryout	9.9	15.0	10.4	11.0	11.3	11.3
Offboard price (dollars/metric ton)	104.9	90.0	112.2	112.2	112.2	112.2
Barley:						
Area planted (million ha.)	5.3	4.3	5.4	5.6	5.9	6.2
Production	12.9	10.4	12.8	13.4	14.4	15.4
Domestic use	8.5	7.2	9.0	9.3	9.6	9.9
Exports	4.3	3.1	3.3	3.9	4.5	5.2
Carryout	5.5	4.9	6.1	6.3	6.6	6.8
Offboard price (dollars/metric ton)	87.0	66.0	87.0	87.0	87.0	87.0
Rapeseed:						
Area planted (million ha.)	2.30	2.83	2.05	1.95	1.91	2.06
Production	2.77	3.50	2.32	2.23	2.22	2.41
Crush	.70	.73	.74	.77	.78	.82
Other domestic use	.11	.37	.11	.10	.11	.12
Exports	1.38	1.72	1.43	1.41	1.35	1.38
Carryout	.94	1.01	.97	.91	.88	.97
Offboard price (dollars/metric ton)	302	300	300	312	328	331

Table 12--Wheat projections after correcting for production and exports in 1978/79

Item	: :Projected :	: :Actual : values	: : 1979/ : 80	: : 1980/ : 81	: : 1981/ : 82	: : 1982/ : 83
Area planted	: : 1/ 10.6 :	: : 10.6 :	: Million hectares : 8.7 10.7 10.8 10.8			
	: :	: :	: Million metric tons			
Production	: : 1/ 21.1 :	: : 21.1 :	: : 16.1 :	: : 20.2 :	: : 20.6 :	: : 20.7 :
Domestic use	: : 5.1 :	: : 5.2 :	: : 5.0 :	: : 4.8 :	: : 4.7 :	: : 4.7 :
Exports	: : 1/ 13.1 :	: : 13.1 :	: : 15.1 :	: : 14.6 :	: : 15.4 :	: : 15.8 :
Carryout (mnt)	: : 15.7 :	: : 15.0 :	: : 11.7 :	: : 12.5 :	: : 13.0 :	: : 13.2 :
	: :	: :	: Dollars/metric ton			
Offboard price	: : 82.9 :	: : 90.0 :	: : 112.2 :	: : 112.2 :	: : 112.2 :	: : 112.2 :

1/ Actual.

To help overcome the problems of a lack of railway investment, the Canadian Government has purchased 8,000 hopper cars in the last 6 years. The CWB also has tendered for an additional 2,000 cars. The railcar shortage continues to be a problem since old boxcars are being pulled out of the system at the rate of 1,800 per year (15).

The compensatory rate for moving grain from the prairies to the west coast was estimated at about three times the statutory rate in 1977. The statutory rate was about \$5 per mt in 1977. Thus, to raise transport costs to the compensatory rate would entail a cost increase of about \$10 per mt.

Under the assumption of a completely elastic export demand curve for wheat facing Canada, this rail rate increase is assumed to be totally passed on to the domestic market through a reduction in producer grain prices. In the model, these prices include the offboard prices of wheat and barley and the Winnipeg price of rapeseed. Table 13 shows the results of a forecast simulation experiment in which the producer grain prices are reduced by \$10 in 1979/80 through 1982/83. The values in table 13 represent the difference between the original solution values (table 11) and the solution values, given the lower grain prices.

Table 13--Change in solution values resulting from an export constraint of 15 million metric tons

Item	1979/80	1980/81	1981/82	1982/83
<u>Million hectares</u>				
Area planted	--	-0.06	--	-0.17
<u>Million metric tons</u>				
Production	--	-.11	--	-.33
Domestic use	--	--	0.01	.06
Exports	-0.10	.01	-.37	-.78
Carryout	.10	-.02	.32	.73
<u>Dollars/metric ton</u>				
Offboard price	-.73	--	- 2.29	- 5.25

-- = not applicable.

As shown in table 14, the reduced offboard price (assumed to result from an increase in the statutory freight rate) caused a reduction in wheat exports of around 1.63 mmt in the initial year, brought about by a reduction in carryout. In subsequent years, wheat exports were projected to decrease by 0.8 mmt and less. This is largely the result of a negative supply response to the lower offboard price.

FURTHER RESEARCH

The conceptual and empirical models developed in this study provide a framework for analyzing Canada's exports of wheat, barley, and rapeseed. As a framework, they should not be considered the final word. Further research on specification and estimation particularly in the wheat and barley models would be worthwhile. One area deserving further work is the specification of the export demand of wheat and barley. At present, wheat and barley exports are obtained as residuals in the model, so they contain the net effects of errors made in the rest of the empirical model.

[illegible]

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APPENDIX

Consider a prairie farmer who is assumed to produce only wheat which is delivered either to the CWB under delivery entitlement or disposed of on the offboard market. The farmer's problem is to maximize net returns subject to expected delivery constraint. Algebraically, the problem may be expressed as:

$$\begin{aligned} \text{MAX } P \cdot QD + PO \cdot QO - rX & \quad (1) \\ F(X) - Q = 0 & \quad (2) \\ QD + QO - Q = 0 & \quad (3) \\ QD \leq D & \quad (4) \end{aligned}$$

with variables Q , X , QO , and QD , and where:

- P = expected CWB price of wheat,
- QD = expected wheat deliveries to CWB,
- PO = expected offboard price of wheat,
- QO = wheat sales to offboard market,
- r = vector of variable costs (per unit),
- X = vector of variable factors,
- $F(X)$ = production function,
- Q = total wheat produced,
- D = expected delivery entitlement.

This problem leads to the Lagrangian

$$L = P \cdot QD + PO \cdot QO - rX + \theta (Q - QD - QO) + \mu (F(X) - Q) + \lambda (D - QD)$$

Variable μ is the dual variable associated with (2) and may be interpreted as the supply-inducing price. It is the minimum price the producer would need to receive to increase production by one unit. Maximizing L with respect to Q and QO (assuming $Q, QO > 0$), we obtain the first-order conditions $\mu = \theta = PO$. Hence, the expected offboard price (PO) is equal to the supply-inducing price. Additional Kuhn-Tucker conditions for a maximum L include:

$$\begin{aligned} (P - \theta - \lambda)QD &= 0 & (5) \\ (D - QD)\lambda &= 0 & (6) \\ \lambda &\geq 0 & (7) \end{aligned}$$

These conditions may be interpreted as follows. If quotas are not expected to be binding ($D > QD$ and assuming $QD > 0$), then $\lambda = 0$ from (6) and hence $P = \theta$ from (5). In other words, the expected CWB price is equal to the supply-inducing price. If, however, quotas are expected to be restrictive ($D = QD$) then $\lambda > 0$ from (6) and $\theta = P - \lambda$. The supply-inducing price will be less than the expected CWB price by an amount λ (the shadow price of delivery entitlement).

Previous Canadian wheat supply studies have used P (the CWB price) and a variable to represent λ as separate explanatory variables. For example, λ has been represented by marketings of wheat divided by farm wheat supply (30), farm stocks on August 1 (43), and total wheat supply in February divided by a 5-year moving average of wheat production (17).

An alternative to using P and a variable to represent λ is P_0 (the expected offboard price).

The producer's objective function could be complicated by adding other grain and livestock enterprises as well as onfarm stocks, but the basic result does not change. It should be noted, however, that for the other (restrictive) quota grains, barley and oats, the expected offboard prices are also appropriate.

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