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AN ECONOMETRIC ANALYSIS OF CANADA'S WHEAT AND FEED GRAIN ECONOMY WITH EMPHASIS ON COMMERCIAL AGRICULTURAL POLICY

by

Robert W. Jolly and Martin E. Abel

Department of Agricultural and Applied Economics

University of Minnesota
Institute of Agriculture, Forestry and Home Economics
St. Paul, Minnesota 55108

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PREFACE

This study analyzes the functioning of Canada's wheat and feed grain economy. Major emphasis is placed on quantitatively integrating Canadian agricultural policies into an economic model of the grain sector. The objectives of the study are (1) to develop an historically consistent economic framework that can facilitate an understanding of how Canada's grain economy operates and the impact of relevant commercial policies on grain production, consumption, exports and imports, and (2) to examine the feasibility of estimating an econometric model from time-series data that could be used to make short-run predictions of exportable surpluses of Canadian feed grains and wheat, and imports of corn.

The study is organized into five chapters. Chapter 1 presents background information on Canadian agriculture and commercial policy. This is included to make the study relatively self-contained and comprehensible to readers not familiar with Canadian agriculture. Chapter 2 is devoted to a theoretical analysis of Canadian agriculture and associated agricultural policies. The theoretical model developed in Chapter 2 is extended in Chapter 3 and utilized to specify the econometric model. Chapter 4 presents and analyzes the statistical results. Finally, Chapter 5 examines the potential utility of the theoretical model and its statistical counterpart for policy makers in the United States and Canada. Areas for future research are also outlined.

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Chapter 1

CHARACTERISTICS OF CANADIAN AGRICULTURE AND COMMERCIAL POLICY

Introduction

Canadian agriculture has several unique characteristics that in one way or another influence the structure and behavior of the grain sector. We will briefly mention the most important aspects, particularly those that should or can be incorporated into an econometric model.

One of the most striking characteristics of Canadian agriculture is regionalism. Agriculture in Western Canada (Manitoba, Saskatchewan, Alberta and British Columbia) is quite distinct from agriculture in the East (Maritimes, Quebec and Ontario). The distinction between East and West lies not only in their different resource bases, but also in their markedly different agricultural institutions.

The major characteristics of the agriculture in Western Canada are as follows:

- Approximately 80 per cent of Canada's improved agricultural land is located in the West.
- Major land use categories are wheat production (hard red spring, durum and utility), summer fallow, barley, oats, rapeseed, flaxseed, and forages.
- The growing season is short and rainfall is often in short supply.
- Large beef cattle and hog populations are maintained.
- The West is the major supplier of export grains--farm income is heavily dependent on export sales.

Agriculture in Eastern Canada possesses the following characteristics:

- The Eastern provinces are geographically quite diverse.
- About 12 per cent of the improved farm land is located in Ontario.
- Major field crops are corn, oats, soybeans, winter wheat, and forages.
- The dairy sector is large, particularly in Ontario and Quebec.
- Hog and beef cattle populations are roughly equal to those maintained in the West.
- The East is an important consumer of Western feed grains.

The description of Canadian agriculture which we have presented is extremely terse. For more information the reader should consult Jolly (1976) or Missiaen and Coffing (1972) and their references.

Canadian Agricultural Policy

In this section we describe several major institutions and policies which have had a strong impact on the Canadian grain-livestock economy since 1948. Most of the material presented is descriptive and focuses on how the policies work from the farmers' points of view. Questions concerning policy objectives and welfare considerations are not addressed. Canadian agricultural policies have tended to be commodity-oriented, and in many cases region-specific.[1/]

Grain Policy in the West

Canadian grain policy, particularly in Western Canada, has always been inextricably linked to grain marketing. Marketing agents and policy

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[1/] For a brief comparison of United States and Canadian agricultural policies see Brandow (1971) and Gilson (1971).

makers merge and often share common instruments. The dominant institution playing this dual role in the West is the Canadian Wheat Board (CWB). In this section we describe the CWB's grain marketing activities and the policies which it administers.

The Canadian Wheat Board

The Canadian Wheat Board is a government-controlled monopoly charged with the responsibility of marketing on behalf of farmers all wheat, oats, and barley grown in the Prairie Provinces and the Peace River area of British Columbia. Prior to August 1, 1974, the Board had monopoly control over all purchases and sales of wheat, oats, and barley moving between provinces and into the export market. Since then a new national feed grain policy has been established which restricts the CWB's domain to marketing wheat for export and domestic consumption and to marketing feed grains destined for export markets. Feed grains (utility wheat, barley, oats) for domestic consumption can now be purchased and sold by the private trade anywhere in Canada.

The CWB owns no marketing or transportation facilities. It contracts for these services with the national railroads and cooperative and private line elevator companies. The Board's function, therefore, is essentially administrative. It controls the pricing, delivery, transportation, and ultimate sale of designated Prairie grains through the private grain trade acting as agents for the CWB. The degree of control which the CWB has over these marketing activities and the manner in which they are controlled have changed periodically since 1948. Details of these changes will be presented later in this section.

The CWB acts as the state grain trading agency for Canada. Prior to 1970, negotiated sales with foreign governments made up a relatively small proportion of Canada's total grain exports. Commercial international grain trading firms performed most of the pricing and transshipping of Canadian grain overseas. These firms would buy grain from the CWB and sell it for their own account in the export market. In recent years, however, the bulk of Canadian grain sales has been negotiated directly by the CWB with the representatives of foreign governments. The CWB is in a unique position to perform state trading, since it has full information on domestic stocks and can control the movement of Prairie grains to the export terminal elevators.

Another related authority given to the Board is control over wheat, oats, and barley imports. The CWB has authority to grant import licenses for these commodities. No licenses have been granted in recent years.

The CWB plays a dominant role in grain marketing in Western Canada. However, an alternative market for Prairie grains exists. Since 1948, when the CWB assumed monopoly control over interprovincial feed grain sales in the West, Prairie farmers could sell wheat, oats, or barley to the CWB, to another farmer within the same province, or, since 1960, to a local feed mill. The selling of grain between farmers, feed mills, country elevators, and feedlot operators is usually referred to as the "off-board" or "non-quota" market. Prices in the off-board market are determined freely; sales are not subject to intervention. However, access to rail transportation facilities and, to a lesser extent, elevator services, is under CWB control. The recent feed grain policy changes extend the off-board market to include inter-provincial trade in both the West and the East.

We now describe the major policy instruments which the CWB controls or administers.

The Price Pooling System. The price pooling system of the CWB is intended to provide some degree of price stability for wheat, oats, and barley. When a farmer in the Prairie provinces delivers grain to the CWB, the country elevator, acting as an agent for the Board, makes a record of the sale and pays the farmer an initial payment less transportation and handling charges to Thunder Bay or Vancouver and quality discounts. The initial payment is essentially a guaranteed floor price for the crop. The size of the initial payment for wheat, oats, and barley is set each year by the federal government in consultation with the CWB. The initial payment is typically set well below current market prices. In 1975/76 the initial payment for #1 Canada Western Red Spring was $Can. 3.75 a bushel, basis Thunder Bay. The CWB's selling quotation for the same grade was $4.68[2/] A similar differential is maintained for oats and barley.

After marketing operations for the crop have been completed, the CWB will subtract its operating expenses and the cost of the initial payment and return the net revenue to farmers on the basis of their deliveries to the board. This is referred to as the final payment. Any losses in market operations will be paid out of the federal treasury. The farmer is always guaranteed the initial payment.

Generally, final payments are announced six months after the close of the marketing year. In other words, final payments for the 1975/76 crop year, ending July 31, 1976, would be announced to producers on January 31, 1977. In the past, delays in the announcement of final payments have occurred for

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[2/] The crop year in Canada begins August 1. We use the slash to designate crop years, i.e. 1975/76.

as long as six months.

The major effects of the price pooling system are as follows:

1. Within a given crop year, price variation is averaged out. In other words, a producer receives the same price for his grain no matter when it was delivered during the crop year.
2. The farmer has limited information about prices during the crop year. Since the final payment is not known until well after the completion of the crop year, certain production and consumption decisions must be made with only partial information about past and current prices.
3. The pooling system annihilates the market mechanism for distributing the crop over the year. There is no advantage for farmers to defer delivery of their crop to country elevators. Consequently, an alternative mechanism is required for the temporal distribution of the crop.

The Grain Delivery Quota System. The grain delivery quota system (hereafter GDQS) of the CWB serves as an instrument of supply management for six Prairie commodities--wheat, oats, barley, rye, flaxseed, and rapeseed--and is used to regulate the rate at which these commodities are marketed. It is a necessary companion piece for the price pooling system. The mechanics and characteristics of the GDQS are best described from an historial perspective[3/].

The first attempt at utilizing a marketing quota came in 1939 when

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3/ This section draws heavily upon Pearson (1971), Agriculture Canada (1969), and Boden, et al. (1970).

the CWB imposed a sales limitation of 5000 bushels of wheat per farmer. This quota was established in an effort to restrict the government's financial obligation resulting from high initial wheat payments. The 5000-bushel quota was retained for only one year.

During the period from 1940/41 through 1953/54, delivery quotas for Prairie grains, for the most part, were based on seeded acreage. That is, producers were allowed to deliver a quantity of grain proportional to the area seeded to the given crop.

If the objective of the quota system is to facilitate marketing, and not to supply control, then a seeded acreage quota is wholly adequate. The CWB could call forth grain from on-farm storage in the desired quantities and at the desired time. Furthermore, since the quota was based on seeded acreage, a simple procedure was provided for distributing the total quota among producers. Larger producers received larger quotas.

Quota levels were declared open every year from 1943/44 through 1951/52. In other words, producers could market at will before the end of the crop year. The seeded acreage quota functioned for the most part as a vehicle of orderly marketing. However, the strong grain markets of the post-war years weakened dramatically during the 1951/52 and 1952/53 crop years. The CWB was unable to accept all Prairie grain deliveries. Large grain inventories began to accumulate on Prairie farms. It was at this point that the weakness of a seeded acreage quota system became apparent. If a producer had acquired excess stocks of a particular grain, in order to obtain a marketing quota for that crop, he was required to replant the crop already in oversupply. Only a crop failure would facilitate the marketing of excess stocks under a seeded acreage quota. Consequently, it was recognized that in order to allow a producer to manage both production and inventories, the quota system must provide him with a means for adjusting both the level and mix of farm production without reducing the size of his marketing quota. This requirement led to the development of the general delivery quota based on a producer's "specified" acreage. This system was introduced in 1953/54 and remained in effect through the 1969/70 crop year. In addition to the general quota, several other types of delivery quotas were developed during this period. Each will be discussed briefly.

The crops controlled by general quotas were wheat, oats, barley, and rye. Total aggregate marketings of these crops were proportional to a producer's specified acreage. Specified acreage was defined as the total area seeded to wheat, oats, barley, or rye; land in summer fallow; and eligible grasses and forage crops. With the exception of oilseeds and miscellaneous crops the definition included all land use categories for Prairie grains. Consequently, a producer's delivery base was relatively constant under any set of land use decisions. This feature facilitated the sale of grain from inventories.

The mechanics of the general delivery quota were relatively simple. At the beginning of the crop year, the CWB would announce the first round of deliveries under the general quota; a producer could deliver one bushel per specified acre of any of the four general quota grains. As elevator space and transportation became available, the quotas would be advanced--successive delivery rounds were authorized. Each time the quota was advanced, the farmer was required to make a decision concerning the allocation of the incremental general quota among the four grains. The cumulative general quota at the end of the crop year specified the maximum deliverable quantity of wheat, oats, barley, and rye per specified acre.

The unit quota was established to provide each producer, regardless of the size of his operation, with an opportunity to deliver a specified quantity of wheat, oats, barley, or rye at the beginning of the crop year. Furthermore, this quota was designed in such a way that returns per acre would be equalized no matter which grain was delivered. Accordingly, each producer received a quota of 100 units. Relative weights were then announced for each grain designating its worth in units per bushel. The weights were assigned in such a way that the unit value of each grain was approximately equal to that for any other grain. The producer then marketed any combination of the four grains consistent with the constraint.

Supplementary quotas were utilized to call forward specific grains not being delivered in sufficient quantities under the general quota. These quotas were usually based on the seeded acreage of a given crop. However, specific quantities were often utilized as lower bounds. For example, in crop year 1965/66, a supplementary oats quota (per producer) was authorized for four bushels per seeded acre or 300 bushels, whichever was larger. This oats-specific quota was issued in addition to the unit and general quotas.

Producer marketings of flaxseed and rapeseed were controlled by the CWB through seeded acreage quotas. These quotas were usually declared open before the end of the crop year and therefore served solely as a means to control producer deliveries of the oilseeds. The inventory management problems associated with the seeded acreage quotas for wheat and feed grains were not significant with oilseeds.

Throughout the 16-year period that the above system was in effect, Canada was plagued by overproduction. By the end of the 1968/69 crop year, wheat stocks approximately equalled two years of average production. Shrinking export markets, technological change in the baking industry and an antiquated grading system for wheat were largely to blame. In addition, there existed a general dissatisfaction with the performance of the GDQS as an instrument of supply control. In 1970/71, the LIFT (Lower Inventories for Tomorrow) program was enacted. LIFT was a one-year program designed to sharply reduce wheat acreage and inventories. Under LIFT, a producer's wheat quota was based on the area of land in summer fallow and the quantity of new land seeded to permanent forages. In addition, a system of diversion payments for temporarily taking land out of wheat production was initiated. Diversion payments were increased if the land taken out of production during LIFT was seeded to perennial forages. This forage incentive program remained in effect until 1974. Delivery quotas for other grains were based on seeded acreage plus summer fallow. In 1970/71, wheat acreage fell by half and beginning stocks for 1971/72 were down 40 per cent from the year before.

Following LIFT, the GDQS was amended to provide the CWB with more positive control over the quantity and timing of producers' deliveries of specific grains. Under the new GDQS, a producer's deliveries of each grain are based on his assigned acreage. Assigned acreage is defined as follows:

1. Land seeded to wheat, oats, barley, rye, rapeseed, and flaxseed.
2. Land in summer fallow.
3. Land in miscellaneous crops (e.g., sunflowers).

4. Land seeded to perennial forages up to a maximum of 1/3 of total land included under classifications 1-3.

Given his assigned acreage, a producer may allocate this aggregate marketing quota between the six quota crops as he sees fit. Since the quota limits only marketings, production and inventory management decisions remain with the individual farmer. After a producer's intended allocation of his assignable acreage has been reported to the CWB, quota delivery rates (in bushels per assigned acre) are announced. By multiplying the quota rate by the acreage assigned to the particular crop, the producer arrives at his delivery entitlement. Under the old GDQS, quotas were cumulative and deliveries could be made at any time during the crop year. The present system employs quotas which expire after a specific time. In other words, if the total delivery rate for barley were 15 bushels per assigned acre, the initial delivery rate might be five bushels per specified acre and would be valid for only a given period of time. This innovation is intended to make producers more timely in their deliveries.

Under the new system, unit and supplementary quotas have been abolished. Special quotas are utilized to control deliveries to specialty markets--oilseed crushers for example.

One important change from the pre-1970 GDQS is the provision of timely information on prices and quotas to producers. Under the old system, initial prices and details of the quota were not announced until well after planting. This made it impossible for producers to effectively incorporate this information into their production decisions until the following crop year. A report is now being sent to Prairie farmers well before planting.

In this report, the details of the GDQS are presented as well as the likely range of minimum delivery rates. Initial prices for the coming crop year are specified as well. However, the lag in the announcement of the final payment still persists.

The marketing of oilseeds has remained essentially unchanged with the adoption of the new GDQS. Prices for rapeseed and flaxseed are discovered freely. However, marketings are still subject to GDQS regulation. In recent years, the quota on oilseeds has been declared open prior to the commencement of the crop year.

The New Domestic Feed Grains Policy. In the fall of 1973 the federal government introduced a temporary feed grain policy directed toward reassigning some of the CWB's areas of responsibility. An amended version of this temporary policy was formally introduced at the beginning of the 1974/75 crop year. The new domestic feed grain policy (NDFGP) eliminated the CWB's monopoly control over interprovincial trade in feed grains. Under the new policy, feed grains can be purchased by the private trade in one province and sold in another.

Farmers now have the option of selling their feed grains to the CWB, to the private off-board market, or both. If the producer sells to the CWB he is subject to price pooling and GDQS. If he sells to the private trade he receives the full cash price at delivery and is not subject to any quota restrictions.

The CWB still maintains control over the grain transportation system. In order to facilitate off-board grain marketing, the CWB relies on stock switches in Thunder Bay. In other words, if a private grain merchant sells western barley to a cattle feeder in Ontario, he will purchase the required quantity of barley in the Prairies' off-board market. The merchant will then deliver the barley to the CWB's account at a country elevator in exchange for equivalent CWB stocks in Thunder Bay. The merchant pays handling and transportation costs from the country elevator to Thunder Bay. From Thunder Bay to Ontario, the exchanged barley moves under the control of the private grain trade.

Corn Competitive Pricing. This policy was introduced as an amendment to the NDFGP in July, 1976. It involved tying the CWB's domestic selling price for feed grains to the price of United States corn. This is accomplished through a pricing formula. The base price for the formula is the Chicago cash price for United States #3 yellow corn plus transportation, handling exchange rate and tariff to Montreal. In order to account for protein and energy differences between corn and CWB feed grains, the United States corn price is adjusted by the current United States soybean meal/corn price relative. The meal price in this case is the Decatur price plus freight and handling to Montreal.

The daily CWB selling price for domestic feed grains at country points is determined from this adjusted Montreal price by subtracting out freight and handling charges.

Policy Implementation for the Federal Government. The CWB also acts as an agent for the federal government in carrying out certain programs. The two major federal programs will be discussed here.

The Prairie Grain Advance Payments Act is a federal policy for which the CWB acts as an administrator. Under this Act, producers are permitted to draw an advance on their initial payment for wheat, oats, or barley prior to delivery. Since sales by farmers are controlled through the GDQS, short-term liquidity problems may result. This act attempts to offset some of the adverse effects of the GDQS during periods of restricted deliveries.

The Temporary Wheat Reserve Act authorized the government to pay the CWB, for the benefit of producers, the carrying charges of wheat in commercial storage in excess of 178 million bushels. The purpose of the Act was to relieve producers (by reducing the operating expenses of the CWB) of the storage charges associated with abnormally high levels of wheat stocks.

The Act was in effect from August 1, 1954, until August 1, 1973, when CWB wheat stocks fell below 178 million bushels, thereby terminating the government's responsibility. The Act applied only to CWB-owned stocks in commercial storage and affected production in two important ways. First of all, by offsetting a portion of the carrying charges on CWB wheat stocks, the final payments for wheat received by producers were larger than they otherwise would have been. Secondly, because the Act applied to wheat stocks in excess of 178 million bushels on July 31, there was an economic incentive for the CWB to plug the marketing pipeline at the end of each crop year. This resulted in deliveries being higher than they otherwise would have been. This Act cost Canadian taxpayers $Can. 718 million while it was in effect.

Western Grain Stabilization Administration

For completeness, we mention the Western Grain Stabilization Act

(WGSA). This act became effective in January 1976. It is a federally administered program aimed at stabilizing net farm income from grain production. The producer is assessed a premium up to $500 per calendar year for this fund. The federal government matches producer contributions up to $1000 per farmer per year. Payments from the fund are based on a five-year moving average for aggregate net cash income from grains. Calculations of net cash income reflect gross returns less estimated costs of production. Participation in this insurance scheme is voluntary and limited to CWB permit holders.

Grain Policy in the East

Grain policy and marketing are more separated in Eastern Canada than in the West. Grain marketing is accomplished by private and co-operative grain merchants, feed mills, and shipping firms. The pricing mechanism for Ontario corn and soybeans is similar to the pricing mechanism in the United States. Daily cash prices are based on the Chicago Board of Trade near-by futures prices with adjustments for transportation, handling, exchange rate and tariffs. Prior to the introduction of the NDFGP, pricing of barley, oats, and wheat was performed by the CWB.

The major grain policies in the East are those of the Agricultural Stabilization Board (ASB). The ASB was created under the Agricultural Stabilization Act of 1958. This act provides for the support of farm prices of nine commodities, among them wheat, oats, and barley grown outside CWB jurisdiction. Prices are supported by the ASB at a rate not less than 80 per cent of a 10-year moving average base price. During the life of the Act, market prices for these commodities have remained above support levels.

Inter-regional Grain Policies

In this section we discuss three policies which do not fit conveniently into the regional categories. The first two policies are grain freight subsidy schemes. The third policy is directed toward stabilizing the domestic price of bread wheats.

The Statutory Grain Rates

In 1897, the government and the Canadian Pacific Railroad negotiated a set of maximum allowable freight rates governing the movement of Prairie grain to export terminals. These rates, usually referred to as the Crows Nest Pass rates, were set by statute in 1927. They remain in effect today. McDougall (1966) estimated that Canadian grain shipped to the Great Lakes ports moves at a third to a fourth of the rates charged by United States railroads for equivalent distances to Duluth-Superior. The Crow rates have been subjected to continual debate since their introduction. They are looked upon by various groups as being the key to prosperity among Prairie grain producers, the bane of the western livestock industry, and the cause of a lack of investment incentive for the railroads. The debate continues. The statutory rates remain unchanged.

The Feed Freight Assistance Policy

The Feed Freight Assistance Policy (FFAP) was established during World War II. Its purpose was to equalize the cost of feed grains throughout Canada. Prior to August, 1976, this was accomplished by a system of subsidies that paid nearly the entire cost of feed grain transportation from Thunder Bay to Eastern Canada or British Columbia. The FFAP was modified in August, 1976 by substantially reducing the freight subsidy on feed grains moving into Ontario, Western Quebec, and British Columbia. Freight subsidies for destinations in the Maritimes and Eastern Quebec were unaffected by the change.

Since 1967, the FFAP has been under the administrative control of the Canadian Livestock Feed Board (CLFB). The mechanics of the FFAP are fairly simple. Grain merchants in the East deduct the rate of subsidy authorized by the CLFB from the retail price of feed grains. Livestock producers in the subsidy areas would then purchase feed at the reduced prices. The grain merchants claim a refund from the federal government after submitting proof that the retail price has been reduced.

Two-Price Wheat

In 1969, the government offered to buy all Canadian wheat intended for domestic consumption at a minimum price of $Can. 1.955 per bushel (basis #1 Northern). This was undertaken as a price support policy. In 1972, this minimum producer price was raised to $3.00 per bushel (basis #1 Canada Western Red Spring). The price paid by domestic millers and processors remained at $1.955 per bushel. The difference between the two prices was subsidized by the treasury. Several revisions in this price structure have occurred recently. On July 19, 1973, a minimum producer price was established at $3.25 per bushel for $1 Canada Western Red Spring basis Thunder Bay. The maximum price is $5.00 per bushel. The price paid by Canadian mills is $3.25. In January 1978, the guaranteed producer minimum price was increased to $3.55 per bushel.

Livestock Policy

Unlike grains, commercial policy and marketing of livestock in Canada can be discussed from a national perspective. It will be convenient to separate the consideration of livestock marketing from policy.

Most cattle in Canada are marketed either through public stockyards or directly to packing plants. Most hogs in Western Canada are marketed directly to packing plants with a smaller proportion being sold at stockyards. In the East, most hogs go through stockyards. Provincial marketing boards play an important role in hog marketing.

Prices for hogs and cattle are determined at public stockyards or by collective bargaining. Both feeder cattle and feeder pigs are sold at public country auctions.

The primary agency for commercial livestock policy is the Agricultural Stabilization Board. The basic format that is employed for grain price support is also provided for livestock. Prices for cattle and hogs are maintained at 80 per cent of a 10-year moving average price. This offers protection from temporary price declines but is of limited value during long periods of depressed prices. A new stabilization program for the cow/calf operation was introduced in 1977. Support for calf prices is based at 90 per cent of a five-year moving average.

The ASB support was provided for hogs from 1958-60. Prices were supported both by governmental purchase programs and through deficiency payments. No support was required from 1960-70. However, in 1971, price supports were once again required due to sharp increases in hog production.

Another area of commercial policy for livestock is centered on the development of pasture, range, or forage production. The forage incentive program has already been mentioned. The Prairie Farm Rehabilitation Administration has been involved in the development of commercial range land in Western Canada since the 1930's.

Chapter 2

THE THEORETICAL MODEL

Introduction

In this chapter, we develop the theoretical basis for an econometric model of Canada's grain economy. The chapter is organized as follows:

1. We begin with the specification of a market clearing identity that indicates which structural relationships are required for the econometric model.
2. A classification scheme is then presented that assists in identifying the agricultural policies for inclusion in the structural relationships.
3. We develop the basic theoretical model using policies which were in effect during the period 1971/72-1973/74.
4. The basic model is then amended to account for policy changes which occurred over the historical period.
5. Finally, structural relationships for Eastern Canada and for national food and industrial demand are specified.

Because the development of the theoretical model tends to be rather complex, we will occasionally repeat the objectives for each section.

The first step in specifying the economic model is to write a market-clearing identity for an arbitrary grain. Because of the important distinctions between Eastern and Western Canada, the identity includes the regional disposition of grain.

$$EFSWC_{t-1} + EFSEC_{t-1} + ECS_{t-1} + (AWC_t) \times (YWC_t) + (AEC_t) \times (YEC_t) - FDWC_t - FDEC_t - CD_t - X_t + M_t - EFSWC_t - EFSEC_t - ECS_t \equiv 0,$$

where

EFSWC = ending farm stocks, Western Canada (WC)

EFSEC = ending farm stocks, Eastern Canada (EC)

ECS = national ending commercial stocks

AWC = seeded acreage, WC

YWC = yield, WC

AEC = seeded acreage, EC

YEC = yield, EC

FDWC = farm disappearance (feed, seed requirement, dockage), WC

FDEC = farm disappearance, EC

CD = national commercial disappearance

X = exports

M = imports

The identity accounts for the disposition of grain supplies between East and West Canada, as well as the commerical domestic and international markets. By solving for $(X_t - M_t)$, the identity specifies Canada's excess supply. Exportable surplus can be determined by solving for $(X_t - M_t)$ plus the change in commercial stocks. In order to estimate either excess supply or exportable surplus, structural relationships must be specified for all remaining components in the identity. The structural relationships reflect aggregate economic response to certain sets of variables. Agricultural policies form one of the sets. However, the broad array of changing governmental policies makes the specification of the set difficult. In the next section, a taxonomy is presented which helps identify agricultural policies that should be integrated with the structural relationships.

A Taxonomy for Agricultural Policies

The classification scheme for agricultural policies which we propose is a simple system with only two branches--primary and secondary policies and short-term and long-term policies. A primary policy introduces new variables which a farmer must take directly into consideration in making production decisions. Secondary policies alter variables upon which producers normally make decisions.

The major impact of a short-term policy is on firm output from one production period to the next. A long-term policy has its major impact on firm growth. The distinction between a short- and long-term policy is obviously arbitrary. Any policy which influences annual output (income) will also influence firm growth.

It will be helpful to give some examples of the four types of agricultural policies. The most obvious primary short-term policy in Canada is the grain delivery quota system (GDQS). Information on delivery rates and rules for computing assigned acreage must be incorporated into the farmer's decision making process. The GDQS is a short-term policy because it is directed toward crop year marketings (and hence farm output).

The feed freight assistance policy is an example of a secondary short-term policy. The freight subsidy influences relative prices between regions. However, producers would still respond to prices in the same way, were the policy not in effect. Other examples are trade barriers and the CWB's price pooling system.

Examples of long-term primary policies are difficult to find; however, land tenure laws and estate tax legislation could be assigned to this category. A farm credit program is an example of a long-term secondary policy since its major impact is on interest rates for investment loans. Table 2.1 summarizes the examples.

Table 2.1 A Taxonomy for agricultural policy

	Primary	Secondary
Short-Term	GDQS Income tax laws	Freight assistance Crow rates Price pooling Tariffs
Long-Term	Land tenure laws Estate taxes	Farm credit programs

The reason for developing the taxonomy was to help identify which policies should be included in the structural relationships and to indicate how they should be represented. Long-term policies are directed primarily toward investment in or transfer of agricultural capital. Because our study is intended for short-run analysis, the long-term policies can be ignored--provided current levels of investment are reflected in the structural relationships.

Primary policies introduce new variables and rules into producers' decision making processes. Consequently, they must be explicitly included in the structural relationships. Furthermore, likely producer response to changes in primary policy variables must be investigated at both the farm and market levels. Once the structural relationships have been identified, secondary short-term policies can be incorporated into the model by adjusting the values of included variables. For example, prices can be adjusted to reflect changes in freight rates between East and West.

The major primary short-term policy in Canada is the GDQS. Consequently, the theoretical analysis in the next section focuses on the effect of the GDQS on farm decision making. This does not imply that the GDQS is "the most important" policy. However, the GDQS introduces new variables and rules which influence farmers' output decisions, and must therefore be reflected in the structural relationships. Because the GDQS applies only to producers in the Prairies, the analysis will center on the West.

The Basic Model: 1971/72-1973/74

The initial focus of the economic model will be on a neoclassical farm firm possessing a range of output opportunities similar to the production mix of Western Canada. This basic economic model is not realistic in that it omits from the analysis many important characteristics of Western Canadian agriculture. However, because of its simplicity, the model is capable of isolating key variables and relationships between variables which are important for correctly specifying the farm level structural relationships in the West.

The model developed here allows one to examine the impact of a general grain delivery quota on crop and livestock production. The farm under consideration is assumed to be capable of engaging in a set of crop and livestock enterprises. The output of the crop enterprises can either be marketed for cash or fed to livestock. Certain crop enterprises may be subject to a delivery quota. Fallowing and stockholding are ignored in this section.

Notation and Definitions

C_i = Gross output, in bushels, of i^{th} crop enterprise; $i = 1...n$

c_{ij} = Consumption of i^{th} crop in j^{th} livestock enterprise; $j = 1...m$

$c_i \equiv C_i - \sum_j^m c_{ij}$; net output of i^{th} crop enterprise

v_{ki} = Quantity of k^{th} variable factor used in production of i^{th} crop; $k = 1...p$

z_{hi} = Quantity of h^{th} fixed factor used in production of i^{th} crop; $h = 1...s$

z_h = Total quantity of h^{th} fixed factor

A_i = Land in acres used to produce i^{th} crop

$\bar{A}$ = Total cultivatable land

L_j = Gross output in cwt of j^{th} livestock enterprise; $j = 1...m$

l_j = Net output of j^{th} livestock enterprise

$l_j \equiv L_j$

v_{kj} = Quantity of k^{th} variable factor used in j^{th} livestock enterprise

z_{hj} = Quantity of h^{th} fixed factor used in j^{th} livestock enterprise

p_i = Price of i^{th} crop

p_j = Price of j^{th} livestock type

r_k = Price of kth variable factor

d_i = Delivery parameter in bushels per quota acre

$a_i \quad = \quad 1/d_i$

$\tilde{A} \quad = \quad$ Quota acreage

$W \quad \equiv \quad$ Set of crop enterprises with positive net output, subject to a delivery quota

$\quad \equiv \quad \{i | c_i > 0, a_i > 0\}$

In the following section, Greek letters denote Lagrange multipliers.

Structure of the Model

Production of the C_i and L_j is assumed to be governed by functions of the following form:

$$f^i(v_{ki}, z_{hi}, A_i) - C_i \geq 0 \qquad \text{II.1}$$

$$f^j(c_{ij}, v_{kj}, z_{hj}) - L_j \geq 0 \qquad \text{II.2}$$

The following assumptions are made regarding the characteristics of the production functions:

A1: The f^i, f^j are continuous, twice differentiable, homogeneous of degree ≥ 1 and exhibit decreasing rates of technical substitution.

A2: Marginal products of all factors are strictly positive.

A3: At least one variable factor and one fixed factor is required in the production of each good.

A4: It is assumed that the number of fixed factors exceeds the number of potential crop and livestock enterprises; $s > m + n$.

A Cobb-Douglas production function, for example, meets requirements A1-A3. Certain CES production functions are admissible as well. Quadratic production functions are not admissible.

Assumptions A1-A4 imply the net production possibility set in the absence of a delivery quota constraint is strictly convex (Khang and Uekawa (1973)). This is equivalent to the requirement that the second order conditions for an unconstrained maximum be satisfied. Therefore, the second order conditions are met when the quota is added to the maximization problem as well.

The fourth assumption is obviously open to contention. Are there in fact more fixed factors than enterprises on a mixed farm? We certainly do not know. Assuming the net production possibility set to be strictly convex facilitates the analysis. We feel this justifies A1-A4.

Prices of both outputs and factors are assumed to be known and given to the firm. For crops sold to the CWB, the p_i represent received final realized prices, known with certainty and discounted to the time of delivery.

It is assumed that a constraint is applied to the farm's grain marketings. For the 1971/72-1973/74 period $\tilde{A} = \bar{A}$. The quota constraint can be expressed as

$$\bar{A} \geq \sum_{w \in W} a_w c_w \qquad \text{II.3}$$

The quota applies to a subset of crops specified by the government and only to those crop enterprises whose net output is positive.

Because the quota constraint plays a central role in the theoretical model, it is essential that it be completely understood. Expression II.3 can be developed directly from the description of the quota given in Chapter 1.

First, using the definitions for assigned acreage, the producer computes $\tilde{A}$ which for the period in question is essentially equal to total land in production. The quota acres can be assigned to any of the six quota grains which the producer wishes to deliver. This can be expressed as

$$\sum_{i=1}^{6} \tilde{A}_i \leq \tilde{A} = \bar{A}$$

where $\tilde{A}_i$ = quota acres assigned to the i^{th} crop. The producer's delivery entitlement can be written as

$$c_i \leq d_i \tilde{A}_i \ .$$

The delivery entitlement can also be written as

$$a_i c_i \leq \tilde{A}_i$$

using the definition $a_i - 1/d_i$. Finally, summing over all quota crops, we obtain

$$\sum_{i=1}^{6} a_i c_i \leq \sum_{i=1}^{6} \tilde{A}_i \leq \bar{A}$$

since a_i, c_i, $\tilde{A}_i \geq 0$. Mathematical considerations require that the quota constraint be written with the inequality reversed

$$\bar{A} \geq \sum_{i=1}^{6} a_i c_i \ .$$

We now have essentially the same expression as II.3, the only difference being the more general definition of the potential delivery set, W. In the following analysis, assume $c_i > 0$ for all crops produced. This will simplify the algebra somewhat.

It is assumed that the quantity of land operated by the farmer is viewed as fixed over the time horizon of the optimizing decision.

$$\bar{A} \geq \sum_{i}^{n} A_i \ . \qquad \text{II.4}$$

The fixed factors are constrained by

$$z_h \geq \sum_{i}^{n} z_{hi} + \sum_{j}^{m} z_{hj} \quad \forall h=1,\ldots s \ . \qquad \text{II.5}$$

Assume that the firm maximizes the value of net output subject to technological restrictions and the land, quota, and fixed factor constraints. Denote the objective as NVA (net value added).

$$NVA = \sum_{i}^{n} p_i \ (C_i - \sum_{j}^{m} c_{ij}) + \sum_{j}^{m} p_j L_j - \sum_{k}^{p} r_k \ (\sum_{i}^{n} v_{ki} + \sum_{j}^{m} v_{kj}) \qquad \text{II.6}$$

Solving the Optimization Problem

The solution of the optimization problem can be viewed as a concave programming problem. In order to apply the Kuhn-Tucker theorems to this problem, three conditions must be met. The objective function and constraints must be (1) differentiable, (2) concave, and (3) a minor condition on the constraints is required to eliminate the possibility of a singular point on the frontier of the constraints. The objective function, NVA, is linear and is, hence, differentiable and concave. The land, fixed factor, and quota constraints are linear and, hence, differentiable and concave. Finally, the production functions are differentiable and concave by assumption A1. The requirements of the Kuhn-Tucker theorems are met.

The Kuhn-Tucker conditions are obtained by forming the Lagrangean function ϕ

$$\phi = \sum_{i}^{n} p_i \, (C_i - \sum_{j}^{m} c_{ij}) + \sum_{j}^{m} p_j L_j - \sum_{k}^{p} r_k \, (\sum_{j}^{n} v_{ki} + \sum_{j}^{m} v_{kj})$$

$$+ \sum_{i}^{n} \mu_i \, (f^i - C_i) + \sum_{j}^{m} \mu_j \, (f^j - L_j)$$

$$+ \sum_{h}^{s} \gamma_h \, (z_h - \sum_{i}^{n} z_{hi} - \sum_{j}^{m} z_{hj}$$

$$+ \lambda [\bar{A} - \sum_{i}^{n} a_i \, (C_i - \sum_{j}^{m} c_{ij})]$$

$$+ \theta [\bar{A} - \sum_{i}^{n} A_i] \qquad \text{II.7}$$

and differentiating with respect to

$C_i, v_{ki}, z_{hi}, A_i, L_j, c_{ij}, v_{kj}, z_{hj}, \mu_i, \mu_j, \gamma_h, \lambda, \theta.$ [1/]

In order to better understand the objective of the farm in the presence of a delivery quota, consider the following example. The farm will be restricted to two cash crop enterprises, C_1 and C_2, produced according to II.1. In Figure 2.1, the ray OA represents the farm's output expansion path for a given set of relative prices.[2/] The objective of the

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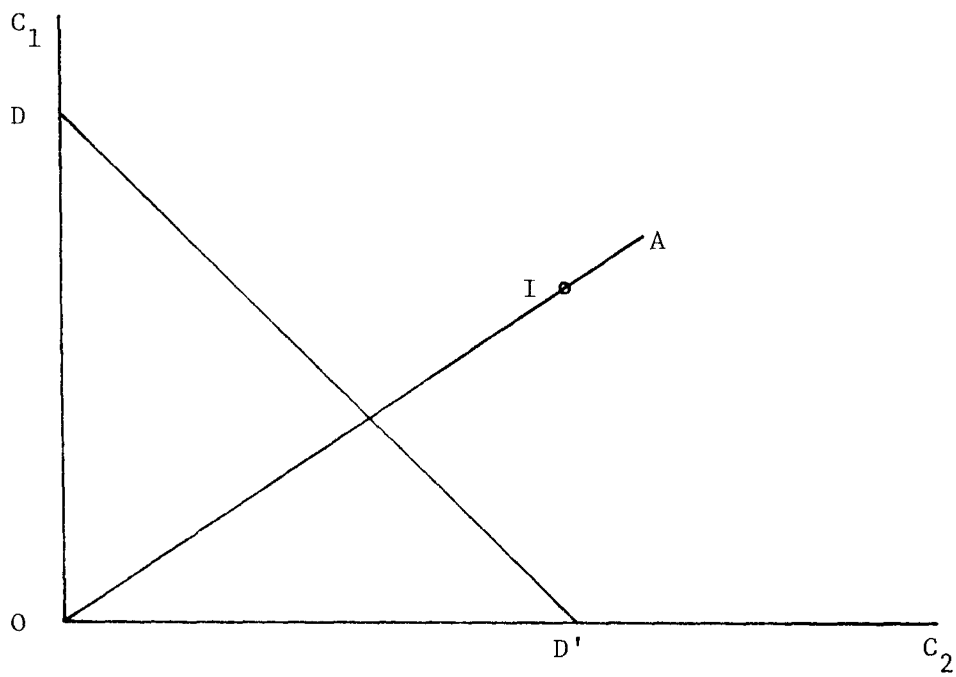
[1/] For a complete list of the Kuhn-Tucker conditions for II.7, see Appendix A.

[2/] Following Henderson and Quandt (1971), the output expansion path for a multi-product firm is defined as the locus of points obtained by holding factor prices and relative product prices constant and varying the absolute level of product prices.

farm is to select the point along OA for a given set of absolute prices that maximizes NVA, (in this case, simple profit). Assume the NVA maximum occurs at point I. Now suppose a general delivery quota is applied to the farm facing the same set of factor and product prices. The quota constraint is represented by DD'. The objective of the farm now is to find the point along DD' that maximizes NVA. The Kuhn-Tucker conditions characterize the optimum occurring along DD'.

Figure 2.1. A farm's expansion path and the quota constraint.



For all crops actually produced by the farm, $C_i > 0$, $i = 1,\ldots n'$, $n' \leq n$, then $p_i - \lambda a_i = \mu_i > 0$. This holds by virtue of the non-negativity requirements of the Kuhn-Tucker theorem. By A3, $\mu_i \, \partial f^i/\partial v_{ki} - r_k$, $i = 1,\ldots n'$, for some $k = 1\ldots p'$, $p' \leq p$. Therefore, one can write

$$(p_i - \lambda a_i) \, \partial f^i/\partial v_{ki} = r_k \qquad \text{II.8}$$

for all crops actually produced and for all variable inputs actually employed.

Similarly for the fixed factors

$$(p_i - \lambda a_i) \, \partial f^i / \partial z_{hi} = \gamma_h \qquad \text{II.9}$$

and land

$$(p_i - \lambda a_i) \, \partial f^i / \partial A_i = \theta \ . \qquad \text{II.10}$$

The Lagrange multipliers represent shadow prices for the fixed factors and are expressed in \$/unit of factor employed. The multiplier specifies the marginal gain in the objective for a marginal easing of the associated constraint.

Because of the assumptions made regarding technology, the fixed factors and land are always fully employed. If $C_i > 0$, this implies

$$\sum_i^{n'} A_i = \bar{A} \text{ and } \sum_i^{n'} z_{hi} + \sum_j^{m} z_{hj} = z_h \ .$$

A similar set of conditions can be developed for all active livestock enterprises and factors actually employed.

$$p_j \, \partial f^i / \partial v_{kj} = r_k \qquad \text{II.11}$$

$$p_j \, \partial f^j / \partial c_{ij} = p_i - \lambda a_i \qquad \text{II.12}$$

$$p_j \, \partial f^j / \partial z_{hj} = \gamma_h \qquad \text{II.13}$$

Now consider the quota constraint. The Kuhn-Tucker conditions for λ are

$$\bar{A} - \sum_{w \varepsilon W} a_w c_w \geq 0; \; (\bar{A} - \sum_{w \varepsilon W} a_w c_w) \, \lambda = 0 \; . \qquad \text{II.14}$$

Lambda (λ) is expressed in \$/quota acre, and represents the price a producer in equilibrium would be willing to pay in order to rent an additional acre of land simply to increase his marketing quota.[3/] Lambda does not represent the productive value of land; in other words, $\lambda \neq \theta$, and presumably $\lambda < \theta$.

Solving II.8 for λ, one obtains $\lambda = d_i \left[p_i - \dfrac{r_k}{\partial f^i / \partial v_{ki}} \right]$

$$= d_i \, (p_i - MC_i)$$

where MC_i = marginal cost of the i^{th} crop in terms of the k^{th} variable factor. Under competition, $p_i = MC_i$ which implies $\lambda = 0$; the quota is not binding. If the quota in fact restricts production, $p_i > MC_i$ by virtue of the neoclassical properties of the production functions (assumption A1). If $p_i > MC_i$, $\lambda > 0$.

Under what conditions will the quota bind? A necessary condition for $\lambda > 0$ is $a_i > 0$ for at least one crop. However, this requirement is not sufficient. Suppose $\lambda = 0$, then from II.14, $\bar{A} > \sum_{w \varepsilon W} a_w c_w$, assuming the strict inequality holds. For any crop enterprise in W, say the first, then

$$1/a_1 = d_1 > \frac{c_1^*}{\bar{A} - \sum_{w \varepsilon W'} a_w c_w^*} \; . \qquad \text{II.15}$$

The asterisks denote the optimal program in the absence of the quota

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3/ In the real world, λ is equal to the cash rent for a so-called "sandy quarter"; land that would have been rented solely to expand the quota acreage.

constraint. The set W' contains all the elements in W except the first. The expression II.15 is not particularly revealing. Indeed, there is nothing contained in the structure of the model that allows the statement of *a priori* sufficient conditions for a restrictive delivery quota. It depends on the optimal program achieved under a given set of prices and the values specified for $\bar{A}$, and the a_i. In a later section, a means for empirically determining whether $\lambda \geq 0$ will be suggested.

It might be helpful to consider a numerical example. Suppose $\bar{A}$ = 1000 acres, that $c_1^* = 6000$ bushels, and that the first enterprise is the only element in W; then $d_1 > 6$ bushels per quota acre implies $\lambda = 0$. As more crop enterprises are added to W, this critical value for d_1 becomes larger, even though the individual values of a_w, $w \varepsilon W'$ may be small. The more crops included in a general quota, the larger the individual delivery parameters required for the quota to be non-binding. In the analysis that follows, it will be assumed that $\lambda > 0$.

Interpreting the Kuhn-Tucker Conditions

The primary use intended for the optimality conditions will be to assist in specifying the econometric model. However, some information can be obtained on the effect of the general delivery quota on crop and livestock production within the framework of the model.

To begin, consider II.8. Define $p_i' \equiv p_i - \lambda a_i$. Since both λ and a_i are positive, $p_i' \leq p_i$. The expression $p_i' \, \partial f^i / \partial v_{ki} = r_k$ is analogous to the familiar requirement that the value of the marginal product equal factor price. In this case, p_i' represents the quota-adjusted market price. The market price differs from the quota-adjusted price only if $a_i > 0$, the crop is under quota and $\lambda > 0$; the quota actually is binding given a particular set of prices.

For any two crop enterprises, denoted 1 and 2, assume a_1, a_2, $\lambda > 0$. Condition II.8 requires, for any variable factor used in both enterprises, that

$$\frac{\partial f^1/\partial v_{k1}}{\partial f^2/\partial v_{k2}} = \frac{\partial C_1}{\partial C_2} = - \left(\frac{p_2 - \lambda a_2}{p_1 - \lambda a_1} \right) = - \left(\frac{p_2'}{p_1'} \right) . \qquad \text{II.16}$$

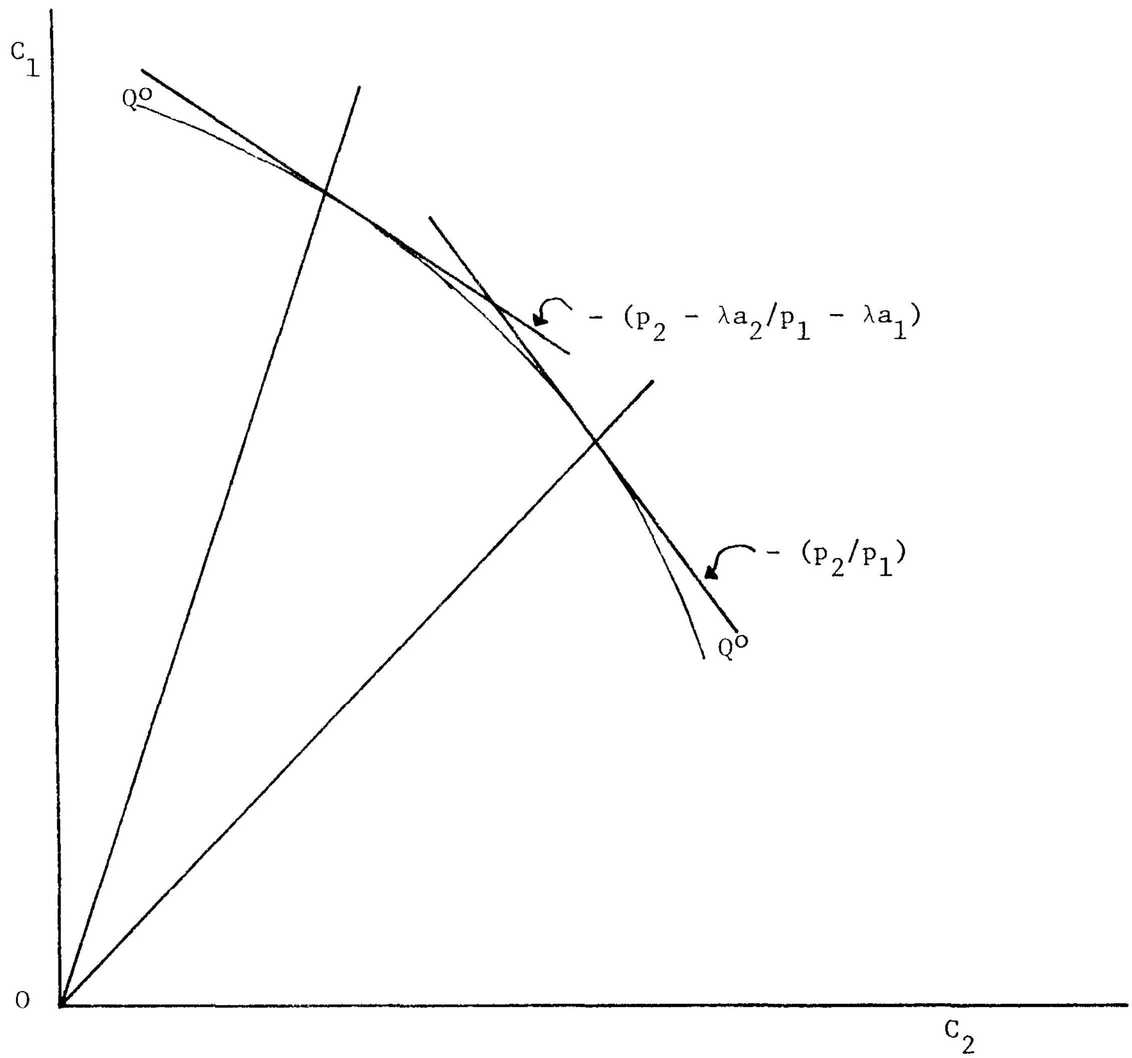
The ratio of marginal products can be interpreted as the rate of product transformation (RPT).

Because of the assumed homogeneity of the production functions, changes in gross output mix can be inferred by examining changes in relative quota-adjusted prices. If the delivery parameters are the same for all quota crops, $a_1 = a_2 = .. = a_n$', then II.16 suggests that the price relative is shifted in favor of the higher priced crop. Figure 2.2 demonstrates this result.

The locus Q^oQ^o shows the unit isoquant for C_1 and C_2. The ray OA shows the gross output expansion path for the relative market prices p_2/p_1. After imposing the delivery quota, with $p_2/p_1 < 1$, $a_1 = a_2$ and $\lambda > 0$, the adjusted relative prices shift in such a way that the output expansion path becomes OA'. The convexity of the production set ensures this result.

If $a_1 \neq a_2$, then, referring again to II.16, the relative quota-adjusted prices may be either greater or less than relative market prices. A quota is defined to be neutral if the relative quota-adjusted prices equal relative market prices. Quota neutrality requires, therefore, that $p_2/p_1 = a_2/a_1 = d_1/d_2$. In other words, if prices of barley and wheat are

Figure 2.2. Shifts in relative output mix.



\$3.00 per bushel and \$5.00 per bushel, respectively, and the delivery parameters are 15 bushels per acre and nine bushels per acre for barley and wheat, respectively, the quota will be neutral. Within the framework of the model, quota neutrality implies no change in relative gross output mix.

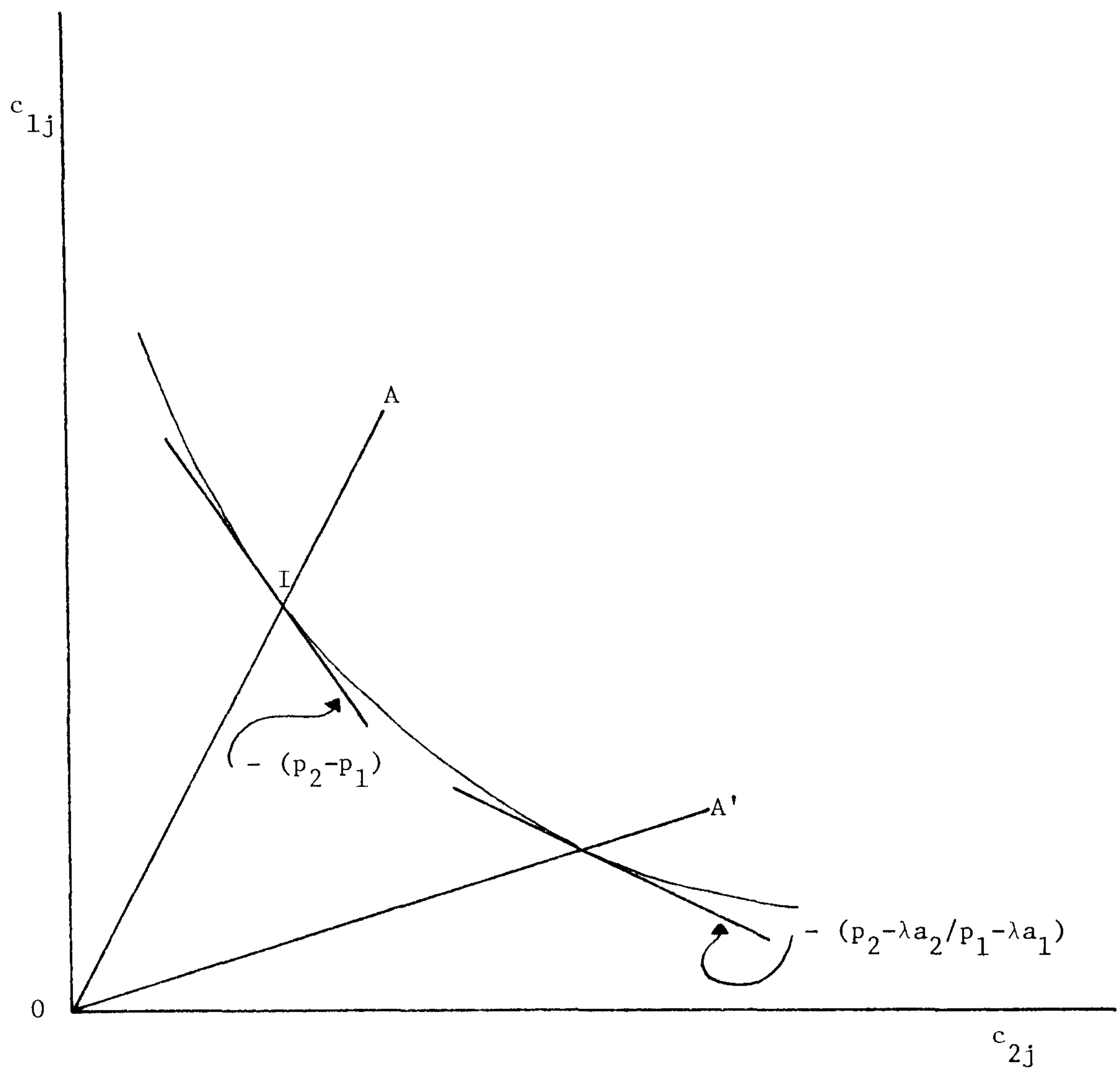
Now consider the effect of a general delivery quota on use of crops one and two as livestock feeds. For a given livestock enterprise, II.12 requires that the value of the marginal product of each quota grain fed be equated with its quota-adjusted price. What effect will a delivery quota have on the relative quantities of two quota crops in the ration?

Referring to Figure 2.3, ray OA shows the input expansion path for the price relative p_2/p_1 for the j^{th} livestock enterprise. If $a_1 = a_2$, then relative quota-adjusted prices shift to favor increased feeding of the lower-priced grain. This is shown by a movement along the unit isoquant from I to I'. The mix of c_{1j}/c_{2j} in the ration changes from OA to OA'. If $a_1 \neq a_2$, any relative mix of the two grains is feasible. Again quota neutrality requires $p_2/p_1 = a_2/a_1$.

The change in relative marketings under quota can be inferred from the preceding results. If $p_2/p_1 < a_2/a_1$, and $p_1 > p_2$, then it was shown that gross output shifted in favor of crop one and feed consumption shifted toward crop two. If relative production of C_1 increases and relative consumption decreases, relative marketings must increase as well.

The imposition of a delivery quota has no effect on variable input mix within an enterprise. Referring again to II.8, for a given quota crop the rate of technical substitution is equated with relative factor prices.

Figure 2.3. Shifts in relative input mix.



Finally, the general quota always shifts the output mix in the favor of livestock relative to quota grains. The impact of the quota is to reduce the effective price of the grain. In other words

$$\partial C_i/\partial L_j = -\left(p_j/p_i - \lambda a_i\right) \quad . \qquad \text{II.17}$$

The price of livestock increases relative to grain under quota. This result does not depend on the relative delivery parameters. If λ, $a_i > 0$, then livestock production is favored relative to grain.

Up to this point, the discussion has focused on relative changes in output and factor mix with and without a binding general quota. Can any statements be made concerning changes in the absolute levels of crop and livestock production or factor use in response to changes in prices and quota variables?

For each active crop and livestock enterprise, for each factor actually employed, and for each binding constraint, the Kuhn-Tucker conditions provide an equality. This system of equations is consistent for decision variables. In other words, for each active decision variable and binding constraint, there is an equation. The system is defined for only a given range of exogenous variables: prices, quota parameters, and constraint constants. The net production set has been assumed to be strictly convex. Therefore, for the range of exogenous variables over which the system is constant, a comparative static analysis can be performed.

The total differential of the system can be expressed as

$$Hdx = db \qquad \text{II.18}$$

where H is a symmetric negative definite bordered Hessian matrix, dx is a vector of endogenous differentials, and db is a vector of exogenous differentials. The existence of intermediate product flows between crop and livestock enterprises in this model introduces a number of ambiguities. All crop and livestock enterprises can compete for the same set of fixed factors. This feature of the model creates interaction effects between and within crop and livestock enterprises. Despite the fact that H is assumed to be negative definite, the slope of the supply function for the i^{th} crop and the slopes of the feed demand functions for the grain cannot be determined with certainty. However, one can make a good argument that the traditional relationships hold even though intermediate products are present.[4/] In the following discussion, assume that

$$\partial C_i / \partial p_i > 0$$

$$\partial c_{ij} / \partial p_i < 0 \ . \qquad \text{II.19}$$

The change in a decision variable due to a change in the quota constraint constant, $\bar{A}$, may be of either sign. For feed supply and demand, the expected relationships would be

$$\frac{\partial C_i}{\partial \bar{A}} > 0$$

$$\frac{\partial c_{ij}}{\partial \bar{A}} < 0 \ . \qquad \text{II.20}$$

[4/] This topic is discussed in more detail in Jolly (1976).

An increase in the quota constraint would increase production, decrease feed consumption, and consequently increase marketings. Nothing in the structure of the model guarantees this result, however. The effect may be of either sign.

Now consider a change in a quota parameter. Since the a_i appear in association both with prices and the quota constraint, there will be two distinct effects. In the case of gross supply for any crop, say the first, the following relationship holds:

$$\partial C_1/\partial a_i = -\lambda(\partial C_1/\partial p_i) - (C_i - \sum_j c_{ij})\ \partial C_1/\partial \bar{A}\ . \qquad \text{II.21}$$

Similarly for feed demand

$$\partial c_{1j}/\partial a_i = -\lambda(\partial c_{1j}/\partial p_i) - (C_i - \sum_j c_{ij})\ \partial c_{1j}/\partial \bar{A}\ . \qquad \text{II.22}$$

Denote the first term in II.21, $-\lambda(\partial C_1/\partial p_i)$, the price effect and the second term, $(C_i - \sum_j c_{ij})\ \partial C_1/\partial \bar{A}$, the quota effect. Suppose $i = 1$ in II.21. The price effect will be negative, since $\lambda > 0$, $\partial C_1/\partial p_1 > 0$. If crop one is "normal" in the sense that $\partial C_1/\partial \bar{A} > 0$, then $\partial C_1/\partial a_1 < 0$. It is conceivable that if the crop were inferior, $\partial C_1/\partial \bar{A} < 0$, then the quota effect could dominate the price effect and $\partial C_1/\partial a_1 > 0$.

Suppose $i = 2$, and that $\partial C_1/\partial p_2 < 0$. The price effect will be positive. If crop one is normal, the quota effect will be negative. Therefore, in this case, $\partial C_1/\partial a_2 \gtrless 0$. If marketings of the second crop are large it is possible that the quota effect would dominate the price effect, consequently, $\partial C_1/\partial a_2 < 0$.

A similar set of relationships exists in the case of feed demand, II.22. Generally, $\partial c_{1j}/\partial a_1 > 0$ if the crop is normal. The signs of the cross effects are ambiguous and depend on the magnitude of cross price effects, magnitude and sign of $\partial C_{1j}/\partial \lambda$, and quantity of the second crop marketed. Table 2.2 summarizes the above relationships.

It also is possible that $\partial C_1/\partial p_2$, $\partial c_{1j}/\partial p_2 \gtrless 0$ under a binding delivery quota even though the two crops are traditional substitutes. Figure 2.4 demonstrates this idea.

Line D_1D_1 in panel A shows a farmer's demand for crop one as feed. Line S_1S_1 is the farmer's supply curve for crop one. Both D_1D_1 and S_1S_1 are relationships that would be identified in the absence of a delivery quota. Optimality condition II.12 requires that the quota-adjusted price $(p_i - \lambda a_i)$ of a given grain be equated with the value of its marginal product in livestock production. Similarly for crop supply, the quota-adjusted price of all active crops must be equated with the opportunity cost (μ_i) of that enterprise. This implies that supply and feed demand are equated with the quota-adjusted price.

An alternative motivation for this concept runs along the following line. Suppose that, for a given set of prices and quotas, the optimal program were known, <u>ex ante</u>. Then the value of the quota's shadow price (λ) could be calculated directly. Suppose that all crop prices were adjusted so that $p_i^* = p_i - \lambda a_i$. If the farmer were offered the set of adjusted prices $\{p_i^*\}$ and allowed to make an optimization without the quota constraint, then the resultant levels of output and factor use would be identical to those attained if market prices $\{p_i\}$ were offered in conjunction with a delivery quota.

The relationships presented in Figure 2.4 can be determined from the optimality conditions and expressed as

$$D_i = f^i(p_1^*, p_2^*, p_3^*)$$

$$S_i = g^i(p_1^*, p_2^*, p_3^*) \qquad i = 1, 2, 3$$

$$p_i^* = p_i - \lambda a_i$$

Table 2.2. Hypothesized price and quota effects for grain supply and demand.

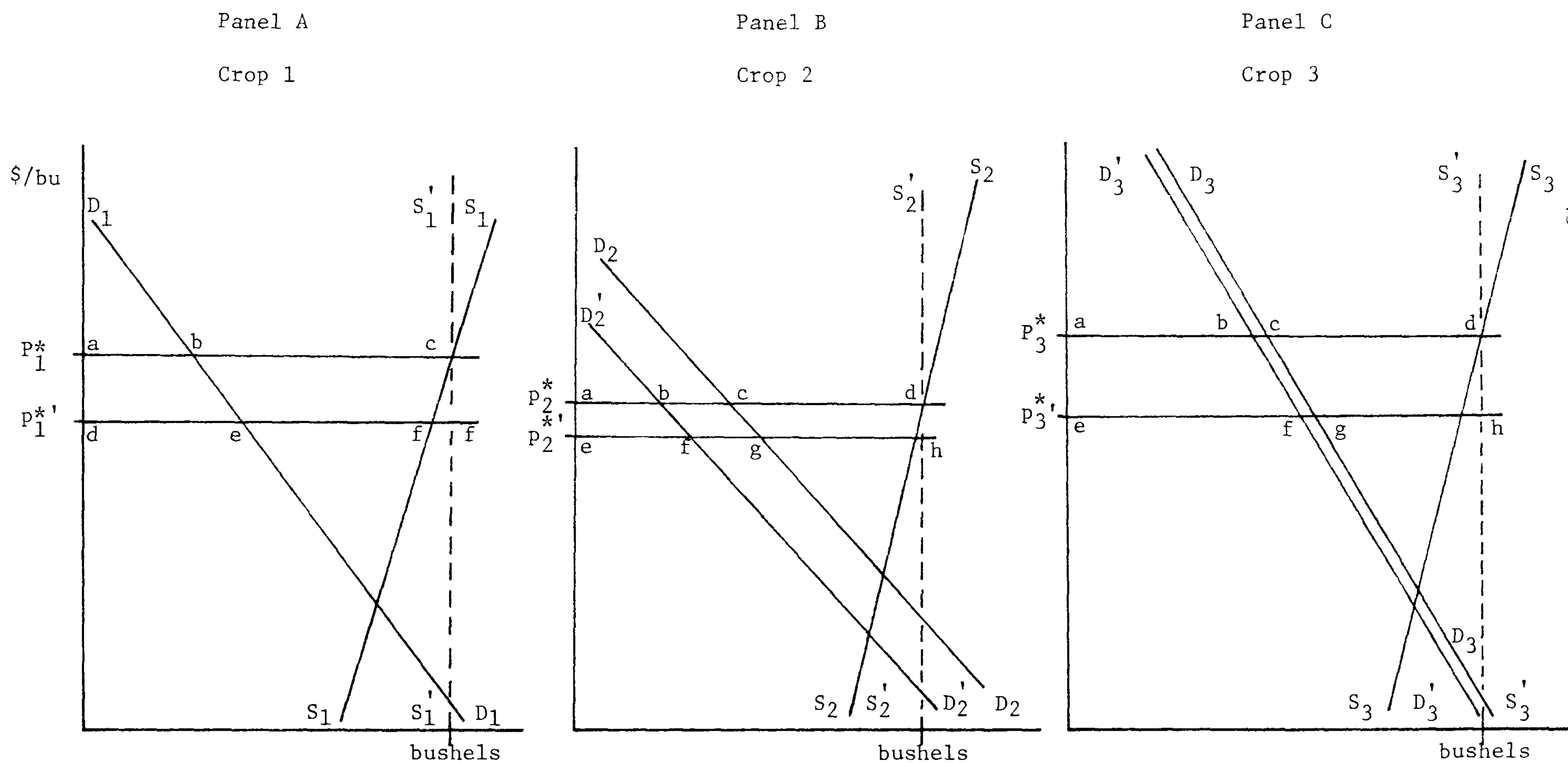
Crop Supply

	$\partial C_1/\partial \bar{A} > 0$	$\partial C_1/\partial \bar{A} < 0$
$\partial C_1/\partial a_1$	-	-/+
$\partial C_1/\partial a_2$	+/-	+

Feed Demand

	$\partial c_{1j}/\partial \bar{A} < 0$	$\partial c_{1j}/\partial \bar{A} > 0$
$\partial c_{1j}/\partial a_1$	+	+/-
$\partial c_{1j}/\partial a_2$	-/+	-

Figure 2.4. Price and quota effects.



where

D_i = feed demand, crop i

S_i = supply, crop i .

To begin, consider why, despite the fact that crops one and two are substitutes in feeding, a decrease in the market price of crop one may either increase or decrease feed consumption of crop two. In order to simplify Figure 2.4 it will be assumed that the supply of all crops ($S_1'S_1'$, $S_2'S_2'$, $S_3'S_3'$) for the crop year is fixed.

Restricting attention to panels A and B with demand D_1D_1 and D_2D_2, suppose the quota-adjusted prices are p_1^* and p_2^*. With this allocation of the general quota, production of crop one (panel A) is given by the line segment ac, consumption is ab, and marketings under quota are bc. Similarly, for crop two (panel B), production is ad, consumption is ac, and marketings are cd. Now suppose the market price of crop one, p_1, decreases. Holding λa_1 constant, p_1^* must decrease, say to $p_1^{*'}$. This initial decline will shift the demand for crop two to the left, since it is assumed to be a traditional substitute for crop one. Now marketings of crop one have decreased to ef, marketings of crop two have increased to bd. Is bc (panel A) + cd (panel B) $\gtrless$ ef (panel A) + bd (panel B)? Suppose that the increase in crop two marketings exceeds the decrease in crop one marketings. In this case, the general quota is being exceeded and total marketings must fall--the quota is effectively more restrictive as a result of the change in p_1. Consequently, the value of λ will begin to rise. In panel B this is represented by a fall in the quota-adjusted price to $p_2^{*'}$. Marketings of crop two decrease to fh in panel B.

There are some second order effects which occur as well; the change in p_2^* will shift demand for crop one to the left. Furthermore, increases in λ cause p_1^* to fall. It has been assumed that $\partial c_{ij}/\partial p_j < 0$ at equilibrium. There is nothing that can be said about the changes in the allocation of the general quota between the two crops. In the above example, feed consumption of crop two fell from ac to ef. Had λ increased sufficiently, however, consumption could have actually increased. Similarly, if total marketings of the two crops had actually fallen, then λ would have been bid downward, p_2^* would have increased, and feed consumption of crop two would have decreased. In other words, $\partial\lambda/\partial p_1 \lesseqgtr 0$ implies $\partial c_{2j}/\partial p_1 \gtreqless 0$.

Figure 2.4 can also be employed to demonstrate the price and quota effects expressed in II.21 and II.22. Suppose that the quota for crop one is decreased, a_1 will increase as a result. Holding λ constant, p_1^* will decline to $p_1^{*\prime}$. This price decrease will induce a leftward shift in demand for crops two and three, $D_2'D_2'$ in panel B and $D_3'D_3'$ in panel C. At this stage, marketings of crop one have decreased; marketings of crops two and three have increased. Like the situation confronted with a price change, $\partial\lambda/\partial a_i \lesseqgtr 0$. However, it would seem that a decrease in a delivery rate (d_i), which implies an increase in a_i, would increase the shadow price (λ) of the quota. If this is the case, quota-adjusted prices of crops two and three must fall to $p_2^{*\prime}$ and $p_3^{*\prime}$. The price effect is shown in panels B and C as a movement from c to b. The quota effect is given by the movement from b to f. For crop two, the price effect dominates the quota effect, and feed consumption falls. On the other hand, for crop three, the quota effect dominates the price effect resulting in an increase in feed consumption.

The results discussed above are quite general. With few exceptions, any demand or supply shift variable will have an ambiguous effect on the dependent variable under a binding quota. Figure 2.4 can be utilized to examine the specific cases.

Accounting for Change in Quota Policy

The analysis up to this point has centered on the farm-level impact of quota policies in effect during the 1971/72-1973/74 period. We now consider how to incorporate changes in quota policy that occurred over the historical period into the micro model.

Quota Policy: 1948/49-1952/53

During this period, seeded acreage quotas were employed to regulate deliveries of wheat, oats, barley and rye. The seeded acreage quotas can be expressed as

$$C_i \leq s_i A_i \qquad \forall_i = 1,\ldots,4$$

where

s_i = delivery rate in bushels per seeded acre.

The four quota constraints would replace II.4 in the basic model. We will not proceed with this analysis. The seeded acreage quotas were always declared open before the end of the crop year. Within the framework of the model, the quota constraints can be omitted *a priori*.

Quota Policy: 1953/54-1969/70

During this period, several different quotas were in effect. The most important type--the general quota--resembled the quota examined in the basic model. The major difference is that for the general quota, the a_i were equal for a particular crop year. The unit and supplementary quotas were also used to regulate producer deliveries during this period. These were described in Chapter 1.

Although producers during this period could market grain under a variety of quotas, the quotas, in total, constitute only a single restriction on sales to the CWB. Figure 2.5 illustrates this idea.

Suppose a producer with two active crop enterprises is subjected to both a unit quota and a general quota. The line AF in Figure 2.5 represents the unit quota; the line BH represents the general quota. The producer is now faced with a two-stage maximization problem. First he must determine the allocation of sales between the two quotas that will maximize his delivery opportunities. Given this frontier, which will be referred to as the delivery opportunity line (DOL), the producer will maximize NVA subject to the constraint.

The DOL can be determined by "adding" the unit and general quotas together in an efficient manner. The following heuristic discussion will give some insight into how the summation can be performed.

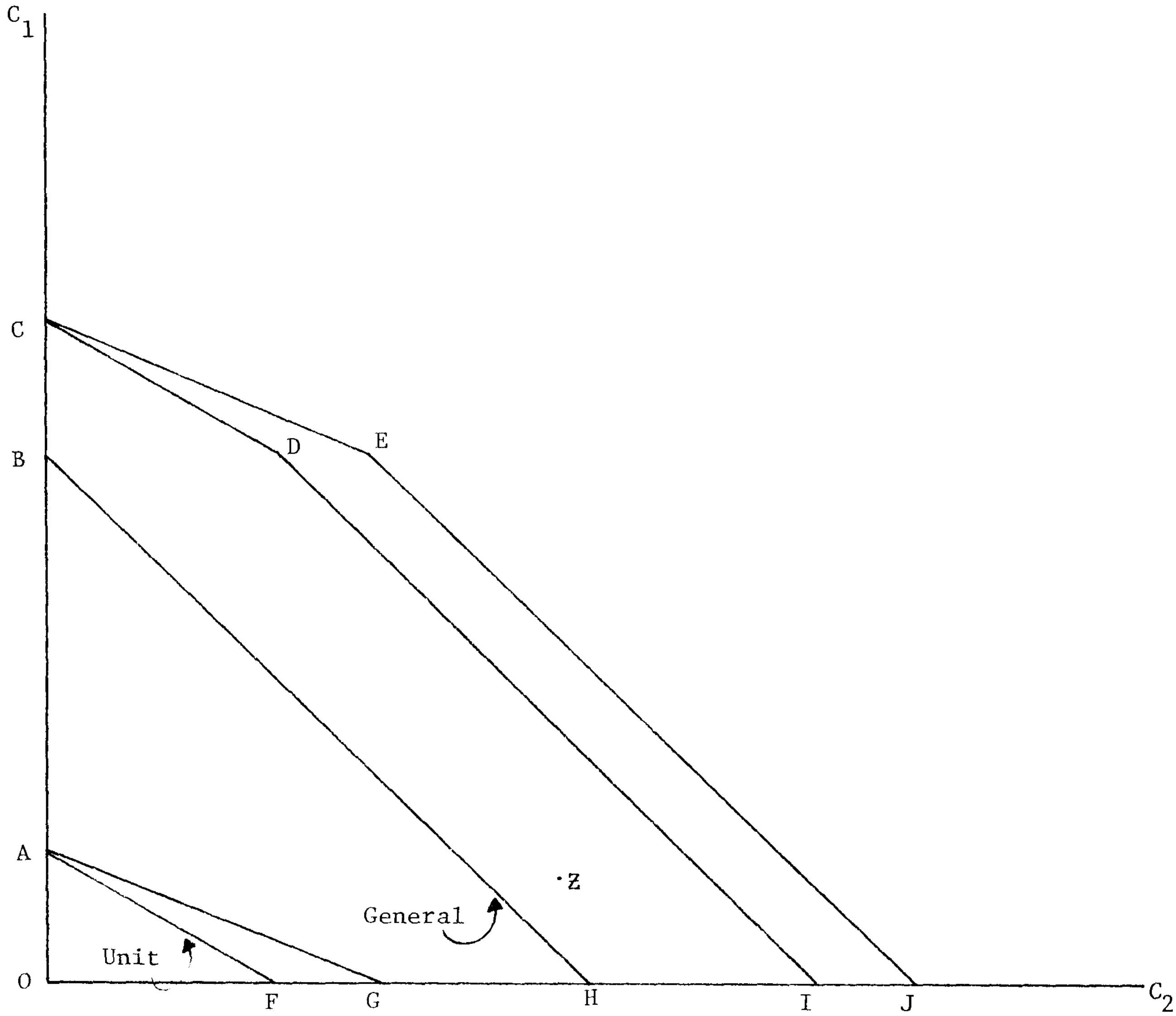
To begin, the unit (AF) and general (BH) quota can be represented by the inequalities

$$a_1c_{11} + a_2c_{21} \leq \bar{A} \text{ ; general quota}$$

$$u_1c_{12} + u_2c_{22} \leq \bar{U} \text{ ; unit quota}$$

where c_{ij} is the quantity of the i^{th} grain delivered under the j^{th}

Figure 2.5. The effect of a unit quota delivery rate change on the DOL.



quota and the a_i and u_i are the delivery rates. Obviously, there are an infinite number of ways to allocate deliveries between the two quotas. We start by considering the four possible extreme points--where a particular quota is filled by deliveries of a single grain. If both quotas are filled by the first grain, c_1, then maximum deliveries are given by OC in Figure 2.5 (OA + OB = OC). Similarly, if only c_2 is delivered, the maximum deliverable quantity is OI. If the general quota is filled by c_1 and the unit quota by c_2, total deliveries are given by point E. If the situation is reversed, deliveries are given by point Z.

As we show toward the end of the section, determining the DOL is equivalent to a parametric linear programming problem. Three of the four points determined so far form the vertices of a polyhedron defining maximum deliveries of c_1 and c_2. The DOL can be drawn by connecting points C, D and I. Point Z is obviously an inefficient allocation of the quotas.

Since the vertices of the DOL are known, the equations for line segments CD and DI can also be written using the two-point formula for a line. At point C, $c_1 = c_{11} + c_{12}$, $c_2 = c_{21} = c_{22} = 0$. Both unit and general quotas are filled at point C, therefore, $c_1 = \bar{A}/a_1 + \bar{U}/U_2$. Similarly at point D, $c_1 = c_{11} = \bar{A}/a_1$, $c_2 = c_{22} = \bar{U}/U_2$, $c_{12} = c_{21} = 0$. The equation for line segment CD is $a_1c_1 + a_1u_2/u_1c_2 = \bar{A} + a_1/u_1\bar{U}$. By similar reasoning, line segment DI can be written $a_1c_1 + a_2c_2 = \bar{A} + a_2/u_2U$.

Suppose the delivery parameter for crop two on the unit quota increases. This is shown in Figure 2.5 by a shift from AF to AG. The resulting DOL is now CEJ. Although the relative delivery rates under the unit quota have changed, ovèr DI, this is equivalent to a parallel shift of the general quota.

In Figure 2.6, the unit quota is AI, the general quota is CK, and the

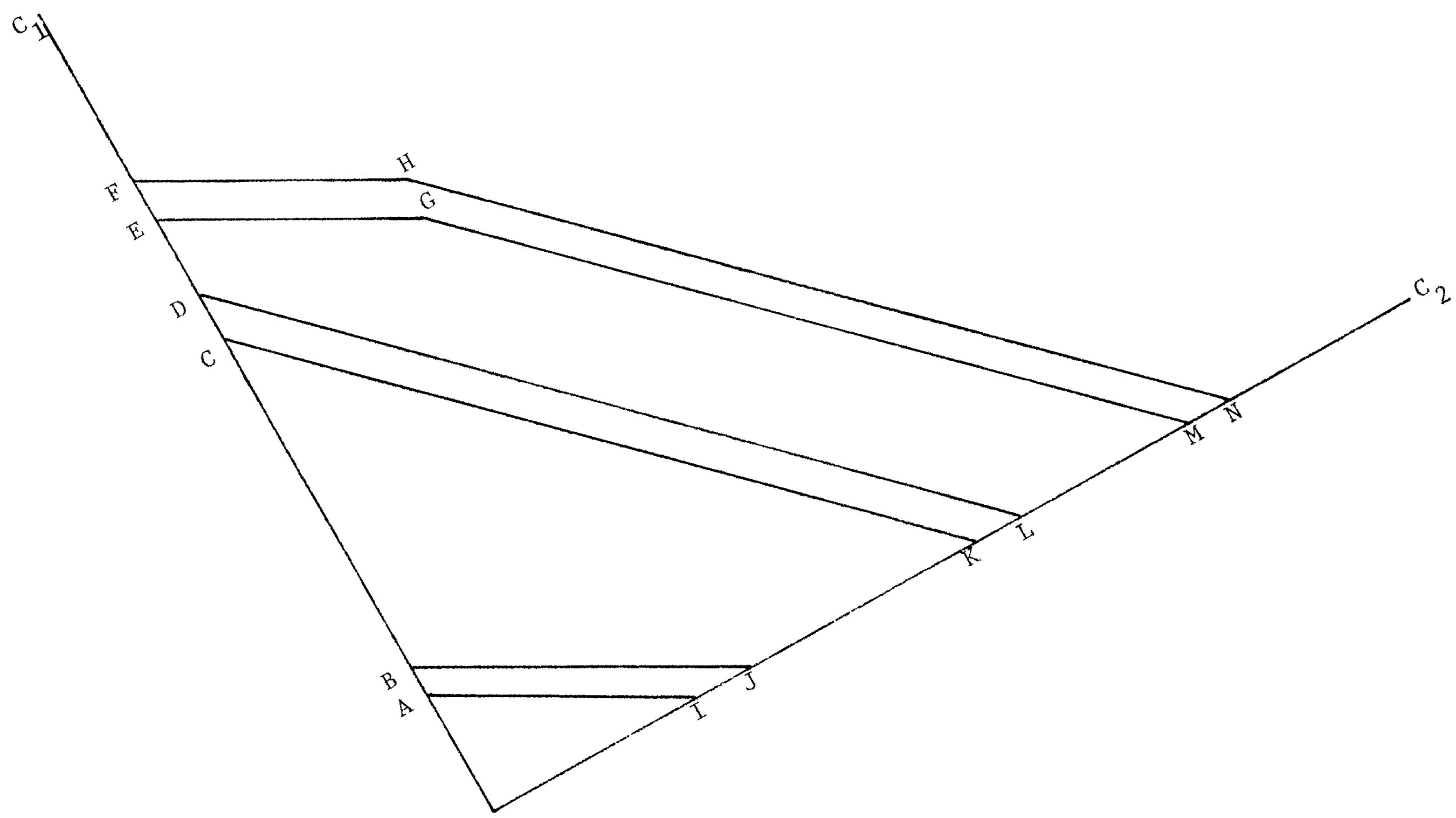


Figure 2.6. A parallel shift in the unit or general quota.

DOL is EGM. If the general quota shifts to DL, the new DOL is given by FHN. Similarly, a parallel shift in the unit quota to BJ results in the DOL FHN.

It should be clear that in order to correctly specify the econometric model, it is important not only to determine the DOL for a given set of quotas, but also to have some idea where on the DOL the NVA maximum would be likely to occur. Before elaborating on this concept, let us introduce supplementary quotas. Supplementary quotas were based on seeded acreage which was predetermined at the time the quota was announced. The supplementary quota was employed in an ad hoc manner to increase deliveries of specific grains during the crop year. If producers did not take supplementary quotas into consideration when formulating their production plans, then this type of quota can be easily incorporated into the model. Suppose again for the two-crop example, that a supplementary quota is announced for both crops. This can be expressed as

$$c_{13} = s_1A_1$$

$$c_{23} = s_2A_2$$

where c_{i3} are deliveries made on the supplemental quota; s_i are the delivery rates in bushels per seeded acre; and A_i are seeded acreages. If the supplementary quotas are combined with a general quota of the form $a_1c_{11} + a_2c_{21} = A$, then the DOL can be expressed as

$$a_1c_1 + a_2c_2 = \bar{A} + a_1s_1A_1 + a_2s_2A_2$$

for

$$c_i = s_iA_i \qquad i = 1,2.$$

This result is shown in Figure 2.7. The general quota is BG; the supplementary quotas for crops one and two are OA and OF, respectively. Point D is obtained by delivering (OF) of c_2 and (OA + OB) of c_1. The DOL is DE.

If the supplementary quota were known or anticipated prior to planting, then the two-stage properties of the optimization process break down. In this case, the delivery opportunity set is dependent on the land use (i.e., production) decision of the farmer. This situation is much more difficult to analyze. Since supplementary quotas occurred rather randomly during the historical period, it is unlikely that crop production plans were made with supplementary quotas in mind. Therefore, the first and much simpler approach to supplementary quotas will be taken.

The assumption that $\tilde{A} = \bar{A}$ introduces an analagous problem. If the definition of quota acreage were not all-inclusive, then the DOL is dependent on the land-use decision of the producer. Again, the two-stage optimization process breaks down. This feature presents no difficulty were an actual program to be run. However, it makes the a priori specification of an econometric model very difficult. The error introduced by assuming $\tilde{A} = \bar{A}$ is a small one and it is hoped the gain from simplification outweighs the loss due to inaccuracy.

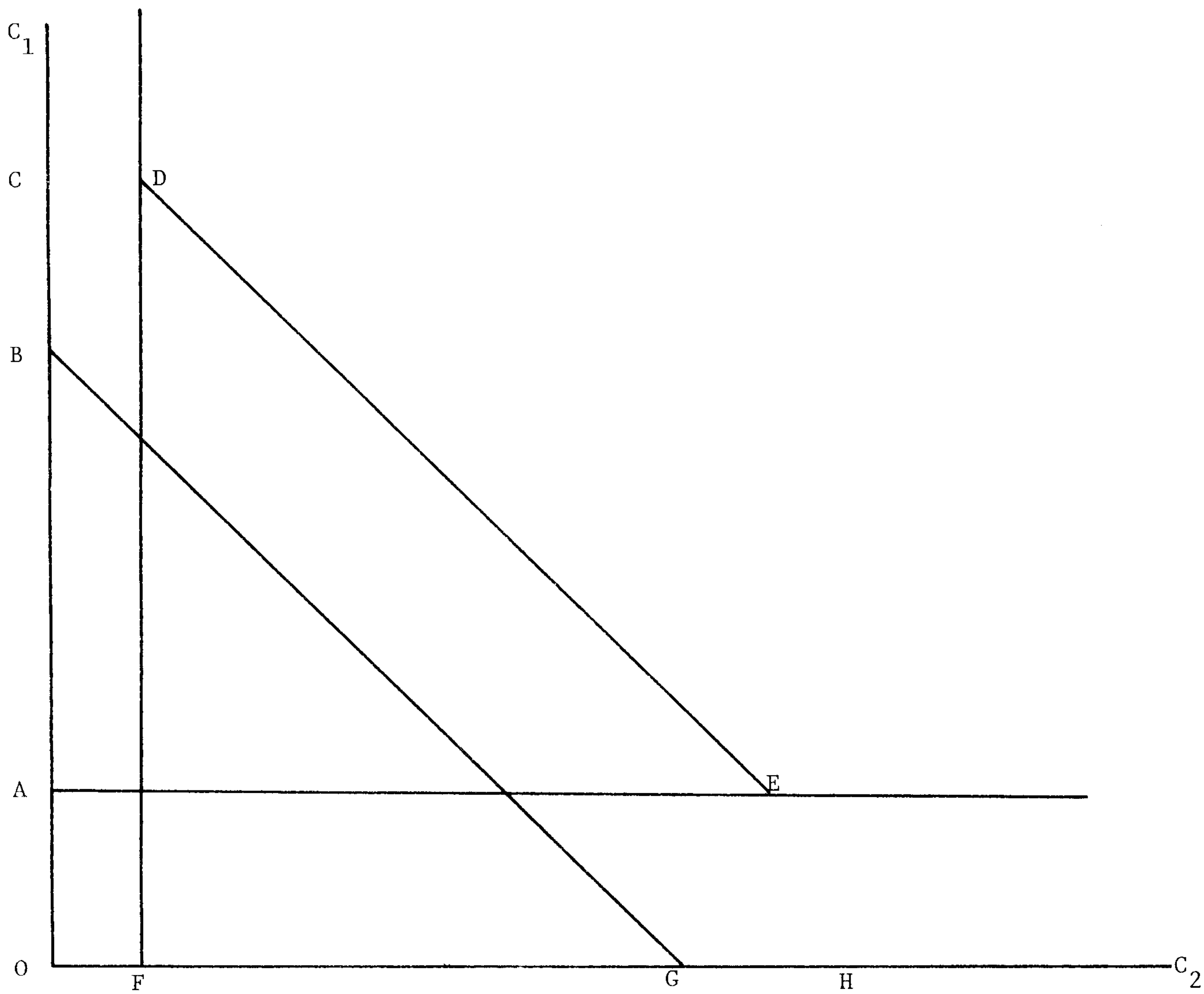
Formally, determination of the DOL for a given set of quota parameters is equivalent to the following parametric linear programming problem:

$$\text{MAX } z = \sum_{i=1}^{4} p_i c_i$$

subject to

$$\sum_{i}^{4} a_i c_{i1} \leq \bar{A} \qquad \text{General quota}$$

Figure 2.7. Adjusting the DOL for supplementary quotas.



$$\sum_{i}^{4} u_i c_{i2} \leq \bar{A} \qquad \text{Unit quota}$$

$$c_{i3} \leq s_i A_i \qquad \text{Supplementary quota}$$

$$c_i \equiv \sum_{j}^{3} c_{ij}$$

where p is a vector of shadow prices. For all possible price combinations, the solutions to the above program will define the delivery opportunity set. In the next chapter, a method will be presented for empirically determining the equation of the relevant hyperplane to be used in the estimating model.

Quota policy: 1970/71

In 1970, the government introduced the LIFT program. For one year, deliveries for wheat were based on land in summer fallow plus the increase in land seeded to forages. Deliveries of other grains were controlled by seeded acreage plus any quota acres not assigned to wheat. Land seeded to wheat did not contribute to the quota acreage. Algebraically, the quota constraints for LIFT can be expressed as follows:

$$\tilde{A} = [A^{sf} + \tfrac{1}{4}A_o^{sf} + (A^f - A_o^f)]$$

where

A^{sf} = land in summer fallow, 1970/71

A_o^{sf} = land in summer fallow, 1969/70

A^f = land in forages 1970/71

A_o^f = land in forages, 1969/70.

Deliveries for wheat were constrained by

$$c_1 \leq d_1 \tilde{A}_1 .$$

Deliveries for other grains were constrained by

$$c_i \leq d_i \, (\tilde{A}_i + A_i) \qquad \forall_i = 2, \ldots n.$$

Where $\tilde{A}_i$ is the quota acreage assigned to the i^{th} crop and A_i is seeded acreage, two other constraints are required as well:

$$\sum_{i=1}^{n} \tilde{A}_i \leq \tilde{A}$$

for quota acreage and for land

$$\sum_{i=1}^{n} A_i + A^{sf} + A^{f} \leq \bar{A} \; .$$

The LIFT quota base was not independent of the producer's land use decision. Therefore, the two-stage approach taken up to now is not applicable. Note, however, that the model still contains the same number of independent variables--prices and delivery rates. The effect of LIFT, within the framework of the model, is to alter the relationships between variables, but not the number of variables. In econometric terms, this type of change would be referred to as a structural shift.

Quota Policy: 1974/75 to Present

In this section, we modify the basic model to reflect the domestic feed grain policy introduced at the beginning of the 1974/75 crop year. The basic model included two outlets for Prairie grain--sales to the CWB and feed consumption. The off-board price for grain was endogenously determined and expressed as $p_i - \lambda a_i$. With the introduction of the New Domestic Feed Grain Policy (NDFGP), the off-board price will reflect supply and demand conditions in both the East and West. Consequently, it is not correct to view the off-board price as being completely determined in the West.

We amend the basic model by explicitly introducing the off-board market as a sales option. Consider the following crop year identity:

$$C_i - C_i^{CWB} - C_i^N - \sum_j c_{ij} = 0 \qquad \text{II.23}$$

where

C_i^{CWB} = deliveries to the CWB

C_i^N = sales to the off-board market for transhipment to Eastern Canada

p_i^N = received off-board price

The objective function of the firm is expressed as:

$$NVA = \sum_i p_i C_i^{CWB} + \sum_i p_i^N C_i^N + \sum_j p_j L_j - \sum_k r_k \left(\sum_i v_{ki} + \sum v_{kj}\right) \qquad \text{II.24}$$

The quota constraint must now be written

$$\tilde{A} - \sum a_i C_i^{CWB} \geq 0 \ . \qquad \text{II.25}$$

The crop year identity is added as a constraint. The remainder of the basic model is left unchanged. Maximization of ϕ leads to the following requirements for all active crop and livestock feeding activities:

1. $p_i - \lambda a_i = \mu_i$ if $C_i^{CWB} > 0$
2. $p_i^N = \mu_i$ if $C_i^N > 0$
3. $p_j \, \partial f^j / \partial c_{ij} = \mu_i$ if $c_{ij} > 0$.

At an interior optimum, the quota-adjusted final realized price is equated with the off-board price. Similarly, the VMP of the grain in livestock production is set equal to the off-board price.

Some basic price relationships are apparent from the above conditions. If the quota is binding and $C_i^N > 0$, $C_i^{CWB} > 0$ then $p_i^N < p_i$. If the quota is not binding, then C_i^N, $C_i^{CWB} > 0$ implies $p_i^N = p_i^{CWB}$. Under the assumption that C_i^N, $C_i^{CWB} > 0$, the comparative statistics from the preceding section are essentially unchanged and will not be repeated. From an empirical point of view, the main result is that following the introduction of the NDFGP, the off-board price should be included in the structural relations for Western Canada in addition to the final realized prices when the quota is binding.

The impact of the NDFGP is more striking when viewed from a market-level perspective. This topic will be addressed in the last section of this chapter.

Intertemporal Activities

Up to now, we have developed a model of a grain-livestock farm operating under a grain delivery quota system similar to the one used during the period from 1971/72-1973/74. This basic model was then amended to include different quota systems in effect over the entire historical period. In this section, we briefly discuss the effects of two important intertemporal activities in Western Canada-- summer fallowing and stock holding. Both of these activities are complex and the simple deterministic model does not do them justice. However, it is important to have some notion of their influence on production and consumption decisions, particularly in the presence of a delivery quota.

Summer Fallowing

Summer fallowing is, next to wheat, the most important land use activity in Western Canada. For the purposes of this study it is necessary to understand what variables influence the fallowing decision, and how these variables might be included in the econometric model.

The primary purpose for summer fallowing is to ensure that moisture available to crops is sufficient to obtain profitable yields from one year to the next. Soil moisture can be stored or carried over from one growing season for use in the next. The actual quantity stored depends on initial soil moisture levels, precipitation, evapotranspiration, and losses due to runoff or percolation through the soil profile. In addition to soil moisture management, other benefits are often ascribed to fallowing. These include increasing soil fertility due to organic matter decomposition, weed and disease control, a more even distribution of labor and machinery requirements over the crop year, and stabilization of farm income. These additional benefits should be borne in mind. However, in the discussion which follows, only soil moisture will be considered.

Fallowing can be conceptualized as follows:

1. It is a production process requiring land, labor, capital services, and variable inputs yielding a non-traded intermediate good, soil water.
2. The production of soil water is intertemporal. In the simplest case, fallowing is a two-period, point-input, point-output process.
3. Since fallowing competes for land and other fixed factors

with contemporaneous crop enterprises, production today must be foregone for increased or less variable production tomorrow.

4. The fallowing decision is made under conditions of uncertainty and risk.

The sequential, stochastic properties of summer fallowing implied by the foregoing characteristics suggest that it should be approached from a dynamic programming perspective.[5/] However, in keeping with the basic model developed in the last section, fallowing will be treated in a relatively simple manner. It will be convenient to make simplifying assumptions in order to gain some insight into how an econometric model might be specified when fallowing is included.

1. The assumption of complete certainty will be retained. This implies the producer has full knowledge, over his planning horizon of prices, precipitation, evapotranpiration, and all other output-influencing variables.
2. It will be assumed that the producer can allocate initial soil moisture supplies to any location on his farm. In reality, the producer brings the crop enterprise to the water, not the reverse. This assumption allows fallowing to be treated like any other production process in the model.

For any unit of land, an acre, a field, or an entire farm, the following accounting identity must hold:

$$M_t + R_t - EVT_t - SL_t \equiv M_{t+1} \qquad \text{II.26}$$

[5/] See Burt and Johnson (1967) and Burt and Stauber (undated).

where

M_t = Stock of soil moisture at the beginning of the crop year.

R_t = Precipitation during crop year.

EVT_t = Evapotranspiration during crop year.

SL_t = Soil losses, runoff, infiltration.

The producer can control soil moisture only through a few variables influencing EVT and SL. His control instruments are cropping intensity, weed control, and certain tillage operations. All other variables implied by II.26 remain outside the producer's domain of control. However, with full knowledge of these exogenous variables, the producer can still determine an optimal production plan.

It is assumed that the production of soil moisture on the farm can be described by a neoclassical production function.

For example,

$$M_t = g(v_{k,\ n+1,\ t}\ z_{h,\ n+1,\ t}\ A_{n+1,t}\ \ m_{n+1,t-1} | R_t) \qquad \text{II.27}$$

where

M_t = Soil moisture production, inches.

$v_{k,n+1,t}$ = Variable factors used in fallowing.

$z_{h,n+1,t}$ = Fixed factors used in fallowing.

$A_{n+1,t}$ = Land in fallow.

$m_{n+1,t-1}$ = Soil moisture produced last period used in fallowing process.

R_t = Exogenous, moisture related variables.

Accordingly, the crop production functions II.2 are changed to

$$C_{it} = f^{i}(v_{kit}, z_{hit}, A_{it}, m_{i,t-1}|R_t) . \qquad \text{II.28}$$

Finally, the following identity is assumed to hold

$$M_t \equiv \sum_{i=1}^{n+1} m_{it} . \qquad \text{II.29}$$

This identity requires that all soil water produced be utilized either to produce crops in the next period or carried over in the fallow land.

If the production functions for crops and soil moisture possess the same properties stated in assumptions A1-A4, then fallowing can be incorporated directly into the basic model. The objective of the firm is amended to be the present value of NVA over a finite time horizon.[6/]

A reduced form equation for each decision variable in each time period can be expressed as a function of all future prices, quota parameters, constraint constants, interest rates, future values of R, and the stock of soil moisture on the farm at time of planting. This can be represented as

$$\text{Decision variable}_t =$$

$$f(p_{it},..p_{iT};...; a_{it},.a_{iT};.R_t.R_t|M_{t-1}) . \qquad \text{II.30}$$

The major point made is that the impact of fallowing on the decision variables of interest can be incorporated into the model by including variables relevant to future crop and livestock profitability and the quantity of soil moisture on the farm at time of planting, M_{t-1}.

[6/] *Details of the maximization are contained in Jolly (1976).*

Grain Inventory Management in Western Canada

The second intertemporal activity in which the farm firm can engage is grain storage. This section examines grain inventory management under a simple general delivery quota. The structure and assumptions of the basic model will be retained.

Traditionally, economists have defined three motives for the holding of commodity inventories--a speculative motive, a precautionary motive, and a transactions motive. Furthermore, it is common to ascribe the first motive to producers, holding stocks of a given commodity as an output, and the last two motives to processors, holding stocks of the same commodity as an input. A mixed grain-livestock farmer is both a producer and a processor of feed grains and wheat. Therefore, all three motives could conceivably influence a farmer's inventory levels. It seems highly unlikely, however, because of the joint influence of the CWB's pricing policy and the GDQS, that Western Canadian farmers would hold stocks for speculative purposes.

Perhaps the most common form of speculation in free market economies such as that in the United States, results from increases in prices within the crop year. Prices are typically lowest at harvest and increase throughout the crop year. In Canada, a producer receives the same initial and final payment for his crop no matter when it was actually sold during the crop year. There is, consequently, no advantage to the farmer in deferring the sale of his crop within the crop year. Distribution of the crop over the year is accomplished through the GDQS, not a market mechanism.

Another possibility for speculation would be to capture an increase in prices from one year to the next. This too would seem to be an unlikely event in Western Canada. One source of price change is initial prices. However, initial prices changed infrequently over most of the period of study. The second source for price change would come from the final payments. If a farmer expected the final payment next year to be higher than the current year's final payment, there would be some motivation to forego current sales.

If, however, the delivery quota is restricting marketings, current foregone sales must be applied against sales under the quota in the next period. Since the producer incurs a cost in holding inventories, it would seem more likely that rather than produce today, store, and sell tomorrow--at the expense of future production--he would simply produce and sell tomorrow. Speculation between crop years would be profitable if expected prices were greater next period and deliveries under the quota would actually exceed the productive capacity of the farm. This would seem to be an unlikely event during the study period.

Feed grains (oats, barley, and utility wheats) are inputs into livestock production. The transactions motive refers to stocks carried to facilitate continuous production. Stocks of feed grains would be carried to support the current livestock population between grain harvests. It seems reasonable to assume feed grains would be stored for transactionary purposes.

Grain production in Western Canada is highly variable. Producers would carry stocks to ensure that livestock could be fed and delivery quotas filled in the event of adverse weather, for example. Hence, the precautionary motive for holding stocks would also seem valid for Prairie farmers.

The conclusion, therefore, is that farm inventories in Western Canada should reflect transactions and precautionary motives. Speculative stockholding, at least prior to 1974, is unlikely. The following expression summarizes this result:

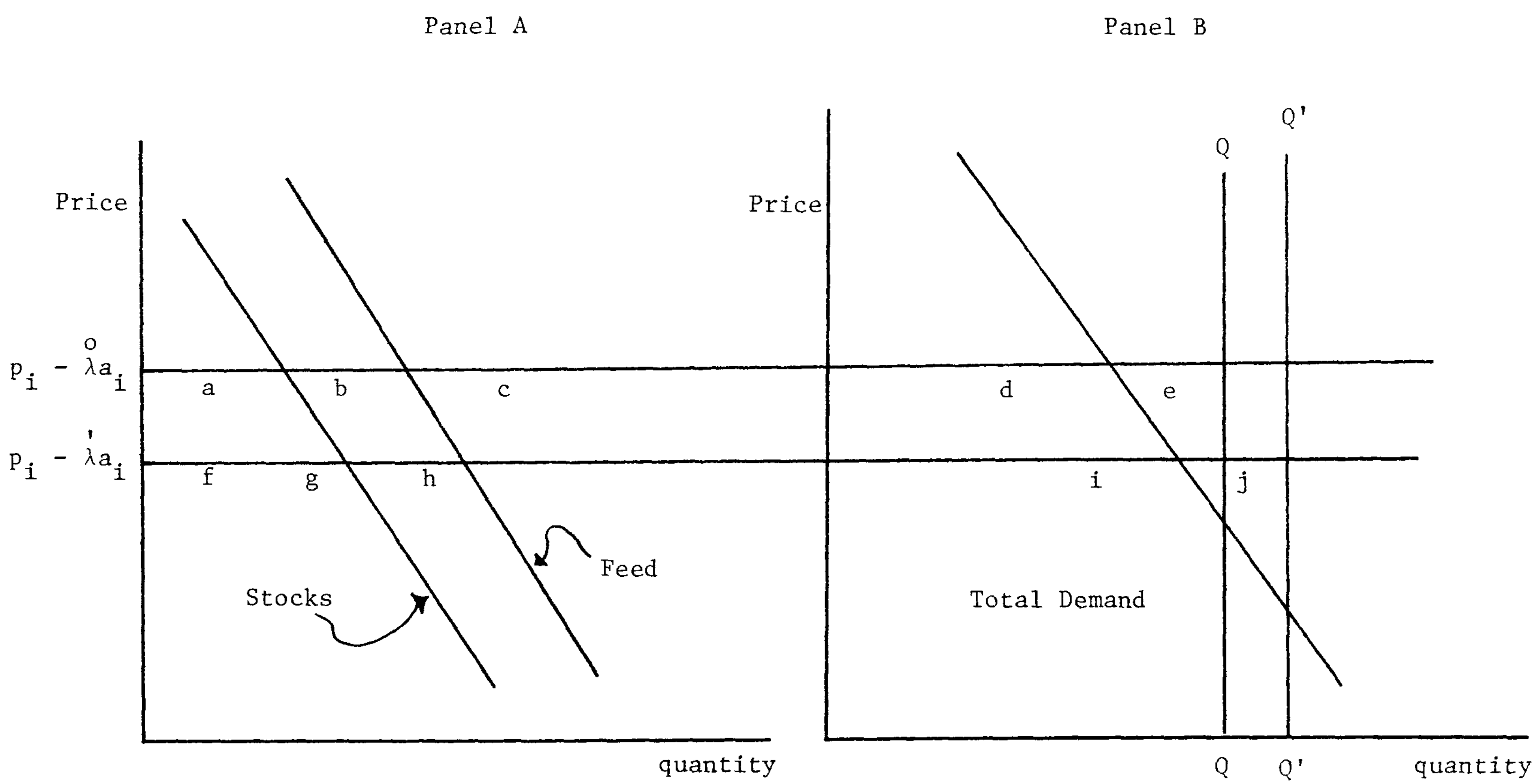
$$\text{Demand for Stocks}_t = f(p_i, p_j, a_i, \bar{A}, z_h) \ . \qquad \text{II.31}$$

Deterministic models ignore adjustment problems resulting from uncertainty. In a real world setting, however, these problems are quite important. The major one which we examine is the effect of yield variability on grain production and consumption when a binding delivery quota is present. The discussion is not rigorous; our objective is to discuss, in an intuitive way, some of the factors overlooked by the deterministic model which affect the specification of the econometric model.

Fluctuation in grain output due to weather will affect a producer's demand for grain and inventories under a binding quota. Unexpected accumulation of stocks will, in turn, affect the production decisions of the farm in subsequent years. Let us first consider demand for stocks.

Panel A of Figure 2.8 shows a farmer's demand for feed and stocks of a given quota grain. Total demand is shown in panel B. Crop year supply is represented by QQ. For a given set of final realized prices and quota variables, the resultant quota-adjusted price is shown by $p_i - \overset{o}{\lambda} a_i$. This implies that stocks of ab would be carried, ac of feed would be consumed, and de would be delivered to the CWB under quota. Now suppose, holding prices and quota variables constant, that crop year supply shifts to Q'Q' due to unexpected higher yields. The quota price will adjust downward by increasing λ, say to $p_i - \lambda' a_i$. Now one observes fg in stocks, fh being fed, and ij being delivered to the CWB.

Figure 2.8. Supply effects under a binding quota.



The decrease in the quota-adjusted price in the given grain causes the demand functions of the other quota crops to shift to the left. The combined effect of the demand shifts and increases in λ result in the same ambiguities discussed earlier. It would seem likely that the own effect would be positive; i.e., an increase in total supplies of the given grain would increase consumption. However, the cross effects can be of either sign.

Under a binding quota, an unexpected increase in yield results in increased grain stocks and, to a lesser extent, increased feed consumption. Inventory adjustments would, in all likelihood, influence a farmer's grain production decisions.

Suppose that a farmer wanted to decrease his inventories of a given grain by a known amount. In the simplest case, the producer would reduce acreage seeded to the grain held in excess supply. The decrease in marketings resulting from the production cutback would be replaced by sales from stocks. Alternatively, the farmer could decrease production of another quota grain. If wheat stocks were higher than desired, barley production and, hence, marketings, could be decreased and wheat substituted for barley on the quota.

The impact of inventory management on acreage response is a disequilibrium phenomenon. Were the delivery quota not binding, unexpected increases in production could simply be dissipated through increased marketings. However, with a quota, the producer cannot increase sales and therefore must either feed or store the excess production. Inertia in the livestock industry precludes greatly expanding feed consumption in the short run. Hence, the producer is forced to store the excess and reduce production of any or all quota grains in the next period. Holding prices and quotas constant, grain production will be affected by inventory management when a quota constrains marketing.

This concludes the development of the farm-level model for Western Canada. The next step is to examine the specifications of market-level relationships and the effects of relevant policies. Before doing so, we will briefly discuss the farm-level relationships for Eastern Canada and grain demand by food and industrial processors.

Farm-Level Relationships for Eastern Canada

We will not formally develop a separate micro model for grain and livestock production in Eastern Canada. The basic model developed thus far would be compatible with Eastern Canada with a few changes. First, most of the short-term agricultural policies in the East are secondary; consequently, they need not be explicitly introduced in a farm-level model. Second, grain prices can be interpreted as market prices since pooling is not performed. Given these changes, equivalent structural relationships can be specified for Eastern Canada. Certainly the set of active crop enterprises in the East will differ from the set in the West. However, this simply introduces different exogenous variables into the reduced form equations for Eastern Canada--the prices of corn and soybeans, for example. If p_i^e represents the price of the i^{th} crop in Eastern Canada, then any decision variable can be expressed as

$$\text{Decision variable} = f(p_i^e,\ p_j^e,\ \bar{A}^e,\ z_h^e). \qquad \text{II.32}$$

Domestic Food and Industrial Demand

We have chosen to eliminate the regional distinction in the specification of the domestic food and industrial demand equations. We specify a farm-level demand for grain by processing industries serving the entire domestic market. The theory of derived demand is well developed; no formal analysis will be performed. The demand for a particular grain by a processor can be represented as

$$q_i = f(p_i,\ p_j,\ r_k,\ Y,\ .\ .\ .\ ) \qquad \text{II.33}$$

where

q_i = domestic food and industrial demand

p_i = price of grain

p_j = price of livestock

r_k = price of variable factors

Y = consumer income

Development of a Market-Level Model

In this section, we consider how the firm-level behavioral relationships can be aggregated into a market model. For the farm-level relationships in Eastern Canada, and the food and industrial demand relationships, we specify the macro structure as a horizontal summation of the micro equations. For the farm-level relationships in Western Canada, a choice exists in macro specifications.

A Reduced-Form Approach

For a given range of exogenous variables, the Kuhn-Tucker conditions derived from the basic model provide a consistent set of equations for the exogenous variables. Since the net production set is assumed to be strictly convex, the requirements of the implicit function theorem are met. Consequently, in the simplest case, each decision variable may be expressed as a function of all the exogenous variables in the system.

$$\text{Decision variable} = f(p_i,\ p_i^N,\ p_j,\ r_k,\ a_i,\ \bar{A},\ z_h)\ . \qquad \text{II.34}$$

he preceding expression may be a supply function--C_i, L_j; a factor demand function--c_{ij}, v_{ki}, v_{kj}; or an excess supply or demand function--c_i. In this formulation, the policy variables enter as shifters.

A Policy-Adjusted Price Approach

An alternative method for specifying the sector model would be to adjust prices in order to account for the quota's effect on crop and livestock production.[7/] Figure 2.9 motivates the basic idea behind this approach. The curve represents a gross output supply function as it would appear in the absence of any quota restrictions. If p_i^o were offered, the farmer would produce C_i^o. Now, suppose a governmental policy, presumably motivated out of concern for farm income maintenance and supply control, determines that the combination of p_i^o and C_i' would be best for all concerned. The price quantity pair observed as a result of the policy (p_i^o, C_i') has little to do with the structural relationship. In the absence of a quantity restriction, C_i' would be produced if p_i' were offered. Denote p_i' as the policy-adjusted price. What is desired, therefore, is a means for expressing $p_i' = g(p_i^o)$. The price-quantity pair (p_i', C_i') correctly identifies the structural relationship.[8/]

The answer to the question posed above was given in the discussion of the price and quota effects. Condition II.12 requires the quota-adjusted price of a given grain to be equated with the value of its marginal product in livestock production. Over most of the historical period, farmers, feedlot operators, and feed mills within a given province were permitted to buy and

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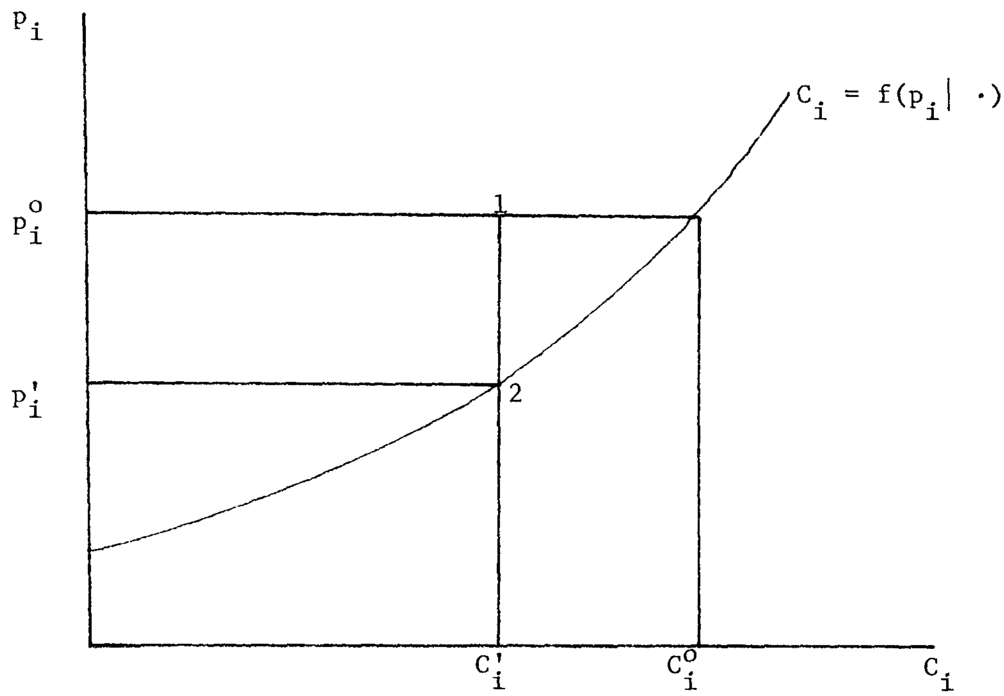
7/ See Houck and Ryan (1973) for a United States example.

8/ Note that the correctly specified reduced form equation includes policy shift variables. Therefore, the output restriction would shift the supply function back through point 1.

Figure 2.9. Policy adjusted prices.



sell grain independently of CWB quota restrictions in the off-board or non-quota market. The conclusion, therefore, is that prices discovered in the non-quota market are the quota-adjusted prices. All structural farm-level relationships for Western Canada can be correctly specified by simply using the non-quota prices for quota grains and eliminating variables associated with the quota. This can be expressed as

$$\text{Decision variable} = f(p_i^N, p_j, \bar{A}, z_h) \; . \qquad \text{II.35}$$

The actual specification of estimating equations will be considered in the following chapter. In the next section, we examine the impact of quota policy as well as interaction with major secondary policies from a market-level perspective. Throughout the section, the farm-level structure for Western Canada will be specified using the policy-adjusted price approach.

Market-Level Analysis of Major Grain Policies

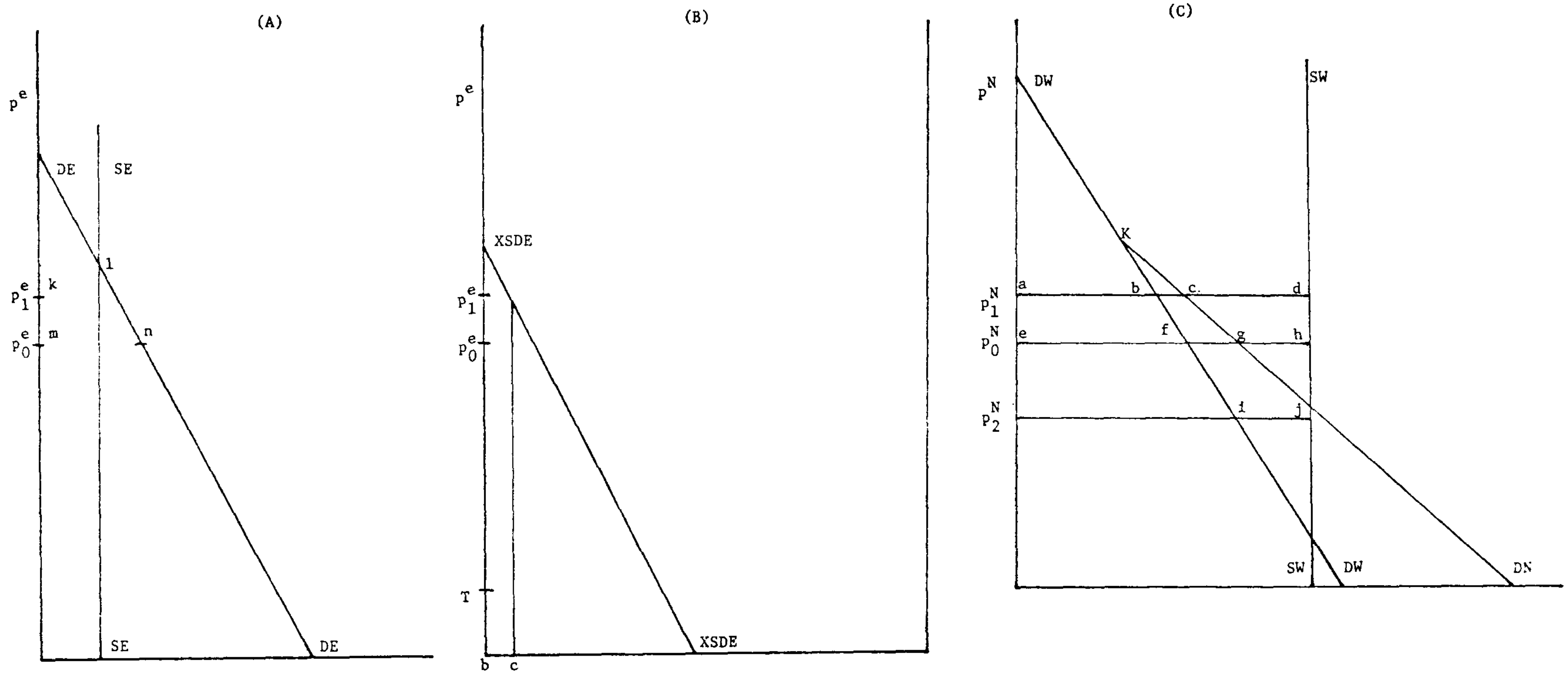
In this section, we examine, in turn, the behavior of the Canadian grain sector prior to the NDFGP, the interaction between quota policy and the freight rate subsidies and the effect of the NDFGP. The major analytical tool for this section will be the partial equilibrium trade model represented by Figure 2.10.

Market Behavior Before the NDFGP

Panel A in Figure 2.10 shows the demand for a feed grain in Eastern Canada (DEDE) and the crop year supply (SESE).[9/] Panel B shows Eastern Canada's excess demand for the feed grain. The left coordinate measures the price of the grain in the East. The right coordinate adjusts the Eastern price to

[9/] DEDE can be interpreted as a summation of feed demand in the East plus national derived demand for food and industrial grain.

Figure 2.10. Geometric interpretation of the NDFGP.



account for the per unit freight charge from West to East (for simplicity, assumed to be constant). In panel C, DWDW represents the structural demand for the feed grain in Western Canada that would be identified in the absence of a delivery quota. This includes grain delivered to primary elevators for re-sale for feed in the West as well as grain fed on the farm where produced. Crop year supply is given by SWSW. The coordinate measures the Western off-board price:

$$p_i^N \equiv p_i - \lambda a_i.$$

Prior to the introduction of the NDFGP, the CWB was the sole supplier of Western feed grains to the Eastern market. The CWB selling quotation for grain can be viewed as a basing point price (basis Thunder Bay). Presumably, the selling quotation would be a world price. In the absence of a binding quota, the following price relationships would be expected to hold under conditions of complete certainty:[10/]

$$p_i^N = p_i = p_i^{TB} - T_i^w - M_i$$

$$p_i^e = p_i^{TB} + T_i^e - S_i^f$$

where

p_i^{TB} = CWB selling quotation, Thunder Bay.

T_i^W = Crows Nest freight charge to Thunder Bay.

M_i = CWB marketing margin.

10/ For the sake of exposition, we assume a fixed marketing margin for the CWB.

T_i^e = freight charge from Thunder Bay to Eastern Canada.

S_i^f = Feed Freight Assistance Policy (FFAP) subsidy.

The difference in grain prices between East and West is

$$p_i^e - p_i^N = T_i^e = T_i^w - S_i^f + M_i \equiv T \ .$$

The transfer charge T reflects transportation and marketing charges less any freight subsidy. In Figure 2.10, p_1^N and p_1^e are the equilibrium prices which would be attained under the specified conditions. Western producers (panel C) would feed ab and deliver bd to the CWB to supply the Eastern market (bc in panel B) as well as export commitments.

Suppose that a binding quota is imposed on the system. Farmers in the West will allocate the quota until, among other things, the quota-adjusted price of the crop is equal to its opportunity cost in livestock production. Suppose an optimal allocation of the quota requires that fh (panel C) be delivered to the CWB. The CWB will still supply bc to the Eastern market. This implies that the off-board price in the West will be bid downward:

$$p_o^N = p_i - \lambda a_i \ .$$

The difference in prices between West and East is $p_i^e - p_2^N > T$. Algebraically, this price spread is

$$p_1^e - p_2^N = p_i^{TB} + T_i^e - S_i^f - p_i^{TB} + T_i^W + M_i + \lambda a_i$$

$$= T_i^e + T_i^w + M_i - S_i^f + \lambda a_i \ .$$

Since λ is unknown, prices in the two regions cannot be linked by transfer charges. This feature of the GDQS introduces some empirical specification problems which will be considered in the next chapter.

The effects of the GDQS and the freight subsidies on prices and quantities traded between the West and East are exactly opposite. The freight subsidies decrease spatial price spreads and encourage trade. The GDQS increases regional price spreads and inhibits trade. In order to correctly specify the market-level model over the historical period, it is essential that this interaction between the two policies be taken into account.

The partial equilibrium model greatly simplifies the impact of the quota on the grain sector. The allocative and distributive effect of the quota should not be forgotten. Figures 2.4 and 2.8 were employed to demonstrate farm-level price and quota effects as well as the role of inventories. However, they can also be interpreted as aggregate relationships for Western Canada.

Market Behavior Following the NDFGP

The major effect of the NDFGP is to extend the off-board market into Eastern Canada. This national off-board demand relationship is obtained by horizontally summing the Eastern excess demand for grain (XSDE) and the Western feed demand (DWDW) for each level of p^N. The resulting curve (DWKDN) in panel C represents the national demand for off-board grain faced by Western producers.

Prior to the NDFGP, in Figure 2.10 equilibrium prices in the West and East are represented by p^N and p^e respectively when a binding quota was present. Now introduce the NDFGP, holding expected final realized prices and quota delivery rates constant. With the addition of the Eastern off-board market, the relevant demand curve becomes DWKDN. At the original Western off-board price, p_o^N, it is reasonable to assume that the producers would reallocate sales so that fg would be delivered to the Eastern off-board market and deliveries to the CWB would be reduced to gh. The reduction in CWB sales, however, would result in the quota not being filled. If $p_i \geq p_i^N$, then producers would shift from non-board to CWB marketings until the quota was binding once again. In this situation, the off-board price must rise until $p_i^N = p_o - \lambda_i a_o$. In Figure 2.10 marketings of the particular grain to the CWB remain constant, fh = cd. This need not be the case. The actual reallocation of the quota among individual grains following a demand shift depends on the relative magnitudes of the price and quota effects. However, the off-board price of at least one grain must increase as deliveries are shifted from non-board to CWB sales. This implies that λ must fall and the off-board prices of all grains will rise. Algebraically, the equilibrium condition prior to the NDFGP was represented by $p_i - \lambda_o a_i = p_{io}^N$; following the NDFGP, $p_i - \lambda_i a_i = p_{i1}^N$. Since $(p_{i1}^N - p_{io}^N) = - a_i(\lambda_1 - \lambda_o)$ if $\Delta p_i^N > 0$, then $\Delta\lambda < 0$.

At the new equilibrium and with p_i and a_i constant, the off-board price has been bid up to p_1^N in the West. The Eastern off-board price is p_1^e . Feed consumption in the West is reduced to ab; bc is delivered to the Eastern off-board market and cd to the CWB. In this case, deliveries to the Board in excess of domestic requirements have actually risen. Prior to NDFGP and with a binding quota, fh was delivered to CWB. Of this quantity, bc was used to supply the Eastern market. Let's consider the effect of decreasing the delivery rate for a particular grain under a binding quota with the NDFGP in effect.

As the delivery rate is reduced, $\Delta a_i > 0$, the quota-adjusted price falls.

Suppose reallocation of sales to the off-board markets will cause the off-board prices to fall from p_1^N to p_o^N. Feed consumption in the West increases from ab to ef. Deliveries to the Eastern off-board market increase from bc to fg and quota marketings are reduced from cd to gh. The Eastern off-board price falls from p_1^e to p_o^e differing from the Western off-board price by transportation and handling charges.

Under the NDFGP, the demand for off-board grain is more elastic because of the addition of the Eastern market. Consequently, the effect of CWB quota policy, in this case a decrease in a delivery rate, is distributed between the two regions. The change in deliveries to the CWB from cd to gh along DWKDN (the off-board demand under the NDFGP) results in a fall in the off-board price from p_1^N to p_o^N. A similar decrease from fh to ij along the old demand curve (DWDW) reduces the off-board price from p_o^N to p_2^N. The NDFGP affects the magnitude of response but not the nature of the grain sector's behavior under a binding quota.

If the delivery quota is non-binding, Western producers will tend to allocate sales between the off-board and CWB markets until the off-board price equals the expected final realized price. Algebraically, $p_i^N = p_i$. An expected increase in the final realized price can be represented in Figure 2.10 by an increase in the off-board price from p_o^N to p_1^N. Note that under the NDFGP, the off-board price in the East is, in part, a function of the expected final price in the West.

Another aspect of the NDFGP is the reduction in freight assistance to portions of Eastern Canada. The effect of this policy change is to increase the price spread between the Western and Eastern off-board markets--or equivalently, to shift the national off-board demand curve to the left.

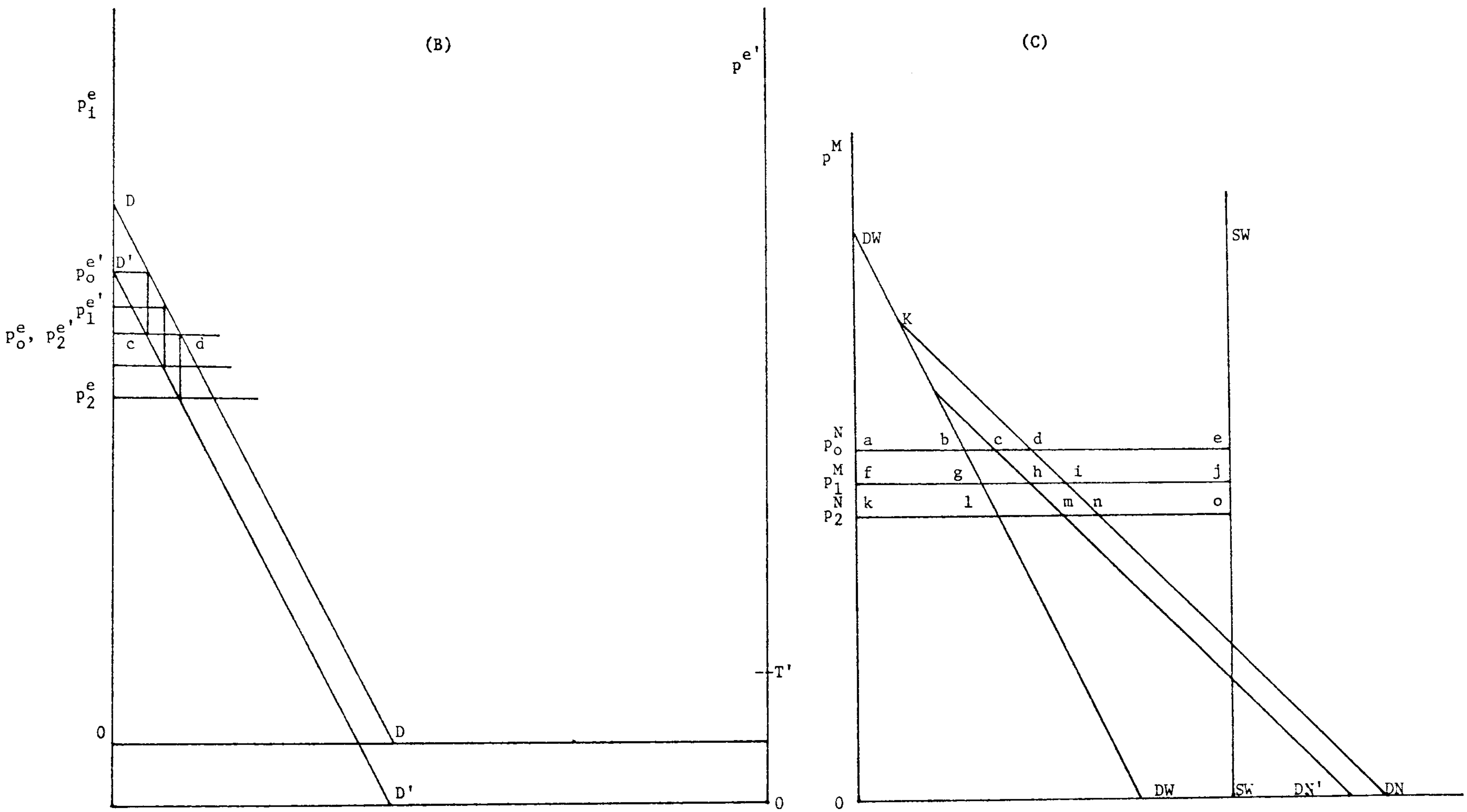
These changes are illustrated in Figure 2.11.

Panel B shows the excess demand for Eastern Canada. The line DD gives the demand at the original level of freight subsidy. Prices for DD are measured along the left coordinate. The line D'D' gives the excess demand following the reduction in freight assistance. Prices for D'D' are measured along the right coordinate. Panel C is redrawn from Figure 2.10. The national off-board demand curve after reduction of freight assistance is DWK'DN'.

Consider first the removal of freight assistance in the absence of binding quotas. The national off-board demand curve is DWKDN. Assume the Western off-board price is p_o^N. At p_o^N, Western feed consumption is ab, deliveries to the Eastern off-board market are bd, and marketings to the CWB are de. Following removal of freight subsidy, the national off-board demand becomes DWK'DN'. If Western farmers' expectations of final realized prices are unaffected by the reduction in freight assistance, p_o^N will remain constant as will feed consumption in the West. Producers will simply shift cd from the non-board to the CWB market. The effect of this reallocation of sales on the Eastern off-board market is to reduce feed consumption by cd and increase the off-board price by the full reduction in the freight subsidy.

Suppose, however, that Western farmers' expectations of the final price are in fact influenced by the reduction in freight rate subsidy. For simplicity, assume that the expected final price drops by the full subsidy reduction. This would be the case if the off-board price in the East were fixed or exogenously determined. This is shown in panel C by a decline in

Figure 2.11. Change in freight subsidy rate.



the Western off-board price from p_o^N to p_2^N. Feed consumption in the West increases, deliveries to the CWB decrease, but marketings to the Eastern off-board market are unaffected by the reduction in the freight subsidy.

The two critical factors in the above analysis are the extent to which Western farmers revise expectations following reduction in FFAP assistance and the degree to which Eastern off-board prices can rise in response to decreased Western deliveries to the off-board market.

By contrast, if freight rates in the West were increased due to a revocation of the Crows Nest Pass agreement, expectations of final prices would be directly affected. The freight charge is deducted from the initial payment at the time of delivery. In this case, the scenario presented in the paragraph above would apply.

Up to now, we have operated under the assumption of non-binding quotas. We briefly examine the impact of freight assistance removal when a binding quota is in effect.

Assume initially that the quota-adjusted price is equated with p_o^N. Removal of the freight subsidy results in an increase in potential deliveries to the Board (from de to ce). Since the quota is binding, the shadow price will be bid upward and the quota-adjusted price will fall, say to p_1^N. In this case, deliveries to the CWB are assumed to be unchanged (de = hj) whereas feed consumption in the West increases (ab to fg). Deliveries to the Eastern off-board market fall from bd to gh. The Eastern off-board price increases from p_o^e to $p_1^{e'}$. Under quota, the price increase is less than the change in freight rates. If the expected final prices are unaffected by the removal of freight subsidy, then

$$\Delta p^e = \Delta T - a_o \Delta\lambda$$

where ΔT is the change in freight rates. If $\Delta T > 0$, then presumably $\Delta\lambda > 0$.

The sign of Δp^e in this case is indeterminate. A similar result holds if the expected final price is reduced by the full subsidy charge.

Finally, note that the removal of CWB control over inter-provincial feed grain trade and the removal of freight subsidies have opposing but not necessarily equal effects on the national off-board market. The former aspect of the NDFGP expands the demand for off-board grain, the latter aspect contracts demand.

The last aspect of the NDFGP which we will discuss is the corn competitive pricing scheme for CWB domestic feed grains. The CWB formula price, p_i^F, is a function of the Chicago cash corn price and the Decatur price for soybean meal basis Montreal with adjustments made for transportation, handling, exchange rates, and tariffs. Therefore, p_i^F is on a corn-equivalent import basis. Furthermore, p_i^F can be considered exogenous to the structural relationships presented in Figure 2.10.

In the preceding section, the critical factors determining the allocation of Western grains between the national off-board market and the CWB were the expected final realized prices and quota delivery rates. The imposition of an exogenous formula selling price for feed grains does not alter the importance of this basic fact. However, the functioning of the mechanism for price arbitrage between the CWB and the off-board market is altered in some circumstances.

Suppose prior to the introduction of formula pricing, that the grain sector is in equilibrium with $p_i = VMP_{ij}^W = p_i^N = p_i^e - T$. Delivery quotas in the West are for the moment assumed to be non-binding. Further, assume that the private trade interprets the formula price as its selling price in

Eastern Canada. The competitive off-board price in the West would be $p_i^N = p_i^F - T$. This then is the price at which Western farmers could sell to the private trade. To see what might happen in this situation, we consider two cases.

Case 1. $p_i^N > p_i$. The off-board price in the West exceeds the expected final price. If Western producers interpret the formula price as the expected final price (with adjustments for freight, handling and temporal discount factors), then they will revise their expectations of p_i upward until the equilibrium conditions are reached. Deliveries to the CWB will increase whereas off-board marketings and feed consumption in the West will decline. The formula price would prevail in the national off-board market.

On the other hand, if producers don't revise expectations of p_i in response to p_i^F, they would abruptly shift deliveries from the CWB to the private trade. The additional deliveries to the off-board market could only be sold in the East at a lower price. Consequently, the private trade would drop the off-board price below the formula price until the original equilibrium conditions were reached. The national off-board market would trade below the corn-equivalent price.

Case 2. $p_i^N < p_i$. The off-board price in the West is less than the expected final price. If producers interpret the formula-based off-board price as the expected final price, they will revise their expectations downward and the off-board market will clear at the formula price. If expectations of p_i are independent of $p_i^F = p_i^N + T$, then a disequilibrium condition exists. The expected selling price in the West (p_i) would be higher than the purchase price (p_i^N) with no mechanism for arbitrage between the two prices. All deliveries would go to the CWB. All off-board grain sales would be made by the CWB at the formula price.

If expectations of p_i are based primarily on conditions in the export market, and yet a portion of farmers' grain deliveries to the CWB are being used to service the domestic market at a lower price, then p_i will not necessarily be obtained. The only opportunity for an equilibrium rests with the revision of producer expectations of final prices.

Up to now, we have assumed that delivery quotas in the West were non-binding. Relax this assumption and assume the following equilibrium conditions hold:

$$p_i - \lambda a_i = p_i^N = p_i^e - T.$$

Suppose we introduce formula pricing and that the private trade establishes its selling price in Eastern Canada as $p_i^e = p_i^F$. The Western off-board price for the private trade would be $p_i^N = p_i^F - T$. Again, we consider two cases.

Case 1. $p_i^N > p_i - \lambda a_i$. With the private trade offering to purchase Western grain at a price higher than the quota-adjusted price, producers would shift from Board to non-board deliveries. If the expected final price and the delivery rates remain constant (are not affected by p_i^F), the private trade will drive the off-board price to its original level. The off-board market price will be below p_i^F. Producers can revise expectations of p_i in accordance with the p_i^N (the a_i are controlled by the CWB). With a binding quota, however, the increase in p_i will be offset by an increase in λ. The original equilibrium conditions will be maintained.

Case 2. $p_i^N < p_i - \lambda a_i$. With the private trade offering to purchase grain below the quota-adjusted price, a disequilibrium condition is again created. Without formula pricing, the increase in off-board purchases of feed grain would drive p_i^N upward until the equilibrium conditions were achieved:

$$p_i^N = p_i - \lambda a_i = p_i^e - T = p_i^F.$$

However, with this policy change, the CWB, by law, is required to supply the domestic market at the formula price. Producers would attempt to shift deliveries from the private trade to the CWB. Feeders would purchase grain from the CWB at the formula price. Quota delivery rates would be advanced sufficiently to meet domestic requirements. This, however, would tend to widen the gap between p_i^N and $p_i - \lambda a_i$. Arbitrage cannot occur and consequently the disequilibrium conditions will persist.

If producers revise their expectations of p_i downward, given quota delivery rates, the quota-adjusted price will remain constant. Deliveries to the CWB will be increased to supply the national off-board market. Therefore, the same disequilibrium conditions will exist.

In this section, we examined the behavior of the Canadian grain sector following the introduction of the NDFGP. The theoretical model interprets the NDFGP as a series of amendments to an evolutionary set of policies. The NDFGP for the most part does not alter the basic functioning of Canada's grain sector--the variables which determine its behavior. Rather, it affects the likely magnitude of response to changes in these variables. Any change in a primary agricultural policy such as the NDFGP induces structural shifts in the behavioral relationships in the market. This will have important implications for the specification of the econometric model.

Final Comments

This concludes the development of the theoretical model. In this chapter we have identified the major technical and policy factors which determine Canadian excess supply of grain. We have developed an historically consistent approach to primary agricultural policies over the period of study. In addition, possible interaction with secondary policies has been considered. From time to time, we have alluded to certain specification problems implied by the theoretical model. In the next chapter we address the problems of equation specification using the theoretical model as a guide.

Chapter 3

THE STATISTICAL MODEL

Introduction

In this chapter, we specify the structural relationships necessary to estimate Canada's excess supply or exportable surplus of wheat, oats, and barley, and excess demand for corn. The specification will follow directly from the theoretical analysis of Chapter 2.

In any econometric analysis, a large number of specification problems must be confronted. Because of the preliminary nature of this study, we will concentrate on specification problems which are unique to Canadian agriculture or agricultural policy. Specification problems which are common to all agricultural sectors--technological change, capital accumulation, risk and uncertainty--will not be discussed in great detail. The period of fit for most structural equations will be 1948/49-1973/74. The regional farm-level relationships will be specified first. Then the domestic commercial demand equations will be considered. For each equation, we indicate how the theoretical variables can be represented using available data. Hypothesized signs for coefficients are stated. Finally, potential specification or estimation problems are considered.

Farm-Level Relationships for Western Canada

In Chapter 2, we indicated that there were two alternative specifications possible for the farm-level structural relationships in the West. The policy-adjusted approach, based on off-board prices, is probably the simplest of the two. There is no need to explicitly represent all of the quota variables. Structural shifts induced by binding and non-binding quotas are avoided. However, two problems must be confronted.

First, there exists a problem of indeterminacy on the demand side. Consider the following model for two crops produced and traded between Eastern and Western Canada. Demands for stocks and exports are omitted for clarity.

1. Supply $\quad i = 1, 2, k = 1, 2, i \neq k$

$$C^{w}_{it}: \; P^{w*}_{it}, P^{w*}_{kt}, SS^{w}_{t} \qquad \text{III.1}$$

$$C^{e}_{it}: \; P^{e*}_{t}, P^{e*}_{kt}, SS^{e}_{t} \qquad \text{III.2}$$

2. Demand for feed

$$c^{w}_{i\cdot t} \equiv \sum_{j} c^{w}_{ijt}: \; P^{w}_{it}, P^{w}_{kt}, DS^{w}_{t} \qquad \text{III.3}$$

$$c^{e}_{i\cdot t} \equiv \sum_{j} c^{e}_{ijt}: \; P^{e}_{it}, P^{e}_{kt}, DS^{e}_{t} \qquad \text{III.4}$$

3. Closing identity

$$C^{w}_{it} + C^{e}_{it} = c^{w}_{i\cdot t} + c^{e}_{i\cdot t} \qquad \text{III.5}$$

4. Quota Constraint

$$a_1(C^{w}_{1t} - c^{w}_{1\cdot t}) + a_2(C^{w}_{2t} - c^{w}_{2\cdot t}) = \bar{A} = 0 \qquad \text{III.6}$$

The superscripts w and e, as before, designate Western and Eastern Canada variables respectively. Supply and demand shifters are identified by SS and DS respectively. The asterisks denote expectational variables.

The system of equations III.1-III.6 describes a standard two-crop/two-region trade model. By appealing to the recursive nature of agricultural supply and demand, C^w_{it} and C^e_{it} can be taken as given in the sub-system III.3-III.6. In other words, gross output is determined by expectations of future prices and other variables. Once the planting decision is made, there is little change which can be effected by the producer.

With the quota constraint, the demand sub-system contains eight endogenous variables and seven equations. In the standard trade model, the system is made consistent by assuming competitive conditions between regions hold; that $p^w_i = p^e_i + t + h$ where t and h are known transportation and handling charges. As shown in Chapter 3, before the NDFGP, the competitive conditions will not occur with a binding delivery quota.

How then can the demand sub-system be made consistent? Perhaps the easiest approach would be to assume one of the prices in Eastern Canada is exogenously determined. There is some justification for assuming the price of barley in the East is determined by the price of United States corn (Kerr, 1966). If the price of barley is taken as exogenous, the demand sub-system is determinate.

A more fundamental problem with the quota-adjusted approach exists, however. Off-board price statistics were not recorded until the early 1970's. Consequently, we have little choice but to estimate the reduced-form model. Official statistics for final realized prices and the quota variables are easily obtained.

Equations III.1-III.6 can also represent the reduced-form model. The quota variables enter as shift variables. The P^*_t are expected final realized prices. The indeterminacy confronted in the policy-adjusted price model is avoided. Because of the CWB's price pooling scheme, the final realized price is not known to producers with certainty during the crop year. Allocation of the crop between feed consumption and sales to the CWB must be made on the basis of expected prices during the crop year. This fact implies that final realized prices can be viewed as predetermined variables. Finally, by specifying prices in Eastern Canada as the CWB selling quotation in Thunder Bay, less transportation, the demand sub-system is made determinate.

Grain Supply

The first set of structural relationships to be specified is the supply functions for Western Canada which reflect production for sale, for feed, and for stocks.

Quantity Supplied

The quantity of grain produced by a farmer reflects both his intentions and the effects of forces outside his control--the weather, for example. What is desired, therefore, is a variable which reflects only a farmer's crop production intentions, not the effects of outside forces.

Consider the following identity:

$$C_t^* = A_t \times Y_t^* \qquad \text{III.7}$$

where C_t^* is intended gross output, A_t is seeded acreage and Y_t^* is the expected yield. Only seeded acreage is exempt from the influence of outside forces and reflects only economic forces. The crop yield will be dependent upon seeding rates, tillage practices, fertilizer and herbicide application, and, of course, weather influences.

Although crop production is a sequential decision process, the impact of later actions once A_t has been determined is small. This does not justify the statement that yields can be treated parametrically. Consequently, C_t^* and A_t are not equivalent. Biases will be introduced in the estimation of structural parameters if A_t rather than C_t^* is employed as a dependent variable.

However, A_t is as good a proxy for C_t^* as can conveniently be obtained. Including the effect of weather or insects in the C_t^* proxy, as would be the case were actual production employed, would not enhance the accuracy of the estimation.

In the supply response literature, it is common to distinguish between intended production, C_t^* , and the desired or long-run production levels. Taking the lead from Nerlove (1958), this distinction suggests a partial adjustment specification for the supply model. The equations estimated in this study are short-run relationships posited on the stock of fixed factors owned by the firm at a point in time. As investment occurs in response to changing profitability, the structural relations will shift. So long as the current capital stock can be specified in the equations, there is no compelling reason to employ a partial adjustment model.

Received Final Prices

Prairie farmers determine their seeded acreage with only partial knowledge of the price which they will receive for their output. Because of the CWB's price pooling scheme, the familiar models of expectation formation (Ezekiel (1938), Goodwin (1947), Cagan (1957), Muth (1961)) are difficult to employ. Before suggesting possible price expectations models for Western

Canada, consider the information available to farmers at the time their planting decision is made.

Figure 3.1 is a timeline. It shows the temporal relationships between planting dates (for simplicity assumed to be on May 1) and the announcement dates of final interim payments for #1 Northern wheat in the early 1960's. Initial payments are assumed to be announced on August 1. In May, 1962, when the 1962/63 crop was seeded, producers knew (1) the final prices for crops planted in 1960 and earlier, and (2) the initial payment for the crop planted in 1961. Note that the final payment for this crop was not announced until March of 1963. In other words, producers had complete information on prices for the two previous crop years and partial information on the price of last year's crop.

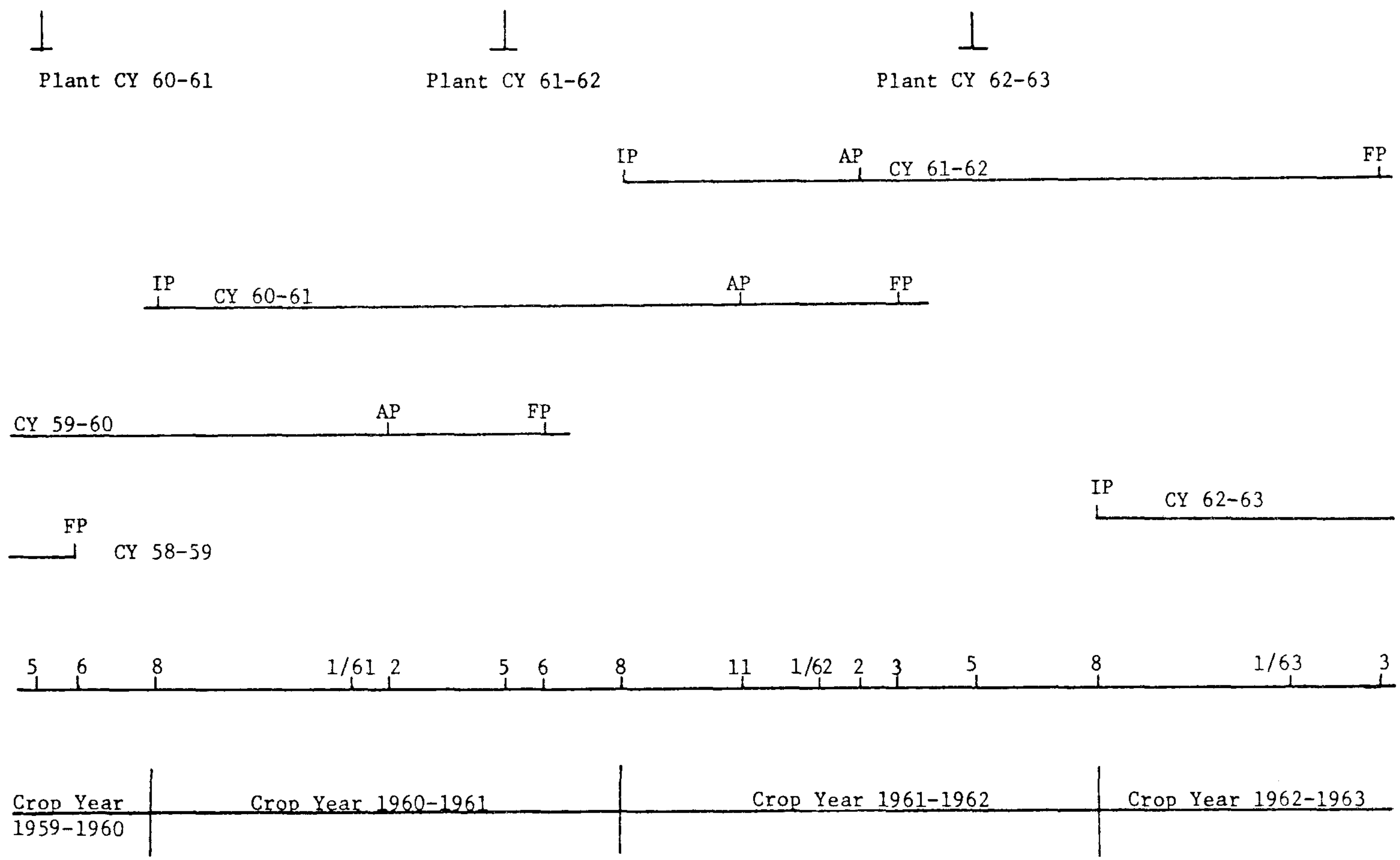
The price expectation models mentioned earlier all base, in one way or another, predictions of future prices on past prices. Since information on past prices is delayed by pooling, it seems likely that farmers would incorporate alternative current price information into their expectations. Export prices, prices in the United States, Europe, or Japan, all reflect current market conditions and could be employed by farmers to make predictions of future final realized prices.

The expected final realized price (p_t^*) for a crop can be written as the sum of the expected initial payment (IP_t^*) and the expected final payment discounted to the time of sale (FP_t^*). This can be expressed as

$$p_t^* = IP_t^* + FP_t^* \qquad \text{III.8}$$

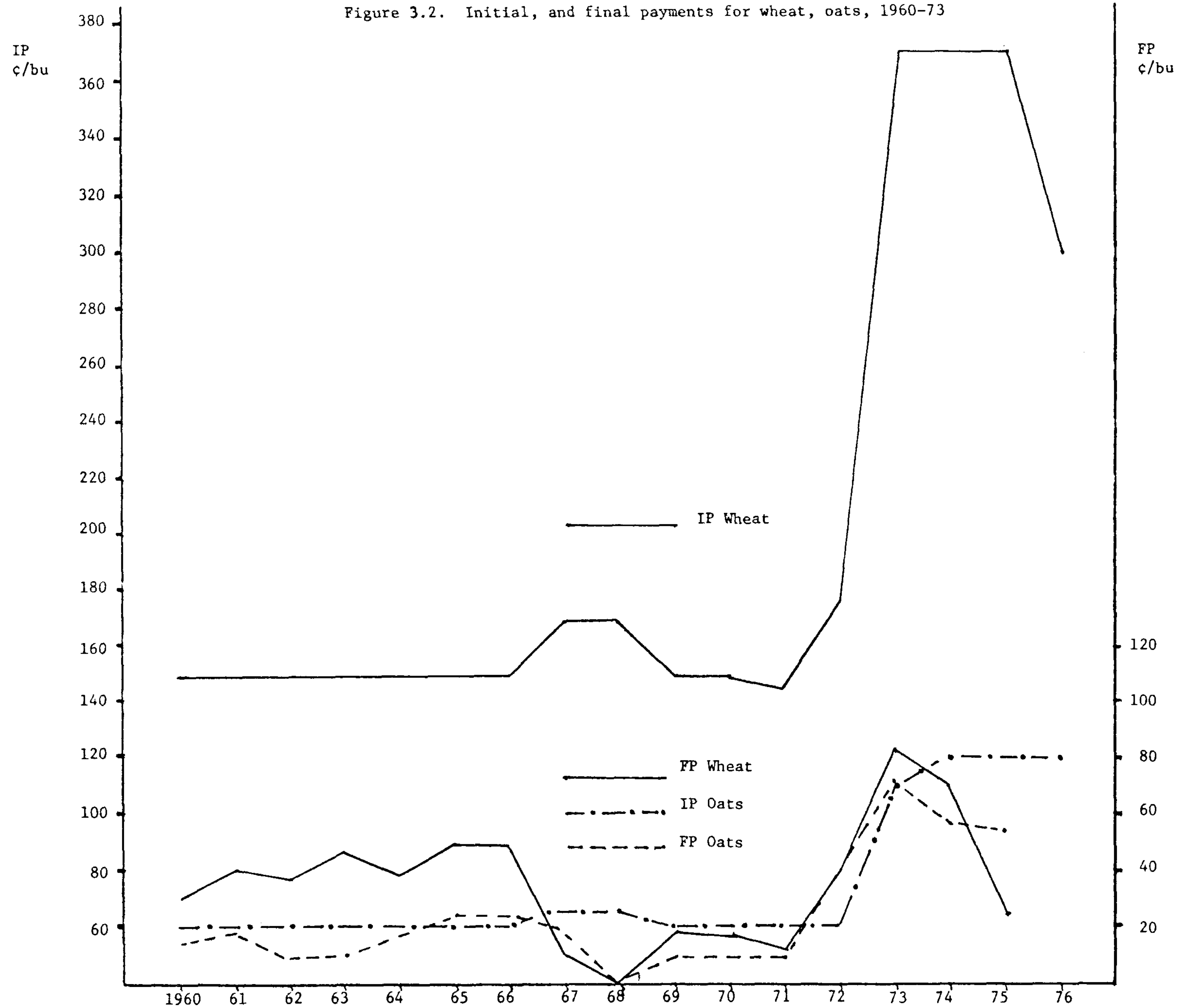
Figure 3.2 shows the movement in the initial payment, and final payments for wheat and oats since 1960. Until 1972, changes in initial payments were

Figure 3.1. Planting dates and announcement of initial and final payments.



IP = Initial Payment; AP = Adjustment Payment; FP = Final Payment

Figure 3.2. Initial, and final payments for wheat, oats, 1960-73



infrequent and gradual. Final payments exhibit a degree of variability characteristic of all grain prices during the same period. As a first approximation, therefore, it would seem reasonable to assume that expectations of future initial payments are based on the latest known initial payment. In other words $IP^*_t = IP_{t-1}$. Given this assumption, it remains to be shown how the expected final payment might be modeled.

At the time the planting decision is made, the producer has full knowledge of final payments received for crops planted at least two years earlier. The final payment for the previous year's crop is unknown. However, it can be roughly estimated by subtracting the current initial payment from the CWB selling quotation. This difference can only approximate the actual final payment since (1) actual operating expenses for the CWB are unknown, (2) quantities sold at the published selling prices are unknown, (3) the selling quotation may change over the three-month period from planting time until the end of the crop year, and (4) the published selling quotation may have little correlation to actual CWB sales prices determined through private negotiations or state trading. However, in view of the information readily available to farmers, the difference between the selling quotation and the initial payment is probably as good a representation of the previous year's final payment as can be obtained.[1/]

Now consider combining the two simple models into a single expression using the identity III.8

$$P^*_t = IP_t + FP^*_t$$

[1/] Meilke (1976) reports 90 per cent of historical variation in final payments can be accounted for by a regression on selling quotations and initial payments.

$$p_t^* = IP_{t-1} + (PS_{t-1} - IP_{t-1})$$

$$= PS_{t-1}$$

where PS = CWB selling quotation. If the two native expectation models seem plausible in isolation, then there is little apparent advantage in employing them separately over simply using the CWB's selling quotations.[2/]

It is beyond the scope of this study to fully develop the topic of rational expectation formation in the presence of price pooling and delivery quotas. Consequently, some compromises are necessary. The expected final realized price will be expressed as one of the following:

$$p_t^* = PS_{t-1} \qquad \text{III.9}$$

$$p_t^* = LRFRP_t \qquad \text{III.10}$$

$$p_t^* = IP_{t-1} + FP_{t-2} \qquad \text{III.11}$$

where

LRFRP = latest received final realized price at time of planting.

All of the above models suffer from at least two shortcomings: (1) they lack a strong theoretical foundation, and (2) they omit some information which could have been used in forecasting. However, they have the advantage in that they are simple to employ, and that they are

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[2/] Meilke (1976) estimated supply response equations for Western Canada using both initial and final payments and selling quotations in the model. On the basis of $\bar{R}^2$, the initial and final payment performed marginally better than the CWB's selling quotation.

based on readily available data.[3/] The selection of one of the above representations will be based solely on its performance in the estimating equations. Ideally, Thunder Bay prices should be adjusted for freight from a mid-Prairie point. However, because of the Crows Nest rates, the Thunder Bay price differs from actual received price by a freight and handling charge which remained fairly constant over the historical period.

Prices of Crops Not Subjected to Pooling

The major non-quota crops produced in Western Canada are rapeseed, flaxseed, and forages. Prices for oilseeds are discovered independently of the CWB. Deliveries to country elevators are controlled by the GDQS, however. A model of expectation formation is required for non-quota crop prices. It will be assumed that expectations for oilseeds are naive; $p^*_t = p_{t-1}$. Prices of forages will be omitted. Forages will be viewed as

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[3/] An alternative expectational model which is more efficient than III.9-III.11 in its use of information but equally devoid of a theoretical base is the following:

$$\text{Let } IP^*_t = IP_{t-1} \qquad \text{N.1}$$

Let the expected final payment be represented as a weighted average of the following form

$$FP^*_t = (1-\gamma)\ [PS_{t-1} - IP_{t-1}] + \gamma FP_{t-2},\ 0 \leq \gamma \leq 1 \qquad \text{N.2}$$

where PS is the CWB selling quotation, basis Thunder Bay. The first term represents the current forecast of FP_{t-1}. The last term is the latest known final payment. The above forecasting rule incorporates some information about current and past final payments. The resulting expression for the expected final realized price, from III.8, therefore, is:

$$P^*_t = \gamma[IP_{t-1} + FP_{t-2}] + (1-\gamma)\ PS_{t-1} \qquad \text{N.3}$$

non-traded intermediate inputs. Consequently, prices are implicitly determined and are reflected in the prices of outputs and purchased substitutes.

The dominant oilseed currently is rapeseed. However, as was mentioned in Chapter 1, rapeseed is a recent addition to Prairie crop enterprises. Prior to 1955, rapeseed acreage was insignificant. Flaxseed, on the other hand, was well established as a crop enterprise prior to 1948. Its acreage rose steadily throughout the historical period.

It will be assumed that rapeseed entered the production possibility set in Western Canada in 1963. This is the first year rapeseed prices were published in the Grain Trade of Canada. Prior to 1963, the price of rapeseed is set equal to zero, after 1963 prices are positive. This approach ignores the gradual adoption of rapeseed production over the historical period. As a first approximation, this technique will suffice. If rapeseed prices indeed appear to be important explanatory variables, then a refinement of the estimation procedure may be warranted.

Prices of Livestock

The theoretical model stated that grain supply on a grain-livestock farm should be specified as a function of livestock prices. The direction of the relationship could not be unambiguously determined either with or without a binding delivery quota. In this section, we elaborate on the sources for the ambiguity and search for an empirical representation of expected livestock price.

For livestock enterprises whose production period is relatively short--hogs for example--an increase in the expected price of hogs would tend to increase hog production and therefore demand for grain. If hog and grain enterprises must compete for fixed factors, there may be a concomitant leftward shift in grain supply. Marketings of grain would decrease. Under a binding quota, the quota-adjusted price for grain would be bid upward causing an upward movement along the grain supply curve. If competition for fixed factors is low--the shift in supply is small--grain production would increase in response to an increase in hog prices. If the quota was non-binding, then production could decrease or remain unchanged.

The production period for beef cattle is relatively long. Consequently, an increase in the price of beef may have several short- or long-term effects. In the short run, feeders may carry animals currently in the lot to heavier weights. This would increase feed consumption per head. Yearlings or long yearlings could be moved from pasture to feedlot. Calves could be fed out rather than slaughtered. On the other hand, in an attempt to expand the breeding herd--a longer-run response--the heifer retention rate would increase and the culling rate for cows would fall. Within a crop year, therefore, feedlot placements may increase or decrease. In the short run, the response to a change in expected beef price remains ambiguous.

One approach to resolving the ambiguity would be to appeal to the recursive nature of grain production and demand. At the time the cropping decision is made, the current level of feed demand reflects the effect of earlier decisions on the livestock activity. Therefore, it would seem reasonable to view grain demand as given at the time the cropping decision is made. Once grain output is determined, the feeding activity can be adjusted in response to new information on prices or quotas during the crop year.

The fixed level of demand will be represented in the supply equations by the grain consuming capacity of the livestock population. Actual livestock numbers are aggregated into animal units. Appendix B describes how the animal unit series were calculated. To repeat, in the absence of a delivery quota, crop production may increase or remain the same in response to a decrease in livestock numbers if grain prices and quotas are held constant. With a binding delivery quota, a decrease in livestock numbers would cause a decrease in crop production.

Quota Variables

In Chapter 2, we discussed how the various quota systems in effect over the historical period could be incorporated in a consistent manner into the theoretical model. In specifying the empirical quota variables, it will be convenient to follow the same historical development.

1948/49-1952/53. During most of this period, seeded acreage quotas were employed by the CWB. However, they were declared open before the end of the crop year. In 1952/53, marketings were constrained by a "basic" quota of 15 bushels per seeded acre of wheat, oats, and barley. The following year, 1953/54, the general quota was introduced without the unit quota. The period from 1948/49-1951/52 can be incorporated into the model by simply omitting the quota variables from the specification, or equivalently, setting them equal to zero. Crop year 1952/53 was an aberration. Farmers' marketings were severely and unexpectedly restricted. Excess production accumulated in inventories. It will be assumed that farmers had some prior knowledge about the new general quota that was introduced in 1953/54 when their land use decisions were made for the 1953/54 crop year. Consequently, the impact of the 1952/53 seeded acreage quota was felt only on farmers' stocks of wheat, oats, and barley. The seeded acreage quota was unknown when the output decision for 1952/53 was made and the general quota was applicable for the year following. To the extent that stocks influence production, the seeded acreage quota affected land use.

1953/54-1969/70. In the last chapter, it was shown that the marketing constraint formed by the system of quotas employed by the CWB during this period described a concave polyhedron. If the equation of the hyperplane in which the NVA optimum occurs is known, then the model developed in Chapter 2 can be applied directly. The equation of the relevant hyperplane collapses the entire quota system into a single constraint that can be expressed generally as

$$\sum_{i=1}^{n'} \alpha_i c_i = \bar{k}$$

where the α_i are combinations of the quota delivery parameters (a_i, u_i), and $\bar{k}$ is a combination of the constraint constants ($\bar{A}$, $\bar{U}$).

The linear programming problem given in Chapter 2 does, under certain assumptions, characterize the delivery constraint imposed by the GDQS. It is, however, in a form that is awkward to employ empirically. A more convenient approach can be developed.

For every crop year t, a vector of deliveries under quota to the CWB is observable. This vector will be designated $\bar{c}_t \equiv [\bar{c}_{1t}, \bar{c}_{2t}, \bar{c}_{3t}, \bar{c}_{4t}]$. In order to determine the equation of the hyperplane in which $\bar{c}_t$ lies, one can arbitrarily select three of the elements of $\bar{c}_t$ and maximize deliveries of the fourth subject to the GDQS. Suppose that the first crop is wheat, then the linear programming problem is

$$\text{Max } c_{1t} \equiv \sum_{j=1}^{3} c_{1jt} \qquad t = 1954\text{-}1969$$

subject to

1. $\sum_{i=1}^{4} a_{it}\, c_{i1t} \leq A_t$; general quota

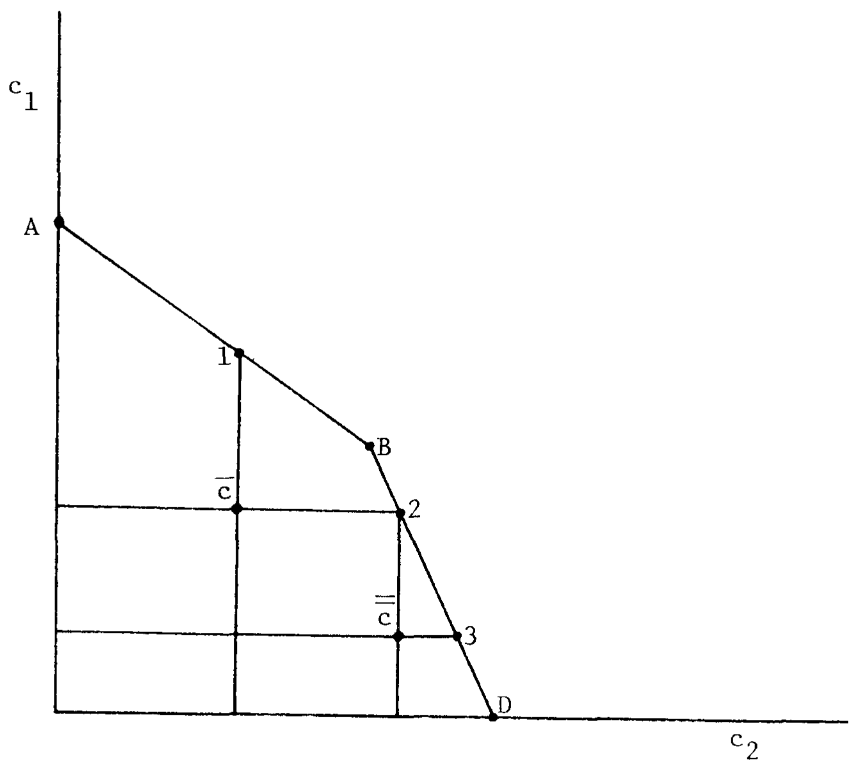
2. $\sum_{i=1}^{4} u_{it}\, c_{i2t} \leq \bar{U}_t$; unit quota

3. $c_{i3t} = s_{it}\, A_{it}$; supplementary quota

4. $\sum_{j=1}^{3} c_{ijt} = \bar{c}_{it}$; $i = 2, 3, 4$

By noting all $c_{ij} > 0$ in the solution set, it is feasible to solve the system 1-4 for the equation of the hyperplane. Because only one observation per year is available, it is not possible to statistically test the hypothesis that the observed $\bar{c}_t$ lies in the hyperplane. The approach taken in this study will be to change the objective function and look for consistency in the basic solutions to the program. In other words, for a given year, the program could be run three times; first to maximize wheat deliveries, then barley deliveries, and finally oats deliveries--subject to the quotas and deliveries of the remaining grains. Figure 3.3 demonstrates the basic idea.

Figure 3.3. Testing for consistency in selection of the quota hyperplane.



For crops c_1 and c_2, the DOL is given by ABD. Suppose the observed delivery vector is $\bar{\bar{c}}$. Maximizing deliveries of c_1 would select the hyperplane BD at point 2. Maximizing deliveries of c_2 would also select BD at point 3. In this case, no ambiguity exists. If, on the other hand, the observed delivery vector is $\bar{c}$, then maximizing deliveries of c_1 would select AB (point 1), and maximizing c_2 deliveries would select BD at point 2.

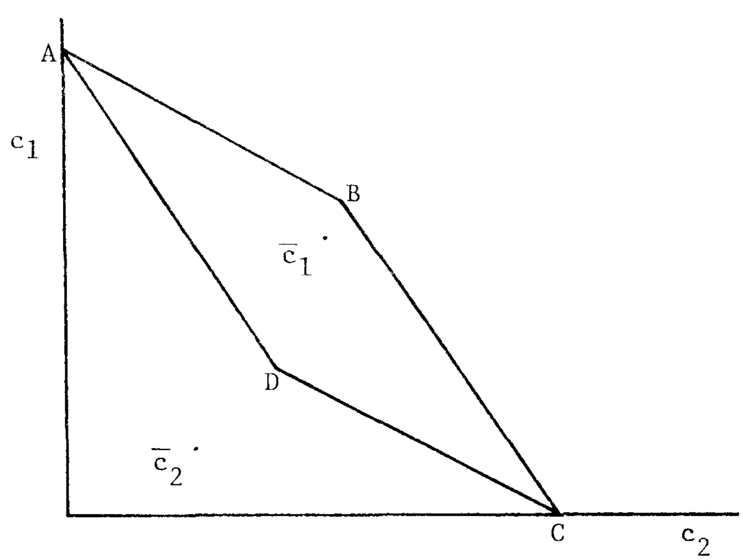
The choice of the relevant hyperplane in this case is up to the researcher.[4/]

1970/71. The LIFT program in 1970/71 was an abrupt change from previous quota policy. Details of LIFT were announced well before planting. By basing wheat deliveries on land in summer fallow and the increase in forages, the CWB induced a single-period structural change which cannot be simply incorporated into the model.

[4/] If the entire program in 1-4 is multiplied through by -1, then the lower boundary of the delivery set, consistent with binding quotas, can be determined. The delivery set for binding quotas in two dimensions is given by the parallelogram ABCD in the figure below.

It would be feasible to analytically determine whether or not an observed delivery vector was within the set. If it were in the interior, say point $\bar{c}_2$, this implies the quota was not binding and the associated variables should be omitted from the structural equations. However, this hypothesis can be tested statistically and is less subject to specification problems associated with the quota. Therefore, the analytical test of $\lambda \geq 0$ will not be undertaken.

Upper and lower bounds of the delivery opportunity set.



Two alternatives are available. First of all, 1970/71 can be thrown out of the sample. This is undesirable, however, because the dynamic impacts of LIFT in the years following would seem to be important. The other alternative is to incorporate the LIFT quota into the model in an approximate manner. As a first approximation, the constraint constant for wheat will be assumed to be the acreage of land in summer fallow and forages. Since the quota acreage for wheat was allocable to other quota grains, the constraint constant for the feed grains will be equivalent to total assigned acreage. The delivery parameters will be those existing on July 31, 1971.

This approach to LIFT is admittedly less than ideal. Although the LIFT quota structure can easily be incorporated into a theoretical model, the changes due to the quota are reflected in changes in the structure of the supply and demand functions and not the exogenous variables upon which they are defined.

1971/72-Present. The new quota structure introduced following LIFT is easily incorporated into the model. The unit and supplementary quotas were eliminated. Consequently, the equation of the relevant hyperplane can be written directly. Quotas for all grains were declared open prior to July 31 from 1972/73 through 1974/75. In 1975/76, ending quotas for wheat averaged 30 bushels per assigned acre. Quotas for barley and oats stood at 50 bushels per assigned acre. At the end of the 1976/77 crop year, the cumulative quotas for wheat, oats, and barley averaged 9, 13, and 75 bushels per assigned acre respectively (CWB Annual Reports).

Expectations. As with prices, farmers based their production decisions on expected quota delivery parameters. As a first approximation, it will be assumed that expectations were formed naively. The quota hyperplane applicable to crop year t-1/t will be assumed to persist in crop year t/t+1. If the quota was declared open in t-1/t, it will be assumed that farmers expect an open quota in t/t-1.

Summary. The incorporation of delivery quota variables into the estimating equations is a complicated process. One of the challenges of this research project was to develop a means for combining time series data generated under a variety of quota systems. Except for crop years 1952/53 and 1970/71, this was accomplished in a relatively straightforward manner. The problems with 1952/53 were sidestepped. Unfortunately, however, 1970/71 proved to be a bit more recalcitrant. The specification of the quota for LIFT can be viewed as an approximation and is only marginally better than omitting the observation.

To repeat the basic results of this section: The delivery quota will be specified to be of the form

$$\sum_{i=1}^{n'} \alpha_{it} \quad c_{it} \leq \bar{k}_t \ .$$

The variables appearing in the structural equations when the quota was binding are the α_i and $\bar{k}$. If a single quota crop was declared open, then $\alpha_i = 0$. If the entire quota was non-binding, then all α_i and $\bar{k}$ are set equal to zero. Naive expectations are assumed to hold for all quota variables. Because rye is a minor crop, the delivery rates for rye will be omitted from the equations.

Using a reduced-form approach leaves one vulnerable to structural changes induced by the binding quota. In other words, response to a price change may be different when the quota is binding than it is when it is not.

This hypothesis can be tested statistically.

Details on the calculation of the quota variables over the historical period are described in Appendix C.

Soil Moisture

The influence of fallowing on crop production was shown to be a function of current soil moisture reserves and expectations of prices, quota parameters, and weather variables over a finite planning horizon. Such a specification is unworkable empirically. One possible simplification would be to assume that weather expectations are invariant over the historical period and that prices are forecast for only one period. Therefore, the only variable that must be added to the model is some estimate of aggregate soil moisture reserves in Western Canada.

One possible measure of soil moisture reserves could be calculated as follows:

$$M_t = \sum_{i=1}^{n} \sum_{j=1}^{2} w_{ijt} \, m_{ijt}$$

where

i = Location of soil moisture observation;

j = Land use, previous year, 1 if stubble,
2 if fallow;

t = 1948-77.

M_t = Average soil moisture, inches of water per rooting depth;

m_{ijt} = Estimated soil moisture in inches, i^{th} location, j^{th} land use category at seeding in year t;

w_{ijt} = Proportion of tillable land in the Prairies represented by location i, use j, at time t, and it is assumed that

$$\sum_i \sum_j w_{ijt} = 1 \text{ for all } t.$$

Soil moisture data is generally not available historically. However, a soil moisture estimator has recently been developed which will predict soil moisture levels based on climatic data (Baier, et al., 1972).

One appealing feature about an index such as M_t, is that it summarizes past land use decisions as well as past rainfall and evapotranspiration. Substantial fallowing in year t-1, given normal rainfall, would result in a larger index, which would have a positive effect on seeded acreage in year t. Similarly, reduced rainfall in t-1 would cause the index to fall, which suggests increased fallowing in t at the expense of acreage seeded crops.

An alternative approach would be to employ spring rainfall as a proxy for soil moisture. This was attempted by Laforge (1973). However, his results are inconsistent with expectations. Rainfall was found to be negatively related to seeded acreage. Furthermore, the coefficient was not significant. It is difficult to separate, statistically, the effect of rainfall on soil moisture reserves from its effect on the mechanical condition of the soil. Up to a point, spring rainfall would tend to increase seeded acreage by reducing the profitability of fallow. However, excessive rainfall would impede field operations, delay planting, and cause a shift to fallow or shorter season crops. A rainfall variable will confound the two effects.

Because of the expense involved in calculating a suitable soil moisture index and the problems associated with a rainfall proxy, the soil moisture variable will be omitted from the specifications. It seems unlikely that any correlation between soil moisture and the included economic variables should exist. A short crop due to inadequate growing season moisture during t-1/t could result in larger quotas and expectations of higher prices.

However, if soil moisture reserves are built up during the remainder of the crop year, then no correlation between the lagged price and M_t would be apparent. A correlation between economic variables would exist if low soil moisture one year implied low soil moisture the next. If this were the case, then presumably omitting soil moisture could bias the estimator obtained for the included economic variables toward zero.

Inventory Adjustments

Under a binding quota, adjustment of grain stocks will have an effect on acreage supply. We include intended changes in stocks in the specification. However, it will be convenient to postpone describing how the stock variables can be specified until demand for on-farm stocks has been discussed.

The Form of the Acreage Supply Functions

Acreage supply response for wheat, oats and barley in Western Canada was estimated for the period 1948/49–1974/75. The equations were specified as linear functions. A representative equation for wheat is given below.

	(+)	(-)	(-)	(-)	(+/-)	(+/-)	(+)
AWWC:	PW*,	PO*,	PB*,	AWL1,	AOL1,	ABL1,	KBARL1,
	(-)	(+)	(+)	(+)	(+)		
	POSL1,	AUWC,	ICSO,	ICSW,	ICSB.		

Expected signs are indicated in parentheses above each variable. Traditional relationships are hypothesized to exist between grain prices. Signs for the quota variables are made on the assumption that the crop is normal. The equations for barley and oats (ABWC, AOWC) have the same independent variables. The expected signs are symmetric to the above specification for wheat.

Variables are identified as follows:

I. Dependent Variables	Description
AWWC, AOWC, ABWC	Seeded acreage of wheat, oats, and barley, respectively, Western Canada. Crop year t/t+1.
II. Independent Variables	
PW*, PO*, PB*	Expected final realized prices for wheat, oats, and barley. Possible candidates are given by III.9, III.10, or III.11.
POSL1	Lagged price of oilseed.
AWL1, AOL1, ABL1, KBARL1	Quota variables as calculated in Appendix C.
AUWC	Animal units, Western Canada, as calculated in Appendix B.
ICSW, ICSO, ICSB	Intended changes in on-farm stocks of wheat, oats, and barley, respectively, Western Canada.

The variables listed above are representative only. The actual representation of prices, animal units, and other shift variables was made on the basis of performance in the estimating equations.

Total Quantity Supplied

Total quantity supplied for Western Canada can be obtained from the identity:

$$(AWC) \times (YWC) \equiv QPWC \qquad \text{III.12}$$

Yield equations for quota grains were not estimated for this study. For examples of yield equations and the associated difficulties, see Williams (1969), Baier and Robertson (1967), or Schmitz and Watts (1970).

Demand for Feed

Quantity Demanded

Conceptually, there are few difficulties present with this variable.

It should simply state the quantity of a given grain fed to livestock in Western Canada during each crop year. Since the feed demand relationship is highly aggregated, quantity demanded would also include grain sold in the local off-board market and fed or processed into feed. Aggregation of feed demand for Western Canada only eliminates some of the loops in the flow of locally produced grain.

The major problem associated with the quantity fed variable is measuring it empirically. For this study, quantity fed in the West for each crop year is determined by means of the following identity:

Residual = beginning on-farm stocks + production + shipments from Western primary elevators to Western points - total Western marketing - ending on-farm stocks. III.13

The residual consists of animal feed consumption, seed requirements, and losses. Feed consumption is the primary component of the residual. Seed reserve is the next most important component. Because it is not possible to separate seed reserve from feed consumption it is important to consider the effect its inclusion will have on the feed demand specification.

Grain reserved for seed reflects the profitability of next year's production relative to current sales or feed consumption. If future grain prices are expected to increase relative to current levels, the seed reserve will increase. Therefore, the seed reserve will be an inverse function of current price. A similar set of relationships can be derived for quota variables and livestock prices. The specifications for feed demand and seed reserve include the same variables. The coefficients estimated using the estimated residual as the dependent variable would reflect changes in both feed demand and seed reserve.

Prices for Quota Grains

In the reduced form specification of feed demand, the relevant price for quota grains is the expected final realized price. Earlier, it was pointed out that, because of pooling, this price isn't known by farmers until six months after the end of the crop year at the earliest. The allocation of sales, whether under a binding quota or not, must be made on the basis of expected prices.

The same difficulties encountered in modeling price expectations on the supply side are present here. Presumably, the farmer has more price information when he sells his crop than was available when it was planted. However, at no time during the crop year does the producer know with certainty what price he will receive when he delivers his crop to the CWB.

The expected final realized price for wheat, oats, and barley is represented by one of the naive models given by III.9-III.11. Again, this model is a compromise and calls for further work. It is assumed that the CWB selling quotation for t/t+1 is known during crop year t/t+1. In addition, the LRFRP is amended as final payments are announced.

The quota grains are all substitutes in the feed ration. The own-price effect is assumed to be negative; cross effects are ambiguous. For feed wheat, there is an element of complementarity since it cannot be fed alone. The substitutability between feed wheat and oats or barley is hypothesized to be the dominant effect.

Livestock Prices and Population

In the supply equation, animal units are used as a proxy for expected market prices for livestock. That is, expectations of future prices are manifested in the number of livestock currently on feed. It is hypothesized that the current price of livestock and the livestock population are relevant variables in the feed demand equation.

As said earlier, a producer may adjust livestock production and, hence, feed consumption, in at least two ways. First, the number of livestock on feed can be changed. Second, the animals on feed can be fed to heavier weights. The former effect is less responsive in the short run than the latter. It seems reasonable to assume that current livestock prices would have an impact on feeding intensity and, hence, on feed demand.[5/] Consequently, feed demand will be specified as a function both of current livestock inventories and of current prices.

Given prices, quotas, and crop year production, the effect of a shift in feed demand due to changes in livestock prices or numbers is ambiguous. This again is due to the unobserved changes in the shadow price of the quota.

The animal unit series is derived in Appendix B. Possible representations of livestock prices are the slaughter steer or hog prices in Calgary or a livestock price index.

Quota Variables

The same quota variables specified for the supply equations are used in the feed demand equations. The only modification made is with the temporal

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5/There is some evidence that current prices may "explain" current inventories as well. See Tryfos (1974).

relationships between the dependent and independent variables. The delivery parameters and constraint constant relevant to crop year t/t+1 are assumed to influence feed demand during the same period.

The expected signs for the delivery parameters are given in table 2.2. An increase in the quota constraint should decrease the demand for feed if the crop is normal.

Supply Effects

Current production and inventory levels influence the quota-adjusted prices for grains and, therefore, feed demand. Total supplies of grain should be included in the demand specification when the quota is binding.

The Form of the Feed Demand Equations

Feed demand equations for wheat, oats, and barley will be specified as linear functions. A representative wheat equation would be specified as follows:

$$\text{WFWC}: \overset{(-)}{\text{PW*}}, \overset{(+)}{\text{PO*}}, \overset{(+)}{\text{PB*}}, \overset{(+)}{\text{AW}}, \overset{(+/-)}{\text{AO}}, \overset{(+/-)}{\text{AB}}, \overset{(-)}{\text{KBAR}},$$
$$\overset{(+/-)}{\text{AUWC}}, \overset{(+/-)}{\text{PLWC}}, \overset{(+)}{\text{TFSWWC}}, \overset{(+)}{\text{TFSOWC}}, \overset{(+)}{\text{TFSBWC}}$$

Expected signs are designated above each variable. Traditional behavior of prices is assumed. Wheat is assumed to be a normal crop with respect to the quota. Symmetric relations hold for oats and barley. Possible candidates for expected grain prices are the CWB selling quotation and the latest final realized price received prior to the end of the crop year. Other variables not previously identified are as follows:

I. Dependent Variables	Description
WFWC, OFWC, BFWC	Wheat, oats, barley fed in Western Canada, crop year t/t+1.

II. Independent Variables

PLWC	Price of livestock in Western Canada.
TFSWWC, TFSOWC, TFSBWC	Total farm supplies, wheat, oats, and barley in Western Canada.

Demand for Stocks

The demand for on-farm stocks in Western Canada includes all of the variables specified for the feed demand equation. Adjusting inventories to changes in economic variables is often characterized by some amount of inertia. A simple way of representing this is through the partial or stock-adjustment model. Suppose that

$$I_t^{\dagger} = a + Z_t^* b$$

where

$I_t^{\dagger}$ = Desired ending stocks period t

a = A scalar

Z_t^* = A 1 x n vector of expected explanatory variables

b = An n x 1 vector of coefficients

The mechanism assumed for adjusting stocks is $I_t - I_{t-1} = \gamma(I_t^{\dagger} - I_{t-1})$ where

I_t = Actual ending stocks

γ = Coefficient of adjustment, $0 \leq \gamma \leq 1$.

Using the adjustment mechanism to eliminate the unobservable $I_t^{\dagger}$, the final form is

$$I_t = \gamma_a + \gamma Z_t^* b + (1-\gamma) I_{t-1} .$$

If it is desired to treat demand for stocks in a partial adjustment setting, the only addition to the specification is the lagged stocks variable. Under a delivery quota, unexpected changes in production are directly translated into changes in the levels of on-farm stocks. The excess stocks, given prices and quotas, can be disposed of either through sales, which implies a reduction in output, or through livestock. Any inertia present in livestock or crop production might be reflected in inventory adjustment.

The Form of the Demand Equations for On-Farm Stocks

A representative demand equation for on-farm wheat stocks can be written as follows:

$$\text{OFSWWC}: \overset{(-)}{\text{PW*}}, \overset{(+)}{\text{PO*}}, \overset{(+)}{\text{PB*}}, \overset{(+)}{\text{AW}}, \overset{(+/-)}{\text{AB}}, \overset{(+/-)}{\text{AO}}, \overset{(-)}{\text{KBAR}}, \overset{(+/-)}{\text{AUWC}},$$

$$\overset{(+/-)}{\text{PLWC}}, \overset{(+)}{\text{TFSWWC}}, \overset{(+)}{\text{TFSOWC}}, \overset{(+)}{\text{TFSBWC}}, \overset{(+)}{\text{OFSWWCL1}}.$$

Other variables not previously identified are as follows:

I. Dependent Variables	Description
OFSWWC, OFSOWC, OFSBWC	On-farm stocks of wheat, oats, and barley in Western Canada on July 31, t+1.

Symmetric equations are specified for oats and barley.

Estimating Intended Changes in Stocks

The supply equations for Western Canada were hypothesized to be a function of intended changes in stocks. In this section, a simple method will be suggested for estimating intended stock changes.[6/]

[6/] Note that a distinction is now introduced between a farmer's <u>desired</u> level of stocks--what he would like to hold--his <u>intended</u> change toward his <u>desired</u> level of stocks and <u>actual</u> stock changes and levels.

Consider the following accounting identity for a particular quota crop.

$$Y^*_{1t}\ A_{1t} - d^*_{1t}\ \tilde{A}_{1t} - F^*_{1t} = \Delta I^*_{1t} \qquad \text{III.14}$$

where

Y^*_{1t} = Expected yield, crop one;

A_{1t} = Seeded acreage, crop one;

d^*_{1t} = Expected delivery rate for crop one;

$\tilde{A}_{1t}$ = Quota acres assigned to crop one;

F_{1t} = Expected quantity fed to livestock;

ΔI^*_{1t} = Intended changes in stocks.

The identity given by III.14 would hold at the time the producer made his land use decision. Now, write the same identity using actual values:

$$Y_{1t}\ A_{1t} - d_{1t}\ \tilde{A}_{1t} - F_{1t}\ \Delta I_{1t}. \qquad \text{III.15}$$

By subtracting III.14 from III.15, one obtains

$$(d^*_{1t} - d_{1t})\ \tilde{A}_{1t} - (Y^*_{1t} - Y_{1t})\ A_t + (F^*_{1t} - F_{1t}) =$$

$$\Delta I_t - \Delta I^*_t \qquad \text{III.16}$$

Expression III.16 states that actual stock changes differ from intended stock changes by a forecasting error. In this case, the forecast error is a linear combination of forecasting errors associated with yields, delivery rates, and feed consumption. Denote the forecasting error by FCE_t; then

The specification for the intended stock change equation differs from the stock demand equations in two important ways.

1. The intended stock change is a decision made at planting time in conjunction with the supply decision. Consequently, it is based upon expectations of prices and quotas formed at planting time.

2. The stocks demand equation specified earlier reflects expectations and decisions made after the crop has been produced.

As a result, the equation for intended changes in stocks for period t/t+1 differs from the demand equation for stocks during the same time period. The former, in essence, represents a forecast of the latter, made prior to planting.

However, all of the variables included in Z_{t-1} already appear in the acreage response equations. Therefore, under the assumption that the partial adjustment mechanism is valid, the effect of intended changes in stocks on acreage response under quota can be represented by simply including the lagged inventory variables for wheat, oats, and barley in the supply equation. The coefficient estimated is the product of the associated structural coefficient in the supply equation and the coefficient of adjustment in the stocks equation.

The acreage response equations for Western Canada can be respecified by replacing ICSW, ICSO, and ICSB with OFSWWC, OFSOWC, and OFSBWC,

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distinction between intended and actual changes in stocks. Suppose the expected value of FCE_t were non-zero. Then the estimated intended changes in stocks would be off, in expected value, by a constant. So long as the supply function in which the estimate of intended stock changes used was linear, only the intercept would be biased.

respectively [8/] The expected sign for each inventory variable in the supply equations is negative.

Farm-Level Relationships for Eastern Canada

Introduction

The farm-level relationships for Eastern Canada are estimated using fairly standard specifications. In addition to the variables suggested by the theoretical model, other variables must be included to account for characteristics unique to Eastern agriculture. The rapid adoption of a corn- and soybean-based agriculture in Ontario, the steady decline in oats production, the relative importance of the dairy and broiler industries, and the strong influence of United States agricultural markets are examples of some of the distinctive differences between Eastern and Western agriculture. The grains considered in this section are wheat, oats, barley and corn.

Grain Supply

Grain supply in Eastern Canada will be represented by seeded acreage. The first group of independent variables which we discuss is expected grain prices. Since price pooling is not performed in the East, traditional representations of expected prices can be utilized. For the moment, we assume

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[8/] The time periods for the stock adjustment model and the supply model may be confusing. $ICSW_t$ refers to the intended change in stocks over the period t/t+1, which influenced planting for crop year t/t+1. Hence, lagged inventory variable $OFSWWC_{t-1}$ in the stock adjustment model refers to the level of wheat stocks on farms on July 31, year t. For wheat, $ICSW_t = f(OFSWWC_{t-1})$. However, to make the time reference consistent with acreage, $AW_t = f(OFSWWC_t : \ldots)$.

that expectations are formed naively. The expected prices for wheat, oats and barley will be represented using lagged CWB selling quotations basis Thunder Bay. Prior to August 1976, the feed freight assistance policy removed most of the freight charge; consequently the Thunder Bay price was the Eastern Canada price. Following the removal of the FFAP subsidy, the Thunder Bay prices should be adjusted accordingly. The price of corn will be specified using the Chatham, Ontario, cash price.

The only major non-grain substitute to be considered is soybeans. The lagged Ontario cash price will represent the expected price of soybeans.

To account for both the adoption and the secular yield improvement of corn and soybeans in the East, a lagged dependent variable and a specific time trend will be employed. This is analogous to the approach taken recently in United States supply response literature (see, for example, Ryan and Abel, 1973a, 1973b).

The effect of the livestock sector on grain supply can be accounted for by the prices of livestock and milk, and by the size of the livestock population. Prices of purchased factors and fixed factor constraints will be omitted from the specification because of data or measurement problems.

Demand for Feed

Farm disappearance of grain, feed, seed reserve and waste is estimated by subtracting the calculated western residual from national farm disappearance, a published statistic. The residual estimated for Eastern Canada serves as the dependent variable in the feed demand equations.

Crop year prices for wheat, oats and barley are specified as CWB quotation basis Thunder Bay. Chatham prices are used for corn. Because of the importance of soybean meal in Eastern Canada, its price is included in the demand model. Livestock prices and numbers are included to account for changes in both the level and duration of feeding activities.

Demand for Stocks

In Eastern Canada, in the absence of price pooling and delivery quotas, all three motives for carrying stocks are potentially operable--transactions, precautionary and speculative. The first two motives are reflected in the current grain demand variables. The strength of the speculative motive is reflected in future price expectations relative to current price levels. As a first approximation, therefore, expected prices are represented by an exponential distributed lag. The lagged dependent variable included in the model can also be justified on the basis of partial stock adjustment.

On-farm stocks in the East for wheat, oats, and barley are calculated by subtracting western stocks from national stocks. Data for on-farm corn stocks are not available.

Dependent variables included in the stocks' equations are the same as described for the feed demand model. The only additional variable is lagged on-farm stocks.

Domestic Food and Industrial Demand

A set of equations is required to account for domestic utilization of wheat, oats, barley, and corn for human food and by processing industries. Standard specifications fo the demand equations are employed.

Data on food and industrial disappearance of grain from Canada are published. These serve as the dependent variables in the demand equations. Crop year grain prices are specified using CWB selling quotations for wheat, oats, and barley and Chatham prices for corn. Other variables included are personal disposable income, population, and a dummy variable accounting for the introduction of the two-price wheat policy. Prices and incomes are specified using both current and deflated values. The consumer price index for all commodities was used as a deflator.

Omitted Structural Relationships

Several structural relationships required for the complete specification of Canada's excess supply were omitted. Demand equations for ending commercial stocks for wheat, oats, and barley were not specified. Commercial stocks for the three grains are largely under CWB jurisdiction. Without a behavioral model for the CWB, it is difficult to correctly specify these relationships. On-farm stock demand for corn is omitted because data are not available. Commercial stocks of corn are omitted. Historically, commercial corn stocks have made up a rather small component of total supplies (in recent years, 1-5 per cent). These represent primarily pipeline stocks. Stocks of corn held in the United States are readily available to supply commercial demand in Canada. Therefore, it is doubtful that commercial stocks significantly influence Canada's import demand for corn. Because commercial demand for stocks is omitted, the model estimates exportable surpluses for Canada's grains.

Appropriate Estimation Techniques

The entire model as it has been specified thus far is completely predetermined. Prices and policy variables cannot be endogenously determined until a behavioral model for the CWB has been developed which will link Canada's structural relationships with the world wheat and feed grain economy. Despite the absence of simultaneity, cross equation correlation cannot be ruled out. In this case, a seemingly unrelated regression technique would be more efficient than OLS (Zellner, 1962). In this preliminary study, we will rely primarily on OLS since OLS estimates are still unbiased.

The analysis of farm-level relationships in Western Canada demonstrated that the behavior of certain variables in the reduced-form model can change when a binding delivery quota is in effect. A binding delivery quota induces structural changes which can be accounted for only by specifying a set of dummy variables which allow the coefficients to change when the quota is binding and when it is not. This procedure essentially doubles the number of variables in each estimating equation. Since the quota may not induce significant structural shifts for all variables, a search would be required to find that subset of variables which displays the greatest degree of change with and without a binding quota. At this stage in the model's development, we do not feel the expected gain from this procedure to be worth the additional effort in estimation. Consequently, we ignore any possible structural shifts. The regression coefficients will reflect the historical net effect of binding and non-binding quotas on the structural variables. Since the bulk of the historical period was marked with apparently binding quotas, their effect should dominate the estimated coefficients.

Chapter 4

STATISTICAL RESULTS

Introduction

The model specified in the previous chapter consists of twenty-four structural equations and four identities. In this chapter, we report estimates of the structural relationships. Our analysis will focus on the following:

1. We test the extent to which identified structural variables influence Canada's grain economy. If there are theoretical ambiguities or shortcomings, we examine how they affect the reliability or interpretation of the estimated coefficients.

2. We assess the adequacy of existing data sources for specifying or measuring the theoretically derived variables.

The statistical results for each major group of structural relationships are presented in tables 4.1 to 4.7. Although several specifications of each relationship are estimated, we present the one equation which we feel displays the greatest consistency with the theoretical model. A more detailed listing of estimated equations for Western Canada as well as the raw data for the study is presented in Jolly (1976).

The format for all tables is the same. The dependent variable is identified in the first column. Independent variables are identified across the top of the table. The constant for the regression and the R^2 and Durbin-Watson (D-W) statistics are given in the last three columns. For each independent variable, the regression coefficient is given first (β), followed by its 't' value. The elasticity evaluated at the mean (E) is computed for all grain prices. If a lagged dependent variable is included in the specification, the short-run elasticity (SRE) and long-run elasticity (LRE) are given. The hypothesized sign for each independent variable is shown above the estimate.

In tables 4.8-4.12, all included variables are identified along with the units in which they are expressed. Details on the calculation of quota variables and animal units are given in Appendices B and C.

All structural equations are estimated from annual time series data using OLS. For certain groups of equations, the period of fit was altered because data were not available. Crop year 1948/49 is the first observation for all structural relationships in Western Canada. Lack of corn disposition data and several price variables necessitates beginning the estimation of Eastern Canada and national food and industrial demand relationships with the 1955/56 crop year. Acreage response equations are estimated through crop year 1974/75 for both Western and Eastern Canada. A drastic change in hog survey techniques in 1974 requires us to end the period of fit for all demand equations with the 1973/74 crop year.

Table 4.1. Acreage supply response for Western Canada, 1948/49-1974/75.

Dependent Variable		SLRFRPW	PSOL1	PSBL1	AWL1	AOL1	ABL1	KBARL1	KBARFGL1	PRPWCL1	AU1WC	AU2WC	Constant	R^2	D-W
		+	-	-	-	+/-	+/-	+							
AWWC	B	159.89	210.22	-154.07	-89702.1	-28013.7	56959.0	66.33					-247.63	.61	2.15
	t	3.37	1.52	-2.07	-3.44	-.62	1.17	1.53							
	E	1.16	.76	-.85											
		-	+	-	+/-	-	+/-		+	-		+			
AOWC	B	-12.56	75.46	-17.20	-5857.2	28762.1	-29502.3		19.81	-5.41		-1.21	8156.2	.88	1.57
	t	-1.39	3.07	-1.17	-1.17	3.59	3.37		2.46	-4.85		-2.33			
	E	-.36	1.06	-.37						-.11					
		-	-	+	+/-	+/-	-		+		+				
ABWC	B	-43.45	-49.11	44.52	32729.2	36987.8	-32480.4		39.68		1.18		8410.5	.56	1.40
	t	-1.41	-.54	.90	1.79	1.29	-1.07		1.32		2.69				
	E	-.94	-.53	.74											

Table 4.2. Feed demand for Western Canada, 1948/49 - 1973/74.

Dependent Variable		PSW	PSO	DLRFRPB	AW	AO	AB	KBAR	KBARFG	AU3WC	CU1WC	HU2WC	PSTRSWC	PHGSWC	TFSBWC1	TFSOWC1	Const.	R^2	D-W
		-	+	+	+	+/-	+/-	-				+/-		+/-	+				
WFWCN	B	-.058	-.37	.17	107.74	200.84	-203.21	.066				.017		.94	-.051		47.79	.39	2.43
	t	-.52	-.84	.91	.76	1.30	-1.31	.43				1.89		1.13	-1.28				
	E	-.16	-.43	.26															
		+	-	+	+/-	+	+/-		-		+/-	+/-	+/-			+			
OFWCN	B	.18	-1.73	.70	-422.45	-453.94	441.31		.096		.017	.038	2.91			.093	32.89	.78	1.43
	t	.81	-1.86	1.53	-1.67	-1.52	1.54		.22		1.76	1.65	1.75			1.14			
	E	.18	-.77	.40															
		+	-	-	+/-	+/-	+		-	+/-			+/-						
BFWCN	B	.049	-.25	-.97	418.25	398.39	-173.86		-.64	.027			6.40				-42.33	.90	1.68
	t	.23	-.28	-2.60	1.77	1.47	-.66		-1.82	3.18			5.00						
	E	.07	-.17	-.83															

Table 4.3. On-farm stocks demand for Western Canada, 1948/49-1973/74.

Dependent Variable		PSW	PSO	PSB	DLRFRPB	AW	AO	AB	KBAR	KBARFG	CU1WC	HU2WC	PSTRSWC	PHGSWC	TFSWWC1	TFSOWC1	TFSBWC1	Const.	R^2	D-W
		-	+	+		+	+/-	+/-	-		+/-	+/-	+/-		+					
OFSWWC	B	-.56	-8.14	4.50		1887.41	-1354.07	1994.19	-3.82		.082	-.13	6.52		-.14		.74	-30.35	.94	2.41
	t	-1.01	-3.84	2.96		3.35	-2.35	3.37	-5.00		4.31	-3.19	2.39		-.97		3.09			
	E	-.68	-.44	3.67																
		+	-	+		+/-	+	+/-		-						+				
OFSOWC	B	.078	-1.95	.87		90.04	-203.87	309.86		-.39						.13		77.24	.56	2.17
	t	.27	-1.76	1.09		.38	-.76	1.28		-1.08						1.73				
	E	.24	-2.63	1.79																
		+	+		-	+/-	+/-	+		-	+/-	+/-	+/-	+/-						
OFSBWC	B	.19	-.83		-.42	597.08	316.27	38.91		-.91	.018	.031	3.83	-1.25				37.53	.89	2.85
	t	1.38	-1.61		-1.58	4.10	1.88	.24		-4.22	3.11	-2.15	3.59	-1.15						
	E	.68	-1.38		-.87															

Table 4.4. Acreage supply response for Eastern Canada, 1955/56-1974/75.

Dependent Variable		PCNECL1	PSOL1	PSBL1	PSWL1	PBNSECL1	LACNEC	LAOECN	LABECN	LAWECN	TRENDC	Const.	R^2	D-W
		+	-				+				+/-			
ACNEC	B	.38	-.36				.87				1.93	-12.39	.99	2.25
	t	3.75	-2.29				22.46				5.98			
	SRE	.67	-.40											
	LRE	5.15	-3.08											
		-	+		-	-		+			+/-			
AOECN	B	2.59	8.89		-2.85	-1.44		.82			-39.50	323.99	.98	2.09
	t	.45	1.51		-1.14	-1.55		8.51			-3.02			
	SRE	.15	.31		-.23	-.17								
	LRE	.83	1.72		-1.28	-.94								
			-	+	-				+		+/-			
ABECN	B		-2.44	2.00	-.30				.86		8.86	31.93	.98	1.90
	t		-2.49	2.49	-.93				17.92		5.63			
	SRE		-.84	1.04	-.24									
	LRE		-6.00	7.43	-1.71									
				-	+					+	+/-			
AWECN	B			-2.88	1.50					.53	-7.82	328.78	.75	2.47
	t			-1.92	1.91					3.54	-1.77			
	SRE			-.78	.62									
	LRE			-1.66	1.32									

Table 4.5. Feed demand for Eastern Canada, 1955/56-1973/74.

Dependent Variable		PSW	PSO	PSB	PCNEC	PSBMLCN	PMFGMLK	PHGSEC	PSTRSEC	CU2EC	HPU2EC	Year	Const.	R^2	D-W
				+	-	+	+	+	+						
CNFTC	B			.21	-.57	4.52	15.06	1.13	-.34			3.15	-185.45	.98	2.27
	t			1.17	-2.00	1.75	1.55	1.76	-.36			4.28			
	E			.47	-1.35	.44									
				-		+	+	+	+						
BFECN	B			-.32		7.59	17.79	-.91	-.42			.20	8.56	.90	2.28
	t			-3.55		4.34	2.44	-2.22	-.57			.37			
	E			-1.14		1.17									
		+	-	+		+	+	+	+	+	+				
OFECN	B	1.05	.92	-1.09		-21.42	-29.69	-3.55	1.86	.13	.03		-326.70	.96	1.95
	t	3.01	1.43	-2.16		-2.99	1.54	-3.89	.83	2.61	1.26				
	E	1.52	.57	-1.03		-.88									
		-	+		+	+	+	+	+						
WFECN	B	-.85	.37		.84	15.34	13.04	.21	1.48			-4.57	162.83	.50	1.94
	t	-1.98	.66		1.22	1.92	.67	.16	.74			-2.73			
	E	-7.69	1.42		5.19	3.92									

Table 4.6. On-farm stocks demand for Eastern Canada, 1955/56-1973/74.

Dependent Variable		PSW	PSO	PSB	PCNEC	PSBMLCN	PMFGMLK	PHGSEC	PSTRSEC	CU1EC	HPU1EC	HPU2EC	Year	LOFSOEC	LOFSBEC	LOFSWEC	Const.	R^2	D-W
			-	+	+	+	+	+	+	+	+			+					
OFSOECN	B		-.48	.34	-.18	.77	-7.08	.26	.17	-.003	-.0001			.58			52.03	.69	2.10
	t		-1.78	1.55	-.91	.43	-1.07	.62	.27	-.28	-.02			1.90					
	SRE		-2.40	2.60	-1.47	.25													
	LRE		-5.71	6.19	-3.50	.59													
				-			+	+	+						+				
OFSBECN	B			-.05			3.76	-.01	.29				-.13		-.26		-.71	.79	1.85
	t			-2.56			1.84	-.09	1.48				-.87		-.98				
	SRE			-2.03															
	LRE			-2.03															
		-		+	+	+	+	+	+	+		+				+			
OFSWECN	B	-.16		.12	.17	1.57	-2.86	-.08	.13	-.01		.001				.13	31.23	.77	2.19
	t	-3.14		2.49	2.32	1.70	-1.26	-.54	.59	-2.72		.25				.42			
	SRE	-10.42		5.29	7.94	2.97													
	LRE	-11.98		6.08	9.13	3.41													

Table 4.7. Food and industrial demand for grain in Canada, 1955/56-1973/74.

Dependent Variable		PSWDEF	PSODEF	PSBDEF	PCNDEF	PDIDEF	CDNPOP	DV2PW	Const.	R^2	D-W
		-				+	+	+/-			
FINCWTCN	B	-.032				11.90	1.83	-1.09	21.20	.87	2.62
	t	-.030				.46	1.48	-.48			
	E	-.001				.087					
					-	+	+				
FINCCNTC	B				-2.38	28.34	1.20		-12.42	.97	.96
	t				-2.10	3.14	2.18				
	E				-.21	.658					
				-		+	+				
FINCBTCN	B			-1.79		17.86	.15		8.78	.93	2.98
	t			-2.99		2.97	.41				
	E			- .17		.480					
			-		+	+	+				
FINCOTCN	B		-.58		.73	-13.46	.74		3.79	.78	1.99
	t		-.82		1.48	- 6.56	5.89				
	E		-.12		.25	- 1.209					

Table 4.8. Animal units.

Variables	Identification	Units
AU1WC	Animal Units, Series 1, Western Canada	1000's
AU2WC	Animal Units, Series 2, Western Canada	1000's
CU1WC	Cattle Units, Series 1, Western Canada	1000's
CU2WC	Cattle Units, Series 2, Western Canada	1000's
CU2EC	Cattle Units, Series 2, Eastern Canada	1000's
HPU1EC	Hog and Poultry Units, Series 1, Eastern Canada	1000's
HPU2EC	Hog and Poultry Units, Series 2, Eastern Canada	1000's
HU2WC	Hog Units, Series 2, Western Canada	1000's

Table 4.9. Quota variables.

Variables	Identification	Units
AB	Delivery parameter, barley demand	Acres/bushel
ABL1	Delivery parameter, barley supply	Acres/bushel
AO	Delivery parameter, oats demand	Acres/bushel
AOL1	Delivery parameter, oats supply	Acres/bushel
AW	Delivery parameter, wheat demand	Acres/bushel
AWL1	Delivery parameter, wheat supply	Acres/bushel
KBAR	Quota constraint constant, demand	Million acres
KBARFG	KBAR, except 1970 = 74.780	Million acres
KBARFGL1	KBARL1, except 1970 = 74.780	Million acres
KBARL1	Quota constraint constant, supply	Million acres

Table 4.10. Prices.

Variables	Identification	Units
DLRFRPB	Latest received final realized price #1 Northern wheat, Thunder Bay, demand model	¢/bushel
PBNSECL1	Price No. 2 or better, soybeans, Ontario, lagged one year	¢/bushel
PCNDEF	PCNEC/CDNCPIAC	constant ¢/bushel
PCNEC	Price No. 2 or better, corn, Ontario	¢/bushel
PCNECL1	Price No. 2 or better, corn, Ontario, lagged one year	¢/bushel
PFSWC	Price No. 1 Canada Western flax seed, Winnipeg	¢/bushel
PHGSEC	Price of index 100 hogs, Toronto, calendar year	$/cwt
PHGSWC	Price of index 100 hogs, Calgary, calendar year	$/cwt
PMFGMLK	Average farm price for manufactured milk, Ontario	$/cwt
PRPWCL1	Price, No. 1 Canada Western rapeseed, Winnipeg, lagged one year	¢/bushel
PSB	CWB Selling Quotation, No. 3 Canada Western 6 row barley, Thunder Bay	¢/bushel
PSBDEF	PSB/CDNCPIAC	constant ¢/bushel
PSBMLCN	Price soybean meal, average feed dealer's price, Ontario	$/cwt
PSBL1	Price of barley, as above, lagged one year	¢/bushel
PSO	CWB Selling Quotation, No. 2 Canada Western oats, Thunder Bay	¢/bushel

(continued)

Table 4.10. Prices (continued).

Variables	Identification	Units
PSODEF	PSO/CDNCPIAC	constant/¢/bushel
PSOL1	Price of oats, as above, lagged one year	¢/bushel
PSTRSEC	Price of good steers, Toronto, calendar year average	$/cwt
PSTRSWC	Price of choice steers, Calgary, calendar year average	$/cwt
PSW	CWB Selling Quotation No. 1 Northern wheat, Thunder Bay	¢/bushel
PSWDEF	PSW/CDNCPIAC	constant ¢/bushel
PSWL1	Price of wheat, as above, lagged one year	¢/bushel
SLRFRPB	Latest received final realized price No. 3 Canada Western 6-row barley, Thunder Bay, supply model	¢/bushel
SLRFRPO	Latest received final realized price, No. 2 Canada Western oats, Thunder Bay, supply model	¢/bushel
SLRFRPW	Latest received final realized price, No. 1 Northern wheat, Thunder Bay, supply model	¢/bushel

Table 4.11. Quantities.

Variables	Identification	Units
ABBC	Barley acreage, British Columbia	Thousand acres
ABECN	Seeded acreage of barley, East Canada	Thousand acres
ABPR	Wheat acreage, Prairies	Thousand acres
ABWC	ABPR + ABBC	Thousand acres
ACNEC	Seeded acreage of corn, East Canada	Thousand acres
ACWDBTC	Animal consumption, waste, dockage, barley	Million bushels
ACWDOTC	Animal consumption, waste, dockage, oats	Million bushels
ACWDWTC	Animal consumption, waste, dockage, wheat	Million bushels
AOBC	Oats acreage, British Columbia	Thousand acres
AOECN	Seeded acreage of oats, East Canada	Thousand acres
AOPR	Oats acreage, Prairies	Thousand acres
AOWC	AOPR + AOBC	Thousand acres
AWBC	Wheat acreage, British Columbia	Thousand acres
AWECN	Seeded acreage of wheat, East Canada	Thousand acres
AWPR	Wheat acreage, Prairies	Thousand acres
AWWC	AWPR + AWBC	Thousand acres
BFECN	[illegible]	Million bushels
BFTCN	[illegible]	Million bushels
BFWCN	[illegible] + QBPWC - SHIPBWC - MKTBWC - OFSBWC	Million bushels
CNFTC	Corn fed, total Canada	Million bushels
FINCCNTC	Food and industrial consumption corn, total Canada	Million bushels

Table 4.11. Quantities (Continued).

Variables	Identification	Units
FINCBTCN	Food and industrial consumption barley, total Canada (TDUBTC - BFTCN)	Million bushels
FINCOTCN	Food and industrial consumption oats, total Canada (TDUOTC - OFTCN)	Million bushels
FINCWTCN	Food and industrial consumption wheat, total Canada (TDUWTC - WFTCN)	Million bushels
LABECN	Acreage barley, lagged one year, East Canada	Thousand acres
LACNEC	Acreage, corn, lagged one year, East Canada	Thousand acres
LAOECN	Acreage Oats, lagged one year, East Canada	Thousand acres
LAWECN	Acreage wheat, lagged one year, East Canada	Thousand acres
LOFSBEC	On farm stocks barley, lagged one year, East Canada	Million bushels
LOFSOEC	On farm stocks oats, lagged one year, East Canada	Million bushels
LOFSWEC	On farm stocks wheat, lagged one year, East Canada	Million bushels
MKTBWC	Farm marketings, barley, West Canada	Million bushels
MKTOWC	Farm marketings, oats, West Canada	Million bushels
MKTWWC	Farm marketings, wheat, West Canada	Million bushels
OFECN	OFTCN - OFWCN	Million bushels
OFSBBC	On farm stocks barley, British Columbia, August 1, year t + 1	Million bushels
OFSBECN	OFSBTC - OFSBWC	Million bushels
OFSBPR	On farm stocks barley, Prairies, August 1, year t + 1	Million bushels

Table 4.11. Quantities (Continued).

Variables	Identification	Units
OFSBTC	On farm stocks barley, Canada, August 1, year t + 1	Million bushels
OFSBWC	OFSBPR + OFSBBC	Million bushels
OFSOBC	On farm stocks oats, British Columbia, August 1, year t + 1	Million bushels
OFSOECN	OFSOTCN - OFSOWC	Million bushels
OFSOPR	On farm stocks oats, Prairies, August 1, year t + 1	Million bushels
OFSOTC	On farm stocks oats, Canada, August 1, year t + 1	Million bushels
OFSOWC	OFSOPR + OFSOBC	Million bushels
OFSWBC	On farm stocks wheat, British Columbia August 1, year t + 1	Million bushels
OFSWECN	OFSWTC - OFSWWC	Million bushels
OFSWPR	On farm stocks, wheat, Prairies, August 1, year t + 1	Million bushels
OFSWTC	On farm stocks, wheat, Canada, August 1, year t + 1	Million bushels
OFSWWC	OFSWPR + OFSWBC	Million bushels
OFSWWCL1	On farm stocks wheat, West Canada, lagged one year	Million bushels
OFTCN	SROTC + ACWDOTC	Million bushels
OFWCN	OFSOWCL1 - QOPWC + SHIPOWC - MKTOWC - OFSOWC	Million bushels
QBPBC	Barley production, British Columbia	Million bushels
QBPPR	Barley production, Prairies	Million bushels
QBPWC	QBPPR + QBPBC	Million bushels

Table 4.11. Quantities (Continued).

Variables	Identification	Units
QOPBC	Oats production, British Columbia	Million bushels
QOPPR	Oats production, Prairies	Million bushels
QOPWC	QOPPR + QOPBC	Million bushels
QWPBC	Wheat production, British Columbia	Million bushels
QWPPR	Wheat production, Prairies	Million bushels
QWPWC	QWPPR + QWPBC	Million bushels
SHIPBWC	Country elevator shipments of barley to Western Points	Million bushels
SHIPOWC	Country elevator shipments of oats to Western Points	Million bushels
SHIPWWC	Country elevator shipments of wheat to Western Points	Million bushels
SRBTC	Seed requirements, barley, for coming crop year, Canada	Million bushels
SROTC	Seed requirements, oats, for coming crop year, Canada	Million bushels
SRWTC	Seed requirements, wheat, for coming crop year, Canada	Million bushels
TOUBTC	Total domestic barley utilization	Million bushels
TDUOTC	Total domestic oats utilization	Million bushels
TDUWTC	Total domestic wheat utilization	Million bushels
TFSBWC1	(QBPWC + OFSBWCL1) x DV1	Million bushels
TFSOWC1	(QOPWC + OFSOWCL1) x DV1	Million bushels
TFSWWC1	(QWPWC + OFSWWCL1) x DV1	Million bushels
WFECN	WFTCN - WFWCN	Million bushels
WFTCN	SRWTC + ACWDWTC	Million bushels
WFWCN	OFSWWCL1 + QWPWC + SHIPWWC - MKTWWC - OFSWWC	Million bushels

Table 4.12. Miscellaneous variables.

Variables	Identification	Units
CDNCPIAC	Canadian consumer price index, all commodities, 1971 = 100	
CDNPDI	Canadian Personal Disposable Income, current dollars	\$ billions
CDNPOP	Canadian population, mid-year	millions
DV1	0 if general quota is declared open prior to July 31; = 1 if not.	
DV2PW	0 if 48 $<$ year $\leq$ 67; = 1 if year $>$ 68	
PDIDEF	CDNPDI/CONCPIAC	constant \$, billions
TRENDC	0, 1948-61; = 1, 2, ... 10 for 1962-1971; = 0, 1972-74.	
YEAR	48, 49, ... 74 for 1948, 1949, ... 1974	

Farm-Level Relationships for Western Canada

Grain Supply

Prices

The estimated coefficients for grain prices have signs consistent with theory. The latest received final realized price serves as a better representation of expected wheat price than does the CWB selling quotation. Elasticities are larger than those previously estimated by Schmitz (1968), Capel (1962), Andrlisak (1973), and Missiaen and Coffing (1972). Most of these studies deal only with wheat. Elasticities are estimated in the range of .49-.88. Meilke (1976) estimated a long-run elasticity of .69 for wheat, 1.35 for barley and 2.13 for oats. Direct comparison between this study and previous studies is difficult because of the marked differences in specification. The direction of bias resulting from the omission of all quota variables is impossible to state *a priori* because of the ambigious price and quota effects.

Quota Variables

Consider first the interpretation of the coefficients. Suppose that the expected delivery rate for wheat increases from five to six bushels per acre. This means AWL1 changes from 1/5 to 1/6, or ΔAWL1 = -1/30 acres per bushel. Multiplying this by the coefficient estimated for AWL1 in the wheat equation, we obtain (-1/30)(-89702) = 2990. In other words, an expected change in the delivery quota for wheat from five to six bushels per acre results in a 2,990,000-acre increase in seeded wheat acreage. Note that as the delivery rate increases, the impact on wheat acreage becomes progressively smaller. If the delivery rate for wheat changes from 12 to 13 bushels per quota acre, $\Delta AWL1 = -.00641$ and seeded wheat acreage would increase 575,000 acres. As the delivery rate becomes large, $\partial AWWC/\partial AWL1$ approaches zero. The interpretation of the other delivery rate coefficients is similar.

The signs for the direct quota coefficients for wheat and barley are correct. The coefficient for AOL1 in the oats equation can be positive only if oats is inferior; i.e., $\partial AOWC/\partial KBARFGL1 < 0$. If the crop is inferior, the cross-quota relationships must be positive. Neither of these requirements is met in the oats equation. The positive sign for AOL1 cannot be explained.

Most of the cross-quota coefficients are negative implying the price effect dominates the quota effect. The reciprocal cross coefficients in the barley and wheat equations are positive; i.e., the quota effect dominates the price effect.

The quota constraint constant was estimated with the expected sign for wheat and oats supply. The sign for KBARFGL1 in the barley equation implies barley is an "inferior" crop. In other words, if the quota constraint increased by 1,000 acres, barley acreage would fall by 40 acres. The net effect of a leftward shift in barley supply and an increase in all quota-adjusted prices would be a decrease in barley production, feed consumption and marketings. The decrease in barley marketings under quota would be allocated to another crop, say, wheat. The signs of cross-quota coefficients are consistent with theory for an inferior crop. However, the concept of an inferior crop is not a particularly appealing one. The effect of the quota on barley supply requires further investigation.

Other Included Variables

Livestock variables are included in both oats and barley equations. The coefficient estimated for AU1WC is consistent with expectations for a binding quota. A one-unit increase in AU1WC causes a 1.18-acre increase in barley. The animal unit variable in the oats equation has the wrong sign for a binding quota. Both AOWC and AU1WC exhibit a strong time trend (r = -.76 and .83, respectively). It would seem that AU1WC is acting as a proxy for the trend not accounted for by other variables.

The price of rapeseed was included in the oats equation. The coefficient is of the correct sign and is highly significant. The estimated response is very inelastic, however.

Other Specifications

Intended changes in stocks are hypothesized to influence the supply decision under a binding quota. When lagged on-farm stocks were included in the equations, the fit improved dramatically and the standard errors of the quota coefficients greatly increased. As we discuss in a later section, the GDQS has a strong influence on the level of farm stocks. By including on-farm stocks and representing expected quota variables, using a one-period lag, we introduce the dependent and primary independent variables of the stocks demand equation into the supply function. To eliminate the multicolinearity, we omitted lagged stocks from the equation. A biased estimate of the quota coefficients was felt to be better than no estimate at all. The direction of specification bias is indeterminate for most included variables.

Feed Demand

Prices

Expected prices for grains in the feed demand equations were represented by CWB selling quotations for wheat and oats and the latest final realized price for barley. Signs of the coefficient were consistent with theory; however, standard errors were generally quite large. This was particularly true for wheat feed demand.

Quota Variables

The interpretation of the quota coefficients for feed demand is the same as for the supply equations. An increase in the wheat delivery rate from five to six bushels per acre would decrease barley consumption by 14 million bushels. Similarly, an increase in the wheat delivery rate from 12 to 13 bushels per acre would decrease barley consumption by 2.7 million bushels. The quota effect dominates the price effect in this case. As the delivery rate for wheat increases, barley consumption falls. The effective increase in the quota is allocated to both barley and wheat.

In general, the quota coefficients were not reliably estimated. Several signs are inconsistent with theory and standard errors are large. The quota variables mirror the same problems encountered with the price coefficients.

Other Included Variables

Both animal numbers and prices are important variables in determining feed demand. As expected, hog numbers and prices have a strong effect on wheat consumption. During periods of restrictive quotas, hog production provided an important alternative to cash wheat marketing. Here again, cause and effect variables appear on the same side of the equation. Restrictive deliveries induced a buildup in the hog population in the West. Consequently, it is difficult to untangle the effect of the GDQS on the hog industry from its effect on feed demand.

Supply effects on feed demand are accounted for by TFSBWC1 and TFSOWC1. The estimated sign is correct in the oats equation and incorrect for wheat. Standard errors for both variables are fairly large.

Summary

Estimation of the feed demand equations was hampered by a number of problems. One problem has been mentioned--the difficulty in separating the effect of the GDQS on feed demand from its effect on other independent variables. This problem is one more of multicolinearity than simultaneity. The GDQS has an effect on livestock production. However, as we discussed in Chapter 3, grain demand and livestock production are not simultaneously determined because their decision and production periods do not coincide.

Another more basic problem affecting the estimation, however, is data accuracy. The dependent variable for a feed demand equation is calculated as a residual. It is, consequently, subject to many errors in estimation. We found our estimates of wheat fed in Western Canada to be particularly subject to error. During periods when on-farm wheat stocks were large, small proportionate changes in stocks would cause large fluctuations in estimated wheat disappearance. In several years, the fluctuations were so large that our estimate of wheat fed in the West exceeded the estimate of national feed disappearance. Consequently calculated wheat fed in the East was negative. When this occurred, the quantity of wheat shipped under FFAP assistance was substituted for on-farm disappearance in the East. The cumulative effect of measurement errors results in an unreliable data series for feed demand. Despite the difficulties encountered, the overall results are encouraging. Additional work on data collection and re-estimation should pay off.

On-Farm Stocks Demand

Prices

For wheat and oats, expected prices are best represented by the CWB's selling quotation. The price of barley in the barley equation is represented by the latest final realized price. Signs of the coefficients are generally consistent with theory, and standard errors are fairly small.

The coefficients for PSO in the wheat, oats, and barley equations are negative. If PSO increases, on-farm stocks of all three grains apparently would fall. Given the unresponsiveness of feed demand in the short run, the reduction in stocks must be marketed. However, with a binding quota, marketings cannot be increased for all three grains. If the cross-price coefficient for PSO is negative in the wheat equation, then its counterpart in the barley equation must be positive. Further work is required to resolve this inconsistency.

Quota Variables

As a group, the quota variables play a significant role in determining on-farm stocks demand in the West. This is not particularly surprising.

With fluctuating production and relatively fixed capacity for consumption in the short run, the impact of CWB quota policy will be transferred directly to on-farm stocks. Stocks act as a shock absorber for the entire grain economy.

Signs of the estimated coefficients are consistent with theory with the exception of AO in the wheat and oats equations. A negative coefficient for PSO in the wheat equation implies that the coefficient for AO should be positive. (See equation II.21 in Chapter 2.) Standard errors are generally small. The interpretation of the coefficients is the same as for feed demand. An increase in the wheat delivery rate from five to six bushels per acre will decrease wheat stocks by 63 million bushels.

Other Included Variables

As with feed demand, most of the other variables relate either to livestock production or on-farm grain supplies at the beginning of the crop year. Both cattle and hog variables influence barley and wheat stocks. Cattle numbers and prices have a positive effect on stocks. Hogs have an apparent negative effect. This probably reflects the hog industry's role as a safety valve for excess grain during periods of restricted quotas. In other words, hog production is increased in order to draw down excessive grain stocks. Livestock variables appeared to have little effect on demand for on-farm oats stocks.

Total farm supplies of grain did have some influence on ending farm stocks during periods of binding quotas. Signs were consistent with expectations. For every bushel increase in barley supplies, wheat stocks increase by .74 bushels.

Farm-Level Relationships for Eastern Canada

Grain Supply

In the acreage response equation for Eastern Canada, we include only the prices of substitutes which seem to be most important. Traditional price relationships are expected to hold in the East and the estimated equations support this hypothesis. Short-run price elasticities are low; however, the supply responses of all crops are highly elastic in the long run. Feed grains exhibit a fairly constant and lengthy adjustment period. Wheat acreage exhibited a much faster adjustment period.

Trend C is included in order to account for the adoption of corn and soybean agriculture in the East. The coefficient is positive for corn and barley and negative for wheat and oats. This would suggest corn and barley were replacing oats and wheat production during the 1960's. Soybean prices had a measurable effect on oats acreage. Both the short-run and the long-run elasticities are inelastic. Livestock prices or numbers do not appear to have an effect on grain supply in the East. In the absence of a GDQS, this is consistent with theory.

The R^2 for all equations is high due in large part to the inclusion of lagged acreage. The Durbin-Watson statistic is not an appropriate measure of serial correlation. Subsequent analysis should be based on Durbin's h statistic (Durbin, 1970).

Feed Demand

As with the acreage supply equations, it is not possible to estimate a full set of direct and cross price elasticities for the grains. We were bothered by extremely high intercorrelation among the price variables. Most of the estimated coefficients have the correct sign. We were not able to estimate a negative coefficient for the price of oats in the oats demand equation. Both barley and soybean meal exhibit complementary relationships with oats. Since both barley and soybean meal are higher in protein relative to oats, this relationship is not implausible. Note, however, that soybean meal acts as a substitute in the barley demand equation. Many estimated elasticities are quite high. In particular, wheat shows a direct price elasticity of -7.7. Disaggregation always leads to higher elasticities; however, this result seems to be too high. A 10¢/bushel increase in the price of wheat implies an 8.5-million-bushel decrease in feed wheat demand. This is roughly a third of the historical average. Inconsistencies of this sort call for improved specification and better data.

Livestock variables play an important role in determining feed demand. Both prices of hogs and steers appear in all equations. The price of milk in Eastern Canada was included to account for the dairy sector's demand for grains. Recent changes in federal and provincial dairy policies have resulted in large increases in milk prices. From 1972 to 1975, the price of manufacturing milk increased from $4.22 to $7.53 per cwt. This implies a 50-million-bushel increase in corn consumption by the dairy industry alone. The dairy sector is simply not sufficiently responsive to adjust feed consumption by this amount in two to three years. The variable needs to be respecified. In particular, a more refined estimate of grain-consuming dairy animals in Eastern Canada would be preferable to the price of the product in the grain demand specifications. This approach would eliminate problems in specifying prices due to the milk marketing board quota policies and federal dairy programs. It would not, however, account for heavier grain feeding due to producers' efforts to increase milk output in the short run.

On-Farm Stocks Demand

As with feed demand, highly intercorrelated grain prices precluded estimating a complete set of price coefficients. We included a subset of price variables which seemed to be the most important. Signs are consistent with expectations. Corn exhibits a complementary relationship with oats stock demand. This complementarity is not apparent in the feed demand equations. Standard errors of the coefficients are small. For all grains, the estimated direct and cross elasticities are large. The highly elastic demand for on-farm grain stocks in the East could have several origins. The most likely explanation would be that the livestock feeding industry in the East has ready access to large commercial grain stocks--wheat, oats, and barley held by the CWB and corn held in the United States. This greatly reduces the requirement to hold large transactions and precautionary stocks. Speculative stocks would presumably be very responsive to current price changes given expectations of future prices. The observed high demand elasticities reflect the opportunity which Eastern farmers have to pass grain stock holding requirements on to the commercial sector.

Livestock variables are included in the stocks demand equation primarily to account for transactions demand. Livestock prices seemed to be more important than livestock numbers. Again, this may reflect the availability of large commercial stocks. The adjustment coefficients for oats and wheat differ substantially. The mean lag for oats is 1.38 and for wheat it is 0.15. On-farm wheat stocks in the East have historically been small relative to oats. Wheat stocks could be adjusted more rapidly. In addition, most of the wheat fed in the East is shipped from the West under FFAP assistance. Feed wheat supplies would be available from commercial sources.

Food and Industrial Demand

The food and industrial demand equations complete the set of structural relationships necessary to estimate exportable grain surplus. The equations were specified in a standard form--own price, price of substitutes, income, and population. All price variables and income were deflated by a consumer price index.

Most estimated coefficients have signs consistent with theory. Demand for oats is a decreasing function of income. The direct price coefficient for wheat demand has the correct sign, but is not significant statistically. This may be the result of very low wheat prices over most of the historical period coupled with the fixing of domestic wheat prices with the two-price wheat policy. Other direct price coefficients have fairly small standard errors. All grain demand curves are highly price inelastic.

The coefficient estimated for DV2PW suggests that the net effect of the two-price wheat policy since its introduction has been to decrease wheat consumption by 1.09 million bushels. The use of an intercept dummy variable to measure the effect of this policy is very imprecise. Concomitant with the introduction of the policy was a rapid increase in international wheat prices. In all likelihood, DV2PW is measuring the effect of wheat price changes rather than the effect of stabilizing domestic wheat prices with this policy.

Little work has been done on estimating food and industrial demand for specific grains in Canada. Hassan and Johnson (1976) report price and income elasticities for all cereals estimated by OLS using a double log function. Their estimates of price and income elasticities for cereals were -.52 and .16, respectively. The differences in elasticities are probably due to differences in specification and levels of aggregation. Hassan and Johnson specify consumer or retail level demand function. We specify farm-level derived demand functions for food and industrial grains. The existence of a positive marketing margin will make the farm-level derived demand less elastic than the retail level.

With linear demand curves, the income elasticity for primary and derived demand should be equal. However, the aggregate income elasticity in a linear system is a weighted average of the individual income elasticities. The weights will be the proportion of the individual commodity in the total aggregate. Consequently, a considerable degree of variation in individual income elasticities can occur. The weighted income elasticity for wheat, oats, barley, and corn using historical mean values to compute the weights is +.19. This corresponds closely to Hassan and Johnson's estimate.

Final Comments

This concludes our discussion of the statistical results. The estimates which we have presented should be viewed as a preliminary test of the theoretical model and as a reconnaissance survey of available data. The results are generally encouraging. Key policy and economic variables were identified and their impact on the grain sector was measured. We will not present a formal validation of the model. Rather, we will conclude by indicating some directions for further research which have been identified through this analysis.

Chapter 5

DIRECTIONS FOR FURTHER RESEARCH

Introduction

In the first part of this chapter, we discuss the utility of the model for interpreting the historical period of study as well as for assessing the future direction of Canada's wheat and feed grain economy. In the last section, we establish some areas for future research.

Understanding the Past

Both the theoretical and empirical models are derived from historical experience. Several major issues are addressed in specifying the economic models which assist in understanding the past behavior of the grains sector:

- the importance of the distinction between Western and Eastern Canada both in their differing resource bases and in their agricultural institutions;
- the identification and analysis of the effect primary agricultural policies have on the structure of the grain sector;
- the interaction between primary and secondary policies;
- the development of an historically consistent treatment of CWB policies in the West despite frequent policy changes.

In this section, rather than review the major developments of the preceding three chapters, we will emphasize a few points which may not have been sufficiently brought out.

Quota policy in Western Canada has been important over the historical period. It is difficult to find an empirical measure of "importance" for a structural variable. Most measures are arbitrary to some degree. The procedure which we employ is to rank variables by their beta coefficients for each structural relationship estimated for Western Canada.[1/] This information is presented in Table 5.1. It is apparent that quota variables have had a major influence on the production, disposition, and stock holding of wheat, oats, and barley in the West.

Price and quota policy are and have been inextricably linked in Western Canada. This fact is brought out in the theoretical model by representing the GDQS as a set of adjustment factors to the final realized prices. The quota variables possess allocative and distributive properties similar to prices. Consequently, the grain pricing system and the GDQS provide the CWB with a dual set of controls with which it can influence both the level and output mix of Western Canada's grain sector. Again, Table 5.1 brings out the joint importance of prices and quota variables over the period of study.

Finally, we emphasize the apparent importance of CWB selling quotations throughout the grain sector. For Western producers, the selling quotations provide relatively current information on expected final realized prices and therefore, guide grain production and disposition decisions. In Eastern Canada, and in the food and industrial sector, the CWB quotations represent basing point selling prices linked directly to world grain prices. The CWB selling prices provide a means for joining the grain sectors in both Western and Eastern Canada to the world economy.

[1/] The beta coefficient is calculated by multiplying the regression coefficient for a particular variable by the variable's standard deviation and then dividing by the standard deviation of the dependent variable.

Table 5.1. Variables ranked by beta coefficients.

Relationship	First	Second	Third	Fourth	Fifth
Supply					
Wheat	AWL1 -1.77	PSBL1 -1.57	PSOL1 1.08	ABL1 .96	KBARL1 .82
Oats	ABL1 -1.73	PSOL1 1.35	AOL1 1.16	KBARFGL1 .86	PRPWCL1 - .84
Barley	AWL1 1.11	ABL1 - .94	KBARFGL1 .84	PSBL1 .78	AU1WC .54
Feed Demand					
Wheat	AB -1.29	AO .86	TFSBWC1 - .84	AW .75	HU2WC .66
Oats	PSO - .90	AW - .87	AB .83	AO - .57	PSTRSWC .46
Barley	PSTRSWC .65	AW .55	KBARFG - .52	AU3WC .45	AO .32
On-farm Stocks					
Wheat	KBAR -1.40	PSB 1.32	PSO -1.21	AW 1.11	AB 1.07
Oats	PSO -1.28	PSB 1.14	AB .79	TFSOWC1 .74	KBARFG - .71
Barley	AW 1.48	KBARFG -1.41	PSTRSWC .74	PSO - .55	CU1WC .49

Assessing the Future

The theoretical and empirical models provide a valuable set of tools for understanding the historical behavior of Canada's grain sector. Two recent events, however, suggest that the future course of the Canadian grain sector may be radically different from the past--the introduction of the NDFGP and the upheaval experienced in world grain markets during the past decade. Unprecedented change would seem to seriously limit the predictive or interpretive value of a model based on historical experience. The future utility of the models developed in this study depends on their capacity to explain and measure the impact of the NDFGP as well as changes occurring in the world grain economy on Canada's grain sector.

The analysis of the NDFGP in Chapter 2 brought out two important factors:

1. The NDFGP can be directly incorporated into the same basic theoretical model of the Canadian grain sector which was developed for the 1948/49-1973/74 period.
2. The NDFGP induces a structural shift in the farm-level behavioral relationships in Western Canada. The specification of the equations is not altered by the NDFGP; however, the magnitude of response to certain variables is most certainly affected.

The major problem to be confronted as a result of the NDFGP, therefore, is one of estimation. Specifically, which set of variables has been significantly altered by the NDFGP? To what extent can future response to economic and policy variables be inferred from past response? Because of data limitations, these issues were not addressed in this report. Further work is clearly required.

The second factor which might limit the future value of the model which we have presented is the likelihood of periods of surplus production in world grain economy. During the fifties and sixties, the grain sector in North America was characterized by several factors--low grain prices and farm incomes, burdensome grain stocks, and cheap fertilizer, energy and other purchased inputs. In the early seventies, world grain supplies began to dwindle and the real price of grain rose dramatically. Concomitantly, oil prices and prices of oil-based agricultural inputs soared. This sharply increased farm production costs as well as interregional transportation costs for bulky agricultural products.[3/]

The early 1970's constitute a significant break from the previous two decades. Agricultural policies, once directed toward farm income maintenance and grain stock management, were redirected toward improving agricultural productivity, increasing the efficiency of grain marketing, transportation and distribution, and stabilizing grain prices and supplies. But recently, in the last half of the seventies, we have experienced a partial return to the "old" problems. Grain prices have declined sharply and grain stocks are accumulating, particularly in the United States. Concerns about grain shortages have given way to renewed worries about grain surplus. Efforts to maintain farm income and control grain production are once again being made.

From our experience in the seventies, it is evident that it is extremely difficult to chart the future course of the world grain economy.

[3/] For a complete discussion of the two events, see Hathaway (1974) and Cochrane (1977).

It is equally difficult to predict the response of policy agents like the CWB to changes which might occur. However, the utility of the models developed in this study is not dependent on one's ability to predict the future of the grain sector, nor on the priorities given to policy areas by governmental agencies. Rather, their utility lies with their ability to interpret and measure the impact of future events on the domestic grain sector. A thorough understanding of the functioning of Canada's grain sector and related policies is a necessary antecedent to forecasting its future course in a global context. In all likelihood, periods of grain shortage will continue to alternate with periods of surplus. The models which we have developed in this study should aid persons concerned with food and agricultural policy in assessing the impact of future events on Canada's grain sector within an historically consistent economic framework.

Future Areas of Research

In this section, we briefly outline some areas for further research. We focus on two issues: (1) the improvement of the existing set of estimating equations; and (2) extensions of the theoretical model.

Refinement and Validation of the Present Estimating Model

One of the most important refinements which could be made would be to identify those variables most affected by the structural shifts induced by binding and non-binding quotas. Identification of this subset and measuring the magnitude of the structural shifts would improve our understanding of the past and increase the accuracy of the forecasting equations.

Re-estimation of the structural equations in the West following the NDGFP is essential. This would involve including off-board prices in the equations along with variables already specified. Structural changes induced by the NDFGP should be identified and measured.

A soil moisture index would be helpful. The current specification does not correctly reflect the effect of summer fallowing on seeded acreage in the West. Summer fallowing is the second largest land use category in Western Canada. Although fallowing is a highly institutionalized practice, it is not correct to view it as exogenous as it is in the present model.

An attempt should be made to incorporate production costs into the estimating equations. This is most critical on the supply side. Isolation of key factors of production influencing acreage response and yields would possibly simplify estimation problems.

A conscientious effort should be undertaken to obtain better data. In particular, estimates of regional feed consumption and on-farm stocks are subject to large errors. Livestock inventory data are not currently available over the period of study in a consistent form. If improved livestock data cannot be obtained, alternative specifications of the livestock variables should be developed.

Finally, the resulting model should be formally validated.

Extensions of the Theoretical Model

One of the recurrent problems in this study was specifying mechanisms for expectation formation. Western farmers' expectations of final realized prices and delivery quota rates play a crucial role in grain production and consumption decisions. Very little work has been done on how expectations are formed with price pooling and delivery quotas. Similarly, a practical method for representing expected livestock prices is called for. The combination of animal numbers with livestock and milk prices employed in this study is a functional method but it lacks a strong theoretical basis.

The dynamic linkages due to fallowing, livestock production and inventory management are poorly understood. The first two enterprises are exogenous to the present estimating equations. If the model is to be employed in a recursive manner to generate a time series of projections, livestock production and summer fallowing must ultimately be incorporated into it.

This analysis has not addressed the effects of delivery quotas, price pooling, and the off-board market within the crop year. Although quotas may be declared open before the end of the year, the distribution of quotas during the year may have an effect on a producer's allocative decisions. The theoretical model is applicable to the analysis of intra-crop year market behavior. The estimating equations would have to be specified on at least a quarterly basis in order to identify these effects.

Agricultural production, particularly in Western Canada, is subject to considerable risk and uncertainty due to scanty rainfall, a short growing season and a heavy reliance on export markets. The effects of risk and uncertainty on producers' responses to economic variables are not addressed in this study. They need to be. This theoretical extension should be incorporated with the analysis of price and quota expectation formation.

Finally, in order to link the domestic structural relationships to models of the world grain economy, a behavioral model of the CWB must be developed. Some work has been done in this area (McCalla, 1966; Bieri and Schmitz, 1974), but the development of the literature is not adequate to guide the specification of the empirical model. In the absence of an understanding of how a public enterprise should behave, it might be helpful to impose some arbitrary objectives on the public enterprise and evaluate the simulated performance of the resulting econometric model over an historical period (Evans, 1974). Techniques of this sort may improve our understanding of public enterprise behavior. The development of a behavioral model for the CWB is a substantial undertaking. However, it is essential if Canada's grain sector is going to be endogenously incorporated with models of the world grain economy.

APPENDIX A

KUHN-TUCKER CONDITIONS FOR THE BASIC MODEL

The Kuhn-Tucker conditions for II.7 are written in full below. For each decision variable, one obtains two requirements which characterize the optimal point. Consider equation 1. The equality requires that $p_i - \lambda a_i - \mu_i = 0$, or $C_i = 0$, or both. The weak inequality requires that $p_i - \lambda a_i \leq \mu_i$. The left-hand side is the quota-adjusted price; μ_i can be interpreted as the opportunity cost of the crop enterprise. If, no matter how production on the farm is reorganized, $p_i - \lambda a_i < \mu_i$, then in order for the equality to hold, $C_i = 0$. If $p_i - \lambda a_i = \mu_i$, $C_i \geq 0$. In other words, if a given enterprise is active, then the classical conditions for an interior optimum hold. If an interior optimum is infeasible, the enterprise is inactive--the crop is not produced.

1. $p_i - \mu_i - \lambda a_i \leq 0; \quad (p_i - \mu_i - \lambda a_i)\, C_i = 0$

2. $-r_k + \mu_i\ \partial f^i/\partial v_{ki} \leq 0; \quad (-r_k + \mu_i\ \partial f^i/\partial v_{ki})\, v_{ki} = 0$

3. $\mu_i\ \partial f^i/\partial z_{hi} - \gamma_h \leq 0; \quad (\mu_i\ \partial f^i/\partial z_{hi} - \gamma_k)\ z_{hi} = 0$

4. $\mu_i\ \partial f^i/\partial A_i - \theta \leq 0; \quad (\mu_i\ \partial f^i/\partial A_i - \theta)\, A_i = 0$

5. $p_j - \mu_j \leq 0; \ (p_j - \mu_j)\, L_j = 0$

6. $-p_i + \mu_j\ \partial f^j/\partial c_{ij} + \lambda a_i \leq 0; \quad (-p_i + \mu_j\ \partial f^j/\partial c_{ij} + \lambda a_i)\ c_{ij} = 0$

Appendix A (cont'd.)

7. $-r_i + \mu_j \ \partial f^j/\partial v_{kj} \leq 0; \ (-r_i + \mu_j \ \partial f^j/\partial v_{kj}) \ v_{kj} = 0$

8. $\mu_j \ \partial f^j/\partial z_{hj} - \gamma_h \leq 0; \ (\mu_j \ \partial f^j/\partial z_{hj} - \gamma_h) \ z_{hj} = 0$

9. $f^i - C_i \geq 0; \quad (f^i - C_i) \ \mu_i = 0$

10. $f^j - L_j \geq 0; \quad (f^j - L_j) \ \mu_j = 0$

11. $z_h - \sum_i^n z_{hi} - \sum_j^m z_{hj} \geq 0; \ (z_h - \sum_i^n z_{hi} - \sum_j^m z_{hj}) \ \gamma_h = 0$

12. $\bar{A} - \sum_i^n a_i \ (C_i - \sum_j^m c_{ij}) \geq 0; \ [\bar{A} - \sum_i^n a_i \ (C_i - \sum_j^m c_{ij})] \ \lambda = 0$

13. $\bar{A} - \sum_i^n A_i \geq 0; \ (\bar{A} - \sum_i^n A_i) \ \theta = 0$

APPENDIX B

COMPUTATION OF ANIMAL UNITS

Several aggregate measures of livestock population in Canada were calculated. The procedure followed was similar to those employed by Wilson (1968), and Laforge (1973). Details of the calculation of each series are presented below.

1. Cattle Units, Series 1 (CU1WC, CU1EC)

Livestock Classification	Weight
1. Milk cows	1.0
2. Bulls	.9511
3. Beef cows	.7975
4. Dairy heifers	.7541
5. Beef heifers	.7133
6. Steers	.7133
7. Calves	.6365

This series is based only on relative digestible energy requirements. The weights were developed by Wilson (1968).

2. Cattle Units, Series 2 (CU2WC, CU2EC)

Livestock Classification	Weight
1. Milk cows	1.0
2. Bulls	.9511
3. Beef cows	0
4. Dairy heifers	.7541
5. Beef heifers	0
6. Steers	.7133
7. Calves	.3182

This series incorporates information on grain versus forage consumption of the various livestock categories as well as relative energy requirements.

The energy weights are adjusted using the rates of grain consumption estimated by Laforge (1973).

3. Hog Units, Series 1 (HU1WC, HU1EC)

Classification	Weight
1. Hogs 6 mos. and over	1.0
2. Hogs less than 6 mos.	.5400

This series is based on the June 1 inventory.

4. Hog Units, Series 2 (HU2WC, HU2EC)

The same weights employed in HU1WC were used to calculate HU2WC. The population estimates were based on the average December 1 and June 1 inventory.

5. Animal Units, Series 1 (AU1WC, AU1EC)

This series incorporated both cattle and hog numbers. Aggregation was based on energy requirements.

6. Animal Units, Series 2 (AU2WC, AU2EC)

This series is similar to CU2WC in that the weights were adjusted to account for forage consumption.

7. Animal Units, Series 3 (AU3WC, AU3EC)

An aggregate of CU1WC and HU2WC.

8. Animal Units, Series 4 (AU4WC, AU4EC)

An aggregate of CU2WC and HU2WC.

9. Hog and Poultry Units (HPU2EC)

An aggregate of hog and poultry inventories adjusted for relative energy consumption.

APPENDIX C

DETERMINATION OF THE QUOTA VARIABLES

The linear programming problem specified in Chapter 3 was run for the period 1954/55 through 1969/70. Table C-1 presents the raw data for the programming problem. It will be helpful to describe how the data were obtained.

A. General Quota

1. The a_i's were calculated as the reciprocal of the delivery rate in the Prairies as of July 31. If the rates were different at various stations, then a weighted average was computed. It is assumed that producers could correctly forecast the quota delivery rate from planting time to the end of the crop year. This is a strong assumption and indicates more work is required on modeling expectation formation. Note that this problem is important only on the supply side.

2. Total specified acreage ($\bar{A}$) was computed from published acreage statistics for the Prairie Provinces and British Columbia in accordance with the relevant definition. This series is certainly subject to error, particularly in the "eligible forages" classification, which consisted only of tame hay and fodder corn. Considering the total magnitude of the $\bar{A}$ series, however, errors in measurement should be proportionately very small.

B. Unit Quota

1. The u_i were calculated as reciprocals of published delivery rates.

2. The $\bar{U}$ series was calculated by multiplying the number of CWB delivery permits issued by 100.

C. Supplementary Quota

Supplementary quotas were calculated by multiplying total seeded acreage of a given crop in the Prairies by the published delivery rate. This implies that all producers, whether they were net sellers or net buyers, completely filled their supplementary quotas.

Information available to the author on details of the supplementary quotas was generally inadequate. Consequently, errors probably have been made in the calculation of deliveries on the supplementary quotas. With better information from the CWB these deficiencies could easily be corrected.

D. Other Considerations

In 1960/61, oats were declared open on the general quota. During the period 1962-67, rye was declared open on the general quota. Due to a lack of available data on deliveries of grains on the various quotas, it was necessary to assume that deliveries of the open grain made earlier in the crop year could be reallocated to other (non-open) grains. If this were not the case, then the theoretically specified quota will overstate the size of the actual quota.

E. Results

Generally speaking, the linear programming problem was run three times for each year. The objective was to maximize deliveries to either wheat, oats, or barley. If, for a given year, more than one hyperplane was selected by the program, the hyperplane selected for use in the statistical model was the one with the smallest residual between actual deliveries and the theoretical maximum.

Tables C-2 and C-3 show the algebraic and numerical solutions, respectively, of the hyperplanes selected by the program. In 1956, 1967, 1968 and 1969, actual deliveries exceeded the theoretically specified quantities. This presumably resulted from misspecification of the quota system. To correct for this, the constraint constant was adjusted to make the observed vector lie in the hyperplane. In Table C-3, the bracketed quantities in the last column are the adjusted constraint constants. The adjusted values were used in the statistical estimations.

The algebraic symbols used in this appendix are similar to those employed in the text. Deliveries of grain under various quotas are expressed in bushels and designated as c_{ij}, where i = 1 = wheat, 2 = oats, 3 = barley, 4 = rye and j = 1 = general, 2 = unit, 3 = supplementary.

Table C-1. Data for quota programming problem.

	General Quota					Unit Quota				
	a_1	a_2	a_3	a_4	$\overline{A}$ '000 (acres)	u_1	u_2	u_3	u_4	$\overline{U}$ (units)
	(acres/bushel)					(units/bushel)				
1954-55	.1250	.1250	.1250	.1250	65536	.3333	.1250	.2000	.2000	23,030,800
1955	.1433	.1433	.1433	.1433	64795	.3333	.1250	.2000	.2000	22,817,000
1956	.1748	.1748	.1748	.1748	62444	.3333	.1250	.2000	.2000	23,085,400
1957	.1477	.1477	.1477	.1477	64859	.3333	.1250	.2000	.2000	22,631,600
1958	.1429	.1429	.1429	.1429	67010	.3333	.1250	.2000	.2000	22,984,400
1959	.1433	.1433	.1433	.1433	68302	.3333	.1250	.2000	.2000	22,529,400
1960	.1429	X	.1429	.1429	68706	.3333	X	.2000	.2000	22,442,500
1962	.0833	.0833	.0833	X	71777	.3333	.1000	.2000	X	22,113,800
1963	.1250	.1250	.1250	X	72193	.3333	.1250	.2000	X	21,487,900
1964	.1667	.1667	.1667	X	71717	.3333	.1250	.2000	X	21,094,300
1966	.1250	.1250	.1250	X	73121	.2500	.1000	.1667	X	19,805,400
1967	.1667	.1667	.1667	X	74246	.2500	.1000	.1667	X	19,205,700
1968	.2037	.2037	.2037	.2037	75029	.2500	.1000	.1667	.1667	19,060,600
1969-70	.2500	.2500	.2500	.2500	73737	.2500	.1000	.1667	.1667	19,000,400

X = Open general quota.

Table C-1 (cont'd.)

	Supplementary Quota (bushels)				Total Deliveries to CWB, 1000 bushels			
	S_1	S_2	S_3	S_4	Wheat c_1	Oats c_2	Barley c_3	Rye c_4
1954-55					319,780	70,221	112,568	13,191
1955				3,990,000	352,975	71,629	114,460	12,486
1956			49,086,000		362,454	69,254	120,661	4,063
1957			55,254,000		378,192	58,272	116,866	7,395
1958				4,310,000	367,723	39,280	122,838	4,667
1959					378,514	24,338	95,591	4,291
1960		X		3,920,000	396,212		87,898	5,824
1962		35,760,000		X	474,293	88,989	80,477	
1963	269,660,000			X	568,620	49,744	91,943	
1964	261,720,000	20,216,000	20,868,000	X	524,515	41,002	74,975	
1966	145,830,000			X	632,362	38,427	112,740	
1967		40,720,000		X	465,015	30,818	87,305	
1968		41,573,000		1,857,000	423,161	41,573	81,766	3,838
1969-70			68,400,000	10,179,000	413,263	20,868	168,423	7,602

Source: Statistics Canada, Canadian Wheat Board Annual Report

Table C-2. Algebraic specification of quotas.

Year	AW	AO	AB	AR	KBAR
1953	a_1	a_2	a_3	a_4	$\overline{A}$
1954	a_1	$a_3\ (u_2/u_3)$	a_3	$a_3\ (u_4/u_3)$	$\overline{A} + (a_3/u_3)\ \overline{U}$
1955	a_1	$a_3\ (u_2/u_3)$	a_3	$a_3\ (u_4/u_3)$	$\overline{A} + (a_3/u_3)\ \overline{U} + a_3\ (u_4/u_3)\ c_{43}$
1956	a_1	$a_4\ (u_2/u_4)$	$a_4\ (u_3/u_4)$	a_4	$\overline{A} + (a_4/u_4)\ \overline{U} + a_4\ (u_3/u_4)\ c_{33}$
1957	a_1	$a_1\ (u_2/u_1)$	$a_1\ (u_3/u_1)$	$a_1\ (u_4/u_1)$	$\overline{A} + (a_1/u_1)\ \overline{U} + a_1\ (u_3/u_1)\ c_{33}$
1958	a_1	$a_3\ (u_2/u_3)$	a_3	$a_3\ (u_4/u_3)$	$\overline{A} + (a_3/u_3)\ \overline{U} + a_3\ (u_4/u_3)\ c_{43}$
1959	a_1	$a_3\ (u_2/u_3)$	a_3	$a_3\ (u_4/u_3)$	$\overline{A} + (a_3/u_3)\ \overline{U}$
1960	a_1	0	$a_1\ (u_3/u_1)$	$a_1\ (u_4/u_1)$	$\overline{A} + (a_1/u_1)\ \overline{U} + a_1\ (u_4/u_1)\ c_{43}$
1961	0	0	0	0	0
1962	a_1	$a_3\ (u_2/u_3)$	a_3	0	$\overline{A} + (a_3/u_3)\ \overline{U} + a_3\ (u_2/u_3)\ c_{23}$
1963	a_1	$a_3\ (u_2/u_3)$	a_3	0	$\overline{A} + (a_3/u_3)\ \overline{U} + a_1\ c_{13}$
1964	a_1	$a_1\ (u_2/u_1)$	$a_1\ (u_3/u_1)$	0	$\overline{A} + (a_1/u_1)\ \overline{U} + a_1\ c_{13} + a_1\ (u_2/u_1)\ c_{23} + \left[\frac{a_1 u_3}{u_1}\right]\ c_{33}$
1965	0	0	0	0	0
1966	a_1	$a_3\ (u_2/u_3)$	a_3	0	$\overline{A} + (a_3/u_3)\ \overline{U} + a_1\ c_{13}$
1967	a_1	$a_1\ (u_2/u_1)$	$a_1\ (u_3/u_1)$	0	$\overline{A} + (a_1/u_1)\ \overline{U} + a_1\ (u_2/u_1)\ c_{23}$
1968	a_1	$a_1\ (u_2/u_1)$	$a_1\ (u_3/u_1)$	$a_1\ (u_4/u_1)$	$\overline{A} + (a_1/u_1)\ \overline{U} + a_1\ (u_4/u_1)\ c_{43} + a_1\ (u_2/u_1)\ c_{23}$
1969	a_1	$a_3\ (u_2/u_3)$	a_3	$a_3\ (u_4/u_3)$	$\overline{A} + (a_3/u_3)\ \overline{U} + a_3\ (u_4/u_3)\ c_{43} + a_3\ c_{33}$

Table C-3. Numerical specification of the quotas.

Year	AW	AO	AB	AR	KBAR	Adjusted KBAR
1953	.1429	.1429	.1429	.1429	65,243,000	
1954	.1250	.0781	.1250	.1250	79,930,250	
1955	.1433	.0896	.1433	.1433	81,715,147	
1956	.1748	.1093	.1748	.1748	91,200,872	[91,963,075]
1957	.1477	.0554	.0886	.0886	79,783,568	
1958	.1429	.0893	.1429	.1429	84,048,252	
1959	.1433	.0896	.1433	.1433	84,444,315	
1960	.1429	0	.0857	.0857	78,664,006	
1961	0	0	0	0	0	
1962	.0833	.0417	.0833	0	82,478,590	
1963	.1250	.0780	.1250	0	119,330,437	
1964	.1667	.0625	.1001	0	129,236,537	
1965	0	0	0	0	0	
1966	.1250	.0750	.1250	0	106,203,800	
1967	.1667	.0667	.1111	0	87,049,798	[89,765,798]
1968	.2037	.0815	.1358	.1358	94,199,957	[101,211,000]
1969	.2500	.1500	.2500	.2500	121,869,151	[150,453,000]
1970 (wheat)	.1250	.0333	.0500	.0500	52,285,000	
1970 (oats, barley)	.1250	.0333	.0500	.0500	74,780,000	
1971	.1111	.0833	.0250	.0250	86,099,253	
1972	0	0	0	0	0	
1973	0	0	0	0	0	

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The following abbreviations are employed:

AER: Agricultural Economics Research

CFE: Canadian Farm Economics

AJAE: American Journal of Agricultural Economics

CJAE: Canadian Journal of Agricultural Economics

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equation III.16 can be rewritten as

$$\Delta I_t^* = \Delta I_t - FCE_t \,. \qquad \text{III.17}$$

Let us represent desired levels of ending stocks again by

$$I_t^{\dagger} = a + Z_t^* b \qquad \text{III.18}$$

and for simplicity, assume $Z_t = Z_{t-1}$.

This time, however, the adjustment mechanism will be specified in terms of intended changes in stocks.

$$I_t^* - I_{t-1}^* = \gamma[I_t^{\dagger} - I_{t-1}] \,. \qquad \text{III.19}$$

By substituting III.18 into III.19, one obtains

$$\Delta I_t^* = \gamma a + \gamma Z_{t-1} b - \gamma I_{t-1} \,. \qquad \text{III.20}$$

The unobservable ΔI_t^* can be removed using III.17. The final form of the equation is

$$\Delta I_t = \gamma a + \gamma Z_{t-1} b - \gamma I_{t-1} + FCE_t \,. \qquad \text{III.21}$$

If it can be assumed FCE_t has the properties of a random disturbance term, then intended changes in stocks, $\Delta I_t{}^*$ can be estimated by (1) regressing actual changes in stocks on right-hand side variables in III.21 and (2) using the back solutions of the regression as estimates of ΔI_t^*. The regression will not be able to "explain" the FCE and that is precisely the desired result. The regression technique will purge the observable ΔI_t of the associated stochastic element FCE_t.[7/]

[7/] The properties of FCE_t are difficult to assess a priori. In the absence of a binding delivery quota, presumably $FCE_t \equiv 0$. A farmer who over-produced would simply oversell. In this case, there is no significant