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by

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A CANADIAN AGRICULTURAL MODEL: AN EXAMPLE OF INTEGRATING ECONOMICS, ECONOMETRICS AND PRACTICAL CONSTRAINTS

Allen W. Shiau*

At the American Economics Association summer meeting in 1972, Richard T. Crowder classified econometric model builders into two groups: the theoretical group and the user group. Both are considered important; however, they are fundamentally different in their approaches to the formulation and application of econometric models. The theoretical group emphasizes rigor, elegance, and complexity in solving theoretical issues, while the user group appreciates only the simplicity and judgment in solving practical problems. It is our challenge to integrate rigorous economic theories and econometric methods with practical constraints in formulating and applying econometric models.

The objective of this paper is to present some unique features of the Chase quarterly Canadian Agricultural Model and our working experience with large-scale econometric model building and forecasting. Particular attention is focused on the problem of integrating or reconciling sound theoretical formulations and rigorous econometric techniques with practical constraints on the specification and estimation of a large-scale, on-going econometric model.

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An overview of the model is presented in the next section followed by examples of combining economics and econometrics with practical constraints. The concluding remark is presented in the last section.

An Overview of the Chase Quarterly Canadian Agricultural Model

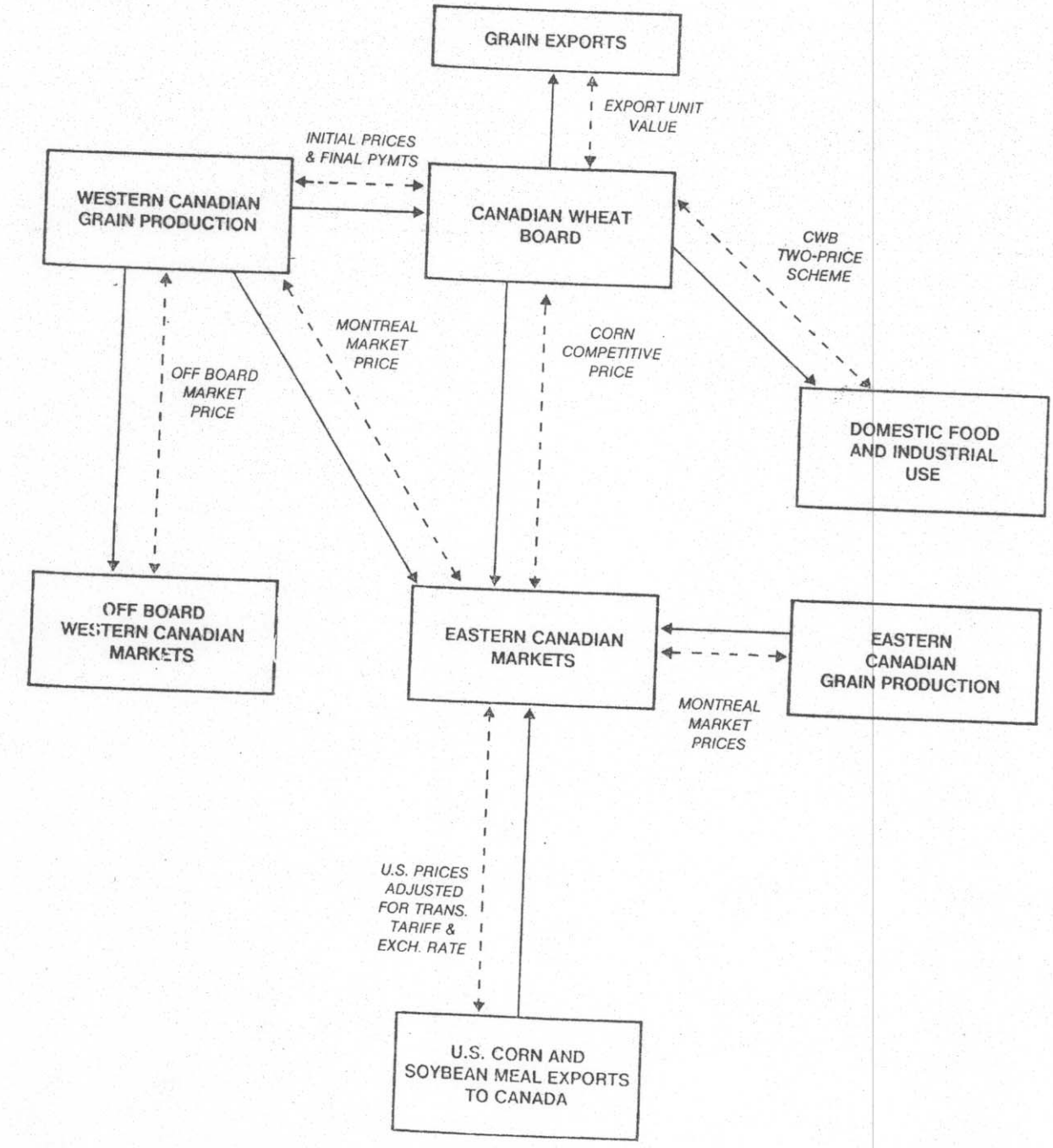
The Chase Canadian Agricultural Model is designed to assist the agribusiness planner and policy analyst in evaluating the fundamental supply and demand relationships for the Canadian agricultural sector. The model incorporates the peculiar characteristics of Canadian geography and agricultural policy.

The east-west dichotomy in crop production characteristics is a critical factor in Canadian agriculture.[1] Wheat, barley, and oats are produced in both regions but are predominantly western crops. Rapeseed and flaxseed are only grown in western Canada while soybeans and corn are primarily eastern crops. The marketing of major grains in western Canada is under the control of the Canadian Wheat Board (CWB). Under the New Domestic Feed Grain Policy, effective August 1, 1974, a western grain producer has three major direct outlets for his grains. These include delivery to the CWB, sale through commercial channels in western Canadian markets, and sale through commercial channels in eastern Canadian markets (Figure 1). The western commercial grain market is referred to as the off-board market.

Livestock producers can purchase grains through off-board markets. However, the CWB retains monopoly control of all wheat, barley, and oats

FIGURE 1

CANADIAN GRAIN MARKET STRUCTURE UNDER NEW DOMESTIC FEED GRAIN POLICY 1974 TO PRESENT



for exports, domestic food, and industrial uses. The CWB also coordinates feedgrain and oilseed transportation and assures adequate supplies and deliveries of grain for domestic purposes, feeding as well as non-feeding.

Grain sold off-board in western Canada moves through normal private channels at prices determined in the marketplace. These prices are referred to as "off-board" prices. Western grain can also be delivered to the Canadian Wheat Board, subject to delivery quotas. Farmers who deliver grain to the CWB receive an "initial payment" which is determined by the federal government, in consultation with the CWB, for each crop. Usually the initial payment is announced in the spring prior to planting and subsequent adjustments can be made during the year as market conditions change. Initial payments are typically set below current market prices and represent "minimum" price expectations. The farmer's actual payment is the initial payment basis Thunder Bay or Vancouver adjusted for quality and transportation and handling costs. After marketing the crop, the CWB deducts operating costs and initial payments from the pooled revenues and distributes the remainder to farmers proportional to their deliveries. These "final payments" are usually made in January or February.

Grain delivered to the CWB can be sold to export and domestic markets for feed, food, and industrial uses. The prices received are different for each outlet. Prices in the export market are determined by both world supply-demand conditions and negotiations between the CWB and foreign buyers. The feedgrain for eastern livestock feeders is

priced at Thunder Bay in relation to the price of U.S. corn in eastern Canada, i.e., Montreal. In 1976 the CWB and the Canadian Livestock Feed Board (CLFB) established a formula for determining a "corn competitive" price for western feedgrains to eastern livestock producers (Bray). The formula is based on relative feeding values of western feedgrains and U.S. corn as derived from the value of energy and protein contained in each grain. It incorporates soybean meal as an indicator of the value of protein. The objective of the formula is to assure that CWB prices will remain competitive with U.S. grains and to prevent large-scale substitution of U.S. grains for western Canadian grains.

The CWB price to eastern livestock producers represents a ceiling for western grain. If off-board prices exceeded CWB prices, the CWB would be the sole supplier of western feedgrains. Because the CWB price is based on U.S. corn prices, the Chicago corn market is the major determinant of Canadian feedgrain prices.

The CWB is sole supplier of grain for domestic non-feed uses. In order to protect domestic consumers from large fluctuations in world prices, the CWB has established a two-price scheme: the export price and the Canadian mill price. The Canadian mill price is defined as the price Canadian millers are charged by the CWB for grain (primarily wheat) for domestic non-feed use. An upper and lower limit is established for the mill price. As long as the export price remains between the upper and lower limits of the Canadian mill price, the millers pay the export price. When the export price exceeds the upper

limit, the miller pays the upper limit and the difference is subsidized by the federal government up to some predetermined limit.

Most cattle are raised in western Canada while other livestock are produced in eastern Canada. Recognizing the importance of geography, production, and policy differences, the model treats Canada as two regions:

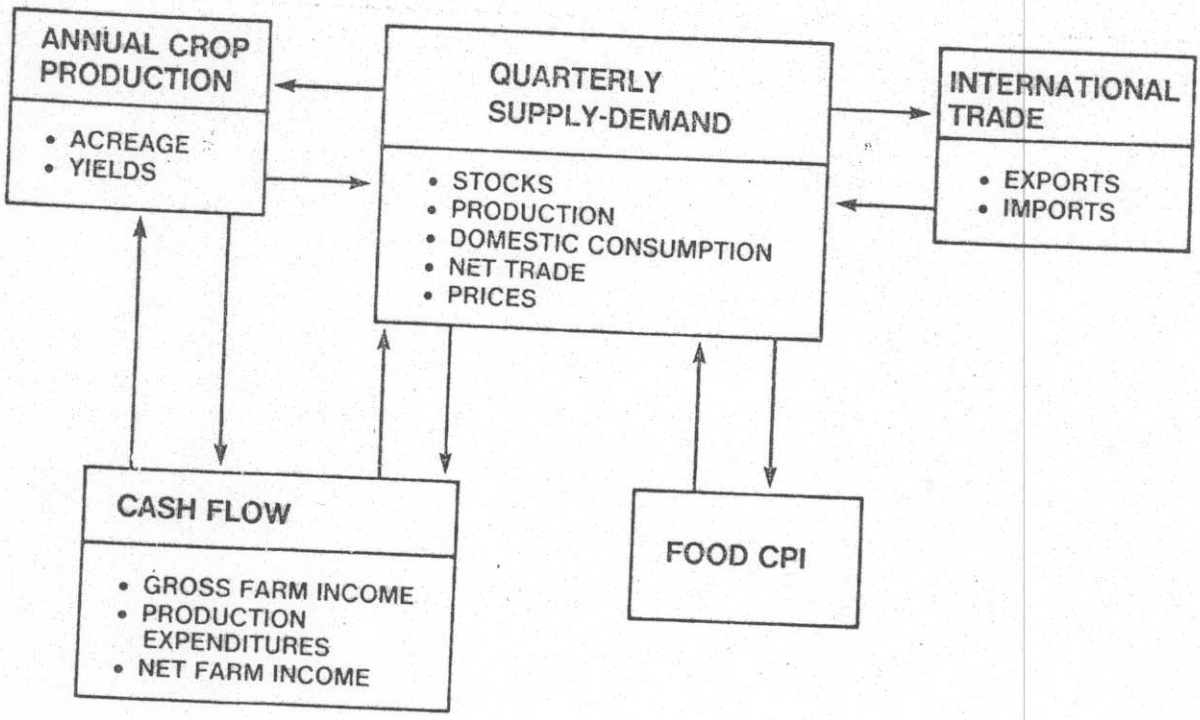
Western Canada	British Columbia
	Alberta
	Saskatchewan
	Manitoba
Eastern Canada	Ontario
	Quebec
	New Brunswick
	Nova Scotia
	Prince Edward Island

The model contains 218 behavioral equations and 224 identities. There are five integral blocks comprising the structural foundation of the model which include: (1) annual crop production, (2) quarterly supply-demand, (3) international trade, (4) cash flow and production costs, and (5) the food component of the consumer price index (CPI). Figure 2 illustrates the model structure.

Annual crop production block

The structural formulation of this block is based on the assumption that crop production decisions are made in three stages. First, farmers decide on the total amount of land to devote to crop production. Reflecting different market prospects, crop production may either be expanded or contracted through the cultivation (noncultivation) of marginal land or the transferring of land in and out of

FIGURE 2. CHASE ECONOMETRICS' CANADIAN AGRICULTURAL MODEL



permanent pasture or nonagricultural uses. Second, producers decide how to allocate available land to various crops to maximize expected profits and minimize risk subject to government policies and weather conditions at planting time. Finally, prior to, during, and after planting the farmer determines the level of herbicide and pesticide treatments and the degree of fertilization.

From the above assumptions, three sets of behavioral equations are formulated--total crop acreage, allocation of total acreage among crops, and yield (Figure 3). The model specifies total crop acreage as a function of expected livestock cash receipts, expected crop cash receipts, expected crop production costs, and a proxy (time trend) for technological changes. If expected cash receipts from crop production are lower than those expected from livestock production, cropland may be converted to pasture and vice versa.

The allocation of cropland to individual crops, the second stage of the three-stage production estimation process, focuses more on short-run profit maximizing decisions. These decisions involve determining an optimal "mix" of crops subject to the land constraint as determined in Stage 1. Relative expected revenues and current government policies are important indicators. Also, weather is important for some crops as unusually dry or wet conditions may favor one crop to another. The percent of each crop to total acreage planted is formulated as a function of own crop and competitive crop prices, expected minimum return per acre, quota constraints, and government farm programs. The expected minimum return is defined as the product of

the previous three-year moving average yield and the CWB initial price in the spring. A three-year moving average of past crop yield is used to estimate the expected yield. Last year's deliveries and stocks at planting time are used as proxies for quota constraints.

The third component of the production estimation process is the determination of average yields. While it is obvious that weather and technological advancements are major factors affecting yields, this model also hypothesizes that for given weather conditions producers adjust production practices in response to profit expectations sufficiently to alter short-run yields around a technological trend. These production practice adjustments can occur prior to, during, and following the planting period in response to changing expectations. Thus, yield variations are hypothesized to be related to crop prices, input costs, weather, and technological trends.

Production is the product of yield and acreage planted. The formulation of the annual crop production block ensures that the allocation of crops is moving on the production frontier according to relative expected profitability (Shiau, Myers, and Klijian).

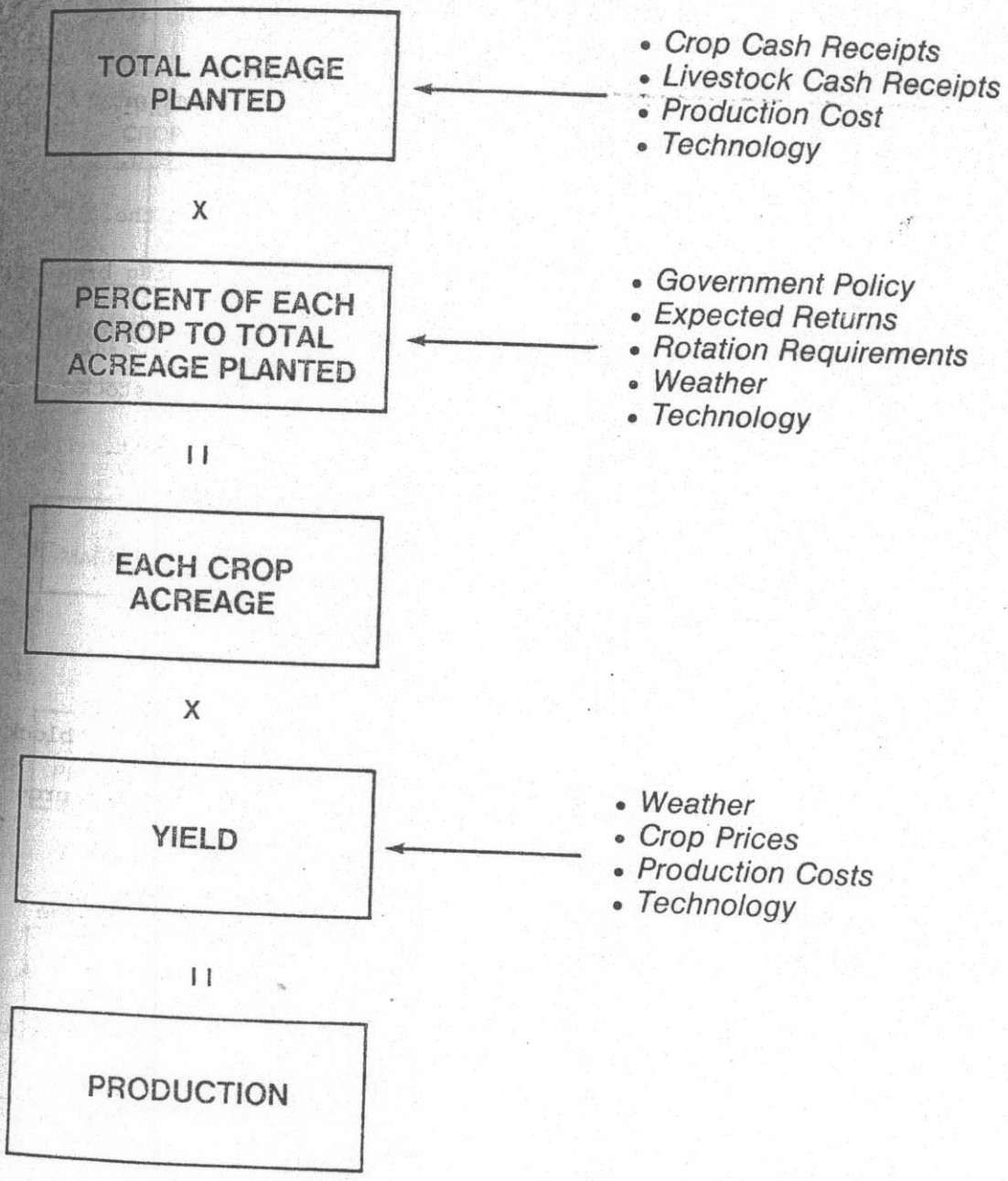
Quarterly crop and livestock supply, disposition and price block

This block provides the primary structural foundation of the model. It contains simultaneously determined quarterly equations of supply, disposition, and prices for 13 commodity groups.

In the livestock sector, the model provides detailed information of animals on farms, production, per capita consumption, stocks, and

FIGURE 3

ANNUAL CROP PRODUCTION MODEL



prices for cattle and calves, hogs, dairy, broilers, turkeys, and eggs. The structural formulation of the cattle and hog subsectors is based on the biological and economic factors of the industries. It also includes equations for the components of the animal and meat balance sheets.

The balance sheet for animals is specified as:

Beginning Stocks + Net Additions = Marketings + Ending Stocks

Net additions are formulated as functions of livestock prices, feed costs, interest rates, and other animals categories, e.g. (1) steer net additions are determined by calves on farms from the previous year, and (2) pigs saved are determined by beginning breeding hog stocks. Marketings are hypothesized to be functions of beginning stocks, livestock prices, and feed costs. Finally, ending stocks are formulated as identities based on the foregoing balance sheet.

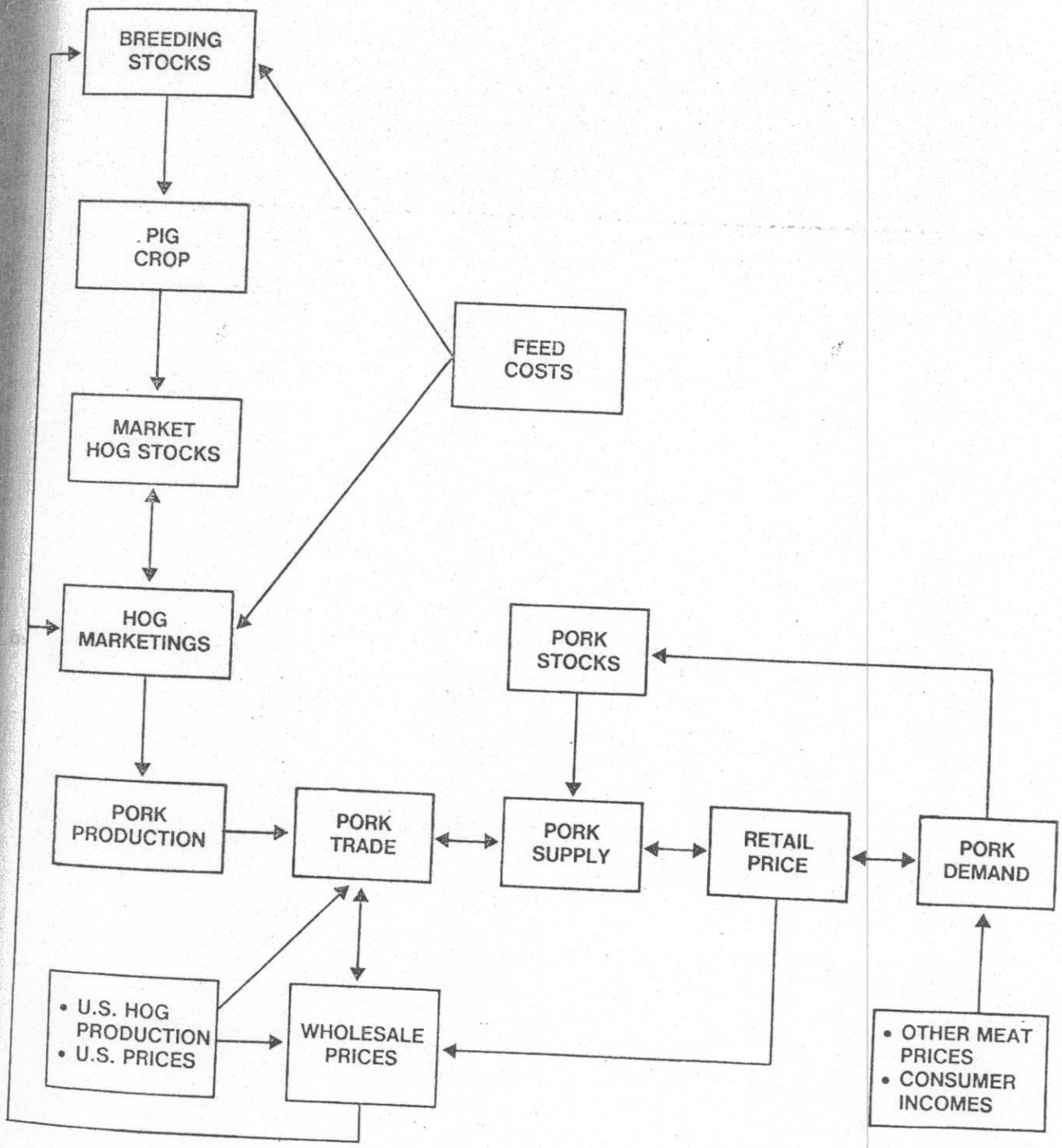
The balance sheet for beef and pork is:

Beginning Stocks + Production + Imports = Consumption +
Exports + Ending Stocks

Imports and exports are linked to the international trade block. The level of carry-out stocks is hypothesized as a function of production and wholesale meat prices. The amount available for per capita consumption is formulated as an identity and linked to the consumer price index block to determine the retail price index. A simplified structure diagram for the Canadian hog market is shown in Figure 4.

FIGURE 4

CANADIAN HOG MARKET STRUCTURE



The preceding structural specification provides an explicit linkage between the animal and meat sectors, ensuring that cattle and hog cycles are consistent with beef and hog production.

The Canadian dairy and poultry sectors are highly regulated. Therefore, to accurately predict these industries, government interventions are endogenized. Government intervention regarding quota allocation and price setting is incorporated with biological and economic factors in both subsectors.

The crop sector includes off-board and commercial markets for wheat, barley, and oats according to the new domestic feed grain policy. The balance sheet for the farm level market is:

Beginning Stocks + Production = Seed Use + On Farm Feed Use + Farmers' Deliveries + Ending Stocks

Seed use is mainly determined by the number of planted acres. On farm feed use reflects the alternative that grain farmers have for marketing their crops through livestock production. It is hypothesized as a function of grain-consuming animal units, grain supply, and off-board prices. Grain-consuming animal units and grain supply have a positive impact on farm feed use while off-board prices have a negative influence on the feed usage. Farmers' deliveries during a given quarter are explained by farm supply, CWB delivery quotas, and expected grain prices as measured by initial prices. Commercial closing stocks, lagged two quarters, are used as proxies for quota

constraints since stocks are the key factor in determining quota allocation. If commercial stocks are reduced, the CWB is likely to relax delivery quotas to rebuild stocks or to prevent them from falling further and vice versa when commercial stocks are building up.

The commercial level consists of CWB and private commercial grain marketing firms. The balance sheet for the commercial grain market is:

Beginning Commercial Stocks + Farmers' Deliveries =

Domestic Use + Exports + Ending Commercial Stocks

Domestic utilization includes human consumption, animal feeding, and industrial use. It is related to population, domestic miller's price, CPI for cereal, grain-consuming animal units, and/or prices of feed-grains. Exports are linked to the international trade block and ending commercial stocks are formulated as identities (Figure 5).

International trade block

The international trade block provides price and trade linkages to the foreign agricultural sector, especially the United States. Cattle and hog trade between Canada and the United States are relatively free and is determined by relative prices and production. Due to proximity and relatively low tariffs between the two countries, Canadian cattle and hog prices are closely related to U.S. prices. Because of its dominant market size, the United States is a price

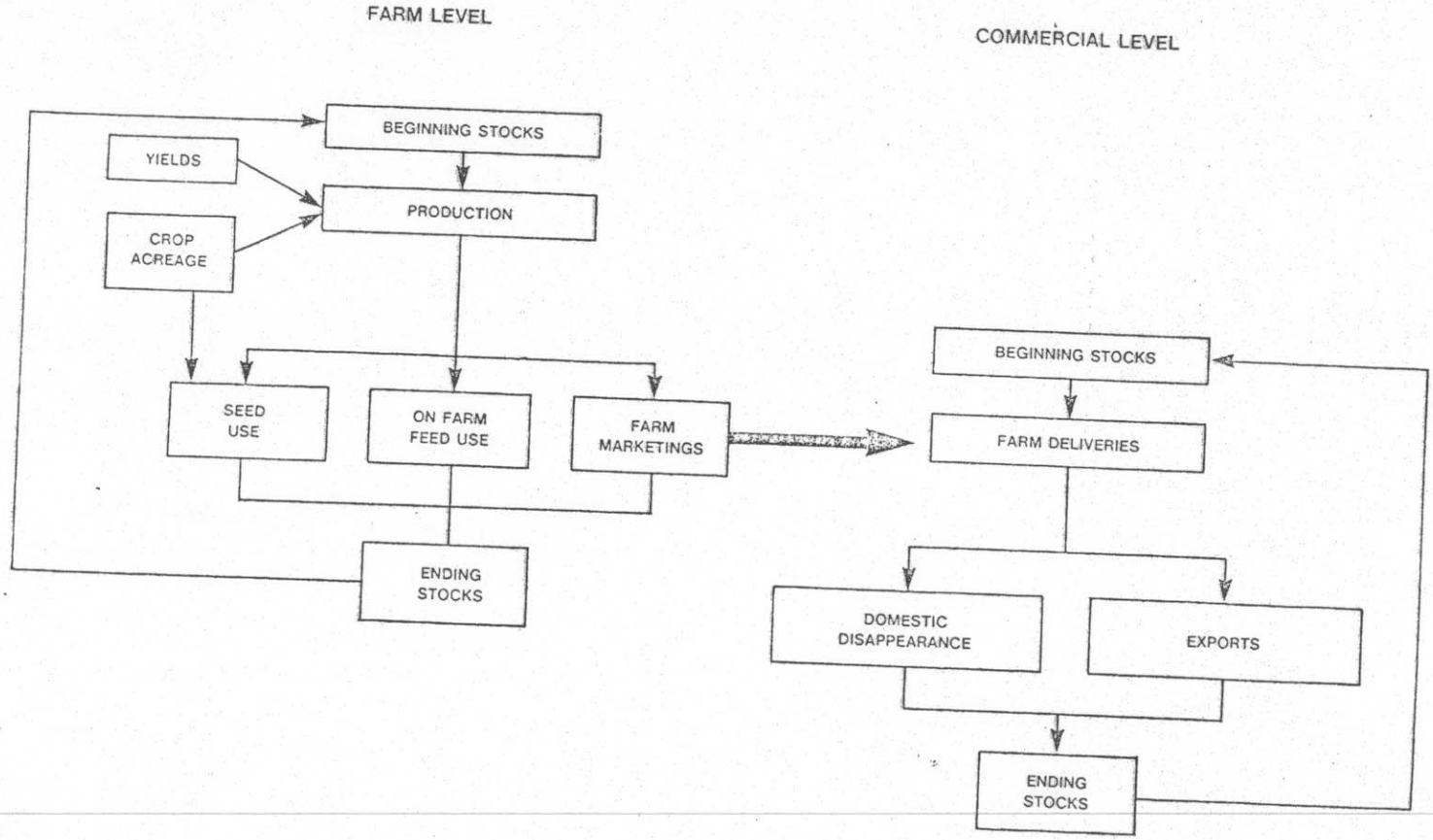


FIGURE 5.
CROP SUPPLY-DISPOSITION MODEL STRUCTURE

leader. Hence, Canadian cattle and hog prices are formulated as functions of U.S. prices, exchange rates, and Canadian demand conditions which in turn are reflected in retail beef and pork prices.

Trade in poultry and eggs is regulated. The available stocks are the key variables in determining the flow of trade in the poultry sectors. Prices to poultry producers are not strongly related to the U.S. prices through trade. Rather, they are determined by provincial marketing boards mainly according to the cost of production.

International trade also plays an important role in the Canadian crop sector. In the model, Canadian crop prices are explained by U.S. prices, exchange rates, and available stocks. Exports are treated exogenously, but will be endogenized in the international wheat submodel which is currently being developed.

Consumer price index block

This block contains equations for various retail price indices and aggregate components of food CPI. The formulation of the retail price index is based on the general equilibrium of the wholesale and retail markets.

The general equilibrium of the markets for the beef and hog sectors is:

1. $Q^{W} = f(P^{us}, P^{W})$ Wholesale Supply by Meat Packers

2. $Q_{d}^{W} = f(P^{W}, P^{r}, WA)$ Wholesale Demand by Retailers

3. $ST = Q_s^w - Q_d^w + ST(-1)$ Wholesale Market Clearing

4. $Q_s^r = f(P^r)$ Retail Supply

5. $Q_d^r = f(P^r, P^s, Y)$ Retail Demand

6. $Q_d^w = Q_s^r$ Retail Market Clearing

7. $Q_s^r = Q_d^r$ Retail Market Clearing

Where:

Q_s^w Wholesale Supply by Meat Packers

P^{us} Wholesale Price, U.S.

P^w Wholesale Price, Canada

Q_d^w Wholesale Demand by Retailer

P^r Retail Price

WA Wage Rate

ST Frozen Pork Stocks

Q_s^r Retail Supply

Q_d^r Retail Demand

P^s Prices of Substitutes

Y Real Per Capita Disposable Income

Through mathematical derivations, the retail price equation can be obtained as:

$$P^r = f(P^s, Y, WA, Q_d^r)$$

A simplified diagram showing the relationship among Canadian beef retail prices, wholesale prices, and U.S. beef wholesale prices is presented in Figure 6. Under the current specification, the model allows Canadian wholesale beef prices to deviate temporarily from the U.S. price if Canadian demand conditions change. The deviation will then cause trade flow to change until the price differential is less than the transportation cost (which includes opportunity cost). In addition, the marketing spread between wholesale and retail markets will affect not only retail prices but also wholesale prices.

Those items without balance sheets in the quarterly livestock and crop supply, disposition, and price block are estimated as functions of related commodity prices and labor costs. These include cereal and bakery products, fats and oils, prepared and partially prepared main dishes, and others.

Food away from home is determined by the demand for and supply of dining and fast food services. It is formulated as a reduced form equation with food CIP at home, wage rates, and real per capita disposable income as regressors.

Since production of fruits and vegetables, sugar, and coffee and tea are not included in the annual crop production block, these items are treated exogenously in the model.

3. $ST = Q_s^w - Q_d^w + ST(-1)$ Wholesale Market Clearing

4. $Q_s^r = f(P^r)$ Retail Supply

5. $Q_d^r = f(P^r, P^s, Y)$ Retail Demand

6. $Q_d^w = Q_s^r$ Retail Market Clearing

7. $Q_s^r = Q_d^r$ Retail Market Clearing

Where:

Q_s^w Wholesale Supply by Meat Packers

P^{us} Wholesale Price, U.S.

P^w Wholesale Price, Canada

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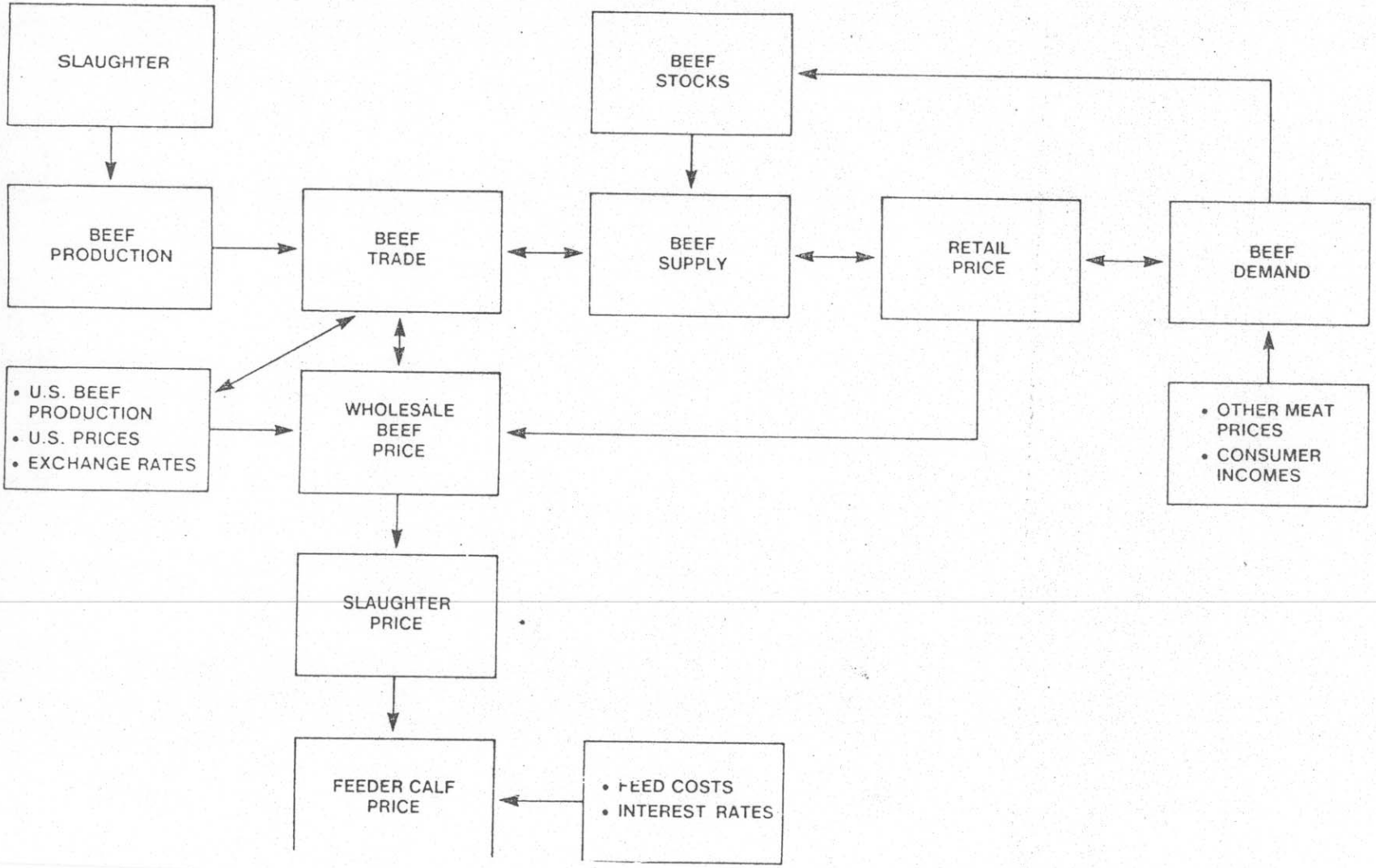
FIGURE 6

BEEF AND CATTLE PRICE STRUCTURE



Farm income and production expenditure block

This block contains behavioral equations and identities for cash receipts, production costs, and income of the agricultural sectors. According to the Statistics Canada definition, cash receipts do not include direct interfarm, intraprovincial transfers. Hence, cash receipts from the sale of agricultural products are formulated as behavior equations. The general specification is:

$$CR_{k,i} = F(PF_{k,i} * D_{k,i}; Q_i)$$

where:

$CR_{k,i}$ = cash receipts from the sale of commodity k during quarter i,

$PF_{k,i}$ = farm price, initial price, or market price of commodity k during quarter i

$DM_{k,i}$ = farm marketing of commodity k during quarter i, and

Q_i = quarterly shifter variables

This block also contains equations for all items of operating expenditures and depreciation charges. They are related to agricultural activities and associated costs. The costs are estimated from various industrial selling price indices obtained from the Chase Fertilizer Model and Chase Canadian Macroeconomic Model.