A MACRO POLICY SIMULATION MODEL OF THE CANADIAN AGRICULTURAL SECTOR

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A MACRO POLICY SIMULATION MODEL OF THE CANADIAN AGRICULTURAL SECTOR

BY

SOE-s LIN

A thesis submitted to the Faculty of Graduate Studies in partial fulfillment of the requirements for the degree of Doctor of Philosophy

Department of Economics
Carleton University
OTTAWA, ONTARIO
May, 1980
The undersigned recommend to the Faculty of Graduate Studies acceptance of the thesis
"A Macro Policy Simulation Model of the Canadian Agricultural Sector"
submitted by Soc Lin, M.Sc. (Economics),
in partial fulfilment of the requirements for the degree of Doctor of Philosophy.

Thesis Supervisor

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May 14, 1980
ABSTRACT

Soe Lipp, Ph. D., Carleton University, May 1980

A Macro Policy Simulation Model of the Canadian Agricultural Sector.

Thesis Supervisor: John F. Chant.

This research is a study of the impact that exogenous forces in the form of changes in fiscal policies, monetary policies, exchange rate policies and world grain and livestock prices have on the Canadian agricultural sector in general and Canadian food prices in particular.

In the first part of the study, the basic theories on production, consumption and inventory holding behaviour are outlined; the institutions and important policies in the Canadian agricultural sector described; and the major studies that have been undertaken on modelling the Canadian grain and livestock sectors and the price transmission process between the farm and retail levels were reviewed.

Relaying upon this body of theoretical work, a priori information and knowledge of the Canadian agricultural institutions and policies, a three sector (grains, livestock, regulated sector comprising of dairy, poultry and eggs) econometric model of the Canadian agricultural sector was constructed and then estimated using Ordinary Least Squares and Two Stage Least Squares econometric techniques. The model was then dynamically simulated over the period 1968-1 to 1977-4, and its simulation performance as measured by several well known non parametric evaluation criteria suggests that the model was a reliable tool to conduct policy experiments. Consequently, five policy experiments - a permanent exchange rate shock, a tight monetary policy experiment, an expansionary fiscal policy experiment, agricultural price shocks in the form of an increase in world
livestock prices relative to world grain prices and finally, a simultaneous absolute rise in world livestock and grain prices, were simulated on the Canadian agricultural sector model.

The results of the experiments suggest that:

1) A permanent exchange rate shock has a permanent and significant impact on food prices.

2) Monetary policy has a pervasive influence on the Canadian agricultural sector and has a strong impact on food prices.

3) The effect of a bond financed expansionary fiscal policy on the Canadian agricultural sector and on food prices is very weak because it generates counteracting forces.

4) World livestock price shocks exert a stronger influence on the grain sector than a comparable shock in world grain prices.

5) A temporary rise in farm level agriculture prices does not have a significant or sustained impact on food prices.

This study has therefore provided empirical support to the often expressed but unarticulated view that exchange rates, disposable income, wage rates, interest rates, the CPI, world livestock and grain prices are important channels through which shocks occurring in the international economy and the domestic macro economy are transmitted to the Canadian agricultural sector. Moreover, the empirical evidence from this study suggests that food prices can be an important channel through which exchange rate changes and monetary policy changes can contribute towards inflationary pressures in the economy.
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I owe a debt of gratitude to Tom Kerr, formerly of Agriculture Canada, who inspired and motivated me to work on this study.

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I benefitted from the opportunity to interact productively with the F.A.R.M. modelling staff at Agriculture Canada particularly, Gerry Robertson, Doug Dau, Gordon MacAulay, and Merritt Cluff.

I would also like to thank Jean Pierre Aubry and Francis Scotland of the Bank of Canada for their assistance with the macro policy simulations.

The financial support provided by Agriculture Canada towards this thesis is gratefully acknowledged.
Micheline Doth's unique ability to decipher my illegible
scrawl has been a great help to me and I thank her for the skill
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My thanks also to Bonnie Savoy for her excellent typing of the final
draft.

Finally, I dedicate this thesis to my parents to whom I owe
so much and to my wife, Hla-Hla, whose unfailing cheerfulness,
understanding and confidence in me made my task so much easier.
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CHAPTER 1: INTRODUCTION

Agriculture is an important sector in the Canadian economy. According to the 1976 census, the production sector of Canadian agriculture consisted of 339,000 farm holdings, of which 39,000 had sales under $1200. The farm sector employed a total of 474,000, approximately 5 percent of the total labour force in 1976 and the capital employed in Agriculture (land, buildings, machinery and livestock) was valued at $48.8 billion. Total new investment in agriculture in recent years has averaged 4.3 percent of gross capital formation in the economy. In 1976 consumers spent $22.5 billion on food and non-alcoholic beverages which is 65 percent of personal expenditure on non-durable consumer goods and services or alternatively 14.5 percent of personal income.

Canada is a major trader in agricultural products (see Tables 1.1, 1.2). The importance of trade to the Canadian agricultural sector and by extension to the rest of the economy is underlined by the fact that during the period covering 1975-77 exports of agricultural products, on average, contributed 38 percent to total farm cash receipts and 10.3 percent to total Canadian merchandise exports.

Over the same period, agricultural imports averaged $3.2 billion which was 8.4 percent of total merchandise imports. Canada’s trade balance in agricultural products has invariably been positive and the average trade surplus is close to $0.9 billion.

One parameter of the agriculture industry that is drawing increasing public attention is the CPI - Food. Its sharp volatility in recent years and the 25 percent weight it has in the CPI (1967 weights) combines
to make this index an economically important and a politically sensitive one.

During the period between 1973-74 food prices rose at a record year to year rate of 14.0 percent. The CPI (all items) in the same period increased by 9.8 (percent). Since food has a 24.8 percent weight in the CPI this means that 35.5 percent of the rise in CPI over the period is attributable to increases in food prices. Again, in 1976, the rate of food price inflation sharply declined to a zero rate of change in the third quarter and a negative 1.1 percent rate of change in the fourth quarter. Since the CPI (ex-food) was hovering steadily around a 9 percent rate during the four quarters of 1976, the decline in the rate of change of the overall CPI from 10.8 percent in 1975 to 7.5 percent in 1976 was largely the result of the decline in food prices. In 1977 and 1978 the year to year rise in food prices was 8 percent and 9 percent respectively. Particularly, over the years 1973-76 the food component of CPI has clearly asserted itself as a major force in movements of the overall CPI, both upwards and downwards. These movements of the CPI - food relative to the CPI - all items are more clearly illustrated in FIG: 1.

This new phenomenon, new because not since the Korean War has farm and food prices been a substantive contributory factor towards inflationary pressures in the economy, puzzled the managers of the economy. Since changes in CPI is widely used as a measure of inflation and hence as a target for macro stabilization measures the "puzzle" was also quite disturbing.
As Hathaway (1974) puts it:

"economic advisers were surprised, if not confused, by this new turn of events, for they understood neither its causes nor its cure. Their ignorance and confusion arose partly from the fact that the legislative and executive branches tend to make food policy in isolation, even though, as contemporary events amply demonstrate, it is deeply significant to total national and international economic policy."

On the other hand, until recently, not many agriculture economists have regarded exchange rate changes, the Central Bank's monetary policy, the Government's budget constraint as issues about which they should be directly concerned. To be fair, this was only consistent with an efficient allocation of scarce intellectual resources to let those issues which were peripheral to the agriculture sector to be treated as part of the given economic environment.

However, when the world entered the decade of the 70's it soon became clear that the institutions and the structure of the world economy had begun to change significantly. A sample set of these changes would have to include the dismantling of the Bretton Woods International Monetary system and the movement towards a more flexible exchange rates system; the formation of OPEC, an oil cartel, which has forced the world economy to adjust to a sharp and continuing rise in the price of oil; the integration of national economies and money markets into an increasingly international network of trade and investment made possible by reducing restrictions on the movement of goods and capital across nations and facilitated by the growth of multinational corporations. These changes in the world economy manifested themselves in unprecedented fluctuations in exchange rates, interest rates
and wage rates, accelerated increases in the price level and slow growth with accompanying high unemployment rates.

The rapid and sharp movements of those economic variables which are largely beyond the control of agriculture policy makers were worrying not only for the large accompanying impacts that were felt in the agriculture sector but also because the nature of the links between the international economy, the macro economy and the agriculture sectoral economy was not clearly understood. Schuh (1976), particularly, has drawn attention to this point in an invited address given to the American Agriculture Economics Association meetings in 1976 where he said:

"Agricultural economics is by definition a sectoral discipline. This has been a source of strength and the source of one of our major weaknesses. It has been a source of strength because it has caused us to specialize in understanding the problems of a single sector of the economy.

At the same time, however, our sectoral emphasis has caused us to neglect the linkages of agriculture with the rest of the economy, and to underestimate (or under-emphasize) the inter-relationships between agriculture and the larger economy. Agricultural economics earned its spurs and has made most of its contributions to science and knowledge with its work at the micro level. If we had one major failing over the years, it has been this failure to fully grasp the macro-economy of agriculture."

In developed economies like Canada, food prices are mainly determined by grain, livestock and dairy product prices. The world price for grains and oilseeds is largely determined by the excess demand in the rest of the world and excess supply of the U.S. which is
the world's largest exporter of grains and oilseeds. Feed grains represent a major input into livestock and dairy production and livestock products are generally highly income elastic. Dairy production, in most developed countries, including Canada, is highly regulated. World grain prices, exchange rate changes, population and income growth, demand management policies and the policies of the regulatory agencies will therefore be expected to have a large bearing on the determination of food prices in Canada.

MOTIVATION

The motivation underlying this thesis can therefore be stated thus: to delineate the Canadian agriculture economy's links with the international agriculture economy on one side and with the Canadian-macro economy on the other through an empirical analysis of the impact of changes in world prices of livestock and grains, exchange rate changes, fiscal and monetary policy changes on the Canadian agricultural sector in general and on food prices in particular.

Towards this end, as a first step, a three sector model of the Canadian agricultural industry will be constructed relying on a priori information, relevant economic theory and knowledge of the institutions and policies important to Canadian agriculture. In the second step, the constructed model will be estimated and validated using appropriate econometric techniques. In the third and final step policy scenarios relevant to the central question posed by this thesis will be set up and the validated model will be used to simulate and analyze the impact of these policies.
The thesis is organized along the following lines: Chapter 1 provides an introduction, motivation for the thesis and procedures that are followed and the organization of the remainder of the thesis. In Chapter 2, a short review of the theory and relevant literature is undertaken.

Chapter 3 comprises three sections - one each for the three sectors of the Canadian agriculture industry that are modelled - namely the grains and oilseeds, the livestock and a conglomerate of the Dairy, Poultry and Egg sectors, which for ease of exposition will henceforth be called the regulated sector. In each of these three sections, the following material will be included: a) a short description of the sector supported by relevant statistics, b) an outline of the major institutions and important policy shifts that significantly affect the sector, c) a discussion of the economic structure of the sector.

Chapter 4 will discuss the econometric specification of the model.

In Chapter 5, Section 1 will discuss appropriate estimation methods and the particular approach taken towards the estimation of the model. In Section 2, the OLS and TSLS results are presented. In Section 3, the final structure of the model is presented in its entirety.

In Chapter 6, the model is validated and the results of the historical and ex-poste simulation of the model are presented and discussed.

In Chapter 7, the background for policy experiments and the results of six policy simulation experiments are presented and discussed.
In Chapter 8, a summary of conclusions and a discussion of the limitations of the thesis and directions for future research are suggested.
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<td>All Commodities</td>
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<td>31,339,458</td>
<td>32,586,855</td>
<td>37,757,693</td>
<td>43,505,799</td>
<td>51,719,054</td>
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<td>Agricultural Products</td>
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<td>2,063,875</td>
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<td>Barley</td>
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<td>52,159</td>
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<td>114,728</td>
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<td>440,666</td>
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<td>Rape-seed</td>
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<td>Oilcake and meal</td>
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<td>18,309</td>
<td>31,230</td>
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<td>Animals, live</td>
<td>74,556</td>
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<td>Cattle</td>
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<td>64,373</td>
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<td>Pork, fresh, frozen</td>
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<td>93,046</td>
<td>93,407</td>
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<td>Other animal products</td>
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<td>159,212</td>
<td>204,381</td>
<td>256,617</td>
<td>301,513</td>
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<td>Furs, hides and skins</td>
<td>63,491</td>
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<td>125,311</td>
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<td>36,314</td>
<td>44,851</td>
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<td>Poultry and eggs</td>
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<td>15,487</td>
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<td>30,999</td>
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<td>Vegetables (excl. potatoes)</td>
<td>40,670</td>
<td>58,050</td>
<td>60,494</td>
<td>71,452</td>
<td>84,646</td>
<td>76,503</td>
</tr>
<tr>
<td>Potatoes and products</td>
<td>13,084</td>
<td>23,484</td>
<td>26,013</td>
<td>45,588</td>
<td>33,119</td>
<td>25,513</td>
</tr>
<tr>
<td>Seeds for sowing</td>
<td>17,490</td>
<td>26,862</td>
<td>19,238</td>
<td>21,426</td>
<td>31,663</td>
<td>31,755</td>
</tr>
<tr>
<td>Maple products</td>
<td>6,731</td>
<td>6,531</td>
<td>5,848</td>
<td>7,851</td>
<td>9,648</td>
<td>11,116</td>
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<tr>
<td>Sugar</td>
<td>4,606</td>
<td>22,390</td>
<td>48,665</td>
<td>17,162</td>
<td>41,875</td>
<td>46,336</td>
</tr>
<tr>
<td>Tobacco, raw</td>
<td>55,395</td>
<td>71,424</td>
<td>69,154</td>
<td>63,135</td>
<td>64,231</td>
<td>99,679</td>
</tr>
<tr>
<td>Tobacco, bright flue-cured</td>
<td>54,318</td>
<td>65,166</td>
<td>64,135</td>
<td>58,725</td>
<td>61,007</td>
<td>92,934</td>
</tr>
<tr>
<td>Vegetable fibres</td>
<td>1,614</td>
<td>4,017</td>
<td>4,702</td>
<td>5,467</td>
<td>6,765</td>
<td>7,132</td>
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<tr>
<td>Plantation crops</td>
<td>3,937</td>
<td>7,132</td>
<td>3,867</td>
<td>10,191</td>
<td>27,535</td>
<td>9,398</td>
</tr>
<tr>
<td>Other agricultural products</td>
<td>51,557</td>
<td>74,510</td>
<td>78,148</td>
<td>79,022</td>
<td>105,740</td>
<td>120,381</td>
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<tr>
<td>Peat and other moss</td>
<td>16,836</td>
<td>26,442</td>
<td>27,140</td>
<td>30,699</td>
<td>37,147</td>
<td>42,983</td>
</tr>
</tbody>
</table>

*a* Excludes seed wheat and seed oats (included in Seeds for sowing).

*b* Excludes oilcake and meal (see Oilseed Products).

*c* Excludes fancy meats (offsals) (beef - $8,455; pork - $10,25R thousand 1973; (beef - $5,320; pork - $10,862 thousand 1974; (beef - $5,086; pork - $10,559 thousand 1975; (beef - $7,354; pork - $10,329 thousand 1976; (beef - $8,463 thousand 1977; (beef - $9,679; pork - $17,183 thousand 1978.

Source: International Trade Policy Division, Agriculture Canada
<table>
<thead>
<tr>
<th></th>
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<th></th>
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<tbody>
<tr>
<td><strong>All Commodities</strong></td>
<td>17,139,007</td>
<td>31,880,299</td>
<td>34,829,715</td>
<td>37,444,389</td>
<td>42,155,973</td>
<td>49,683,997</td>
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<tr>
<td><strong>Agricultural Products</strong></td>
<td>1,605,207</td>
<td>2,826,412</td>
<td>2,811,095</td>
<td>3,128,667</td>
<td>3,555,775</td>
<td>4,012,741</td>
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<tr>
<td>Grains</td>
<td>46,800</td>
<td>181,721</td>
<td>132,408</td>
<td>121,523</td>
<td>81,698</td>
<td>84,457</td>
</tr>
<tr>
<td>Corn</td>
<td>34,164</td>
<td>151,219</td>
<td>102,671</td>
<td>95,091</td>
<td>53,704</td>
<td>47,255</td>
</tr>
<tr>
<td>Grain products (human)</td>
<td>25,859</td>
<td>61,040</td>
<td>49,702</td>
<td>57,229</td>
<td>77,014</td>
<td>78,725</td>
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<td>Bakery products</td>
<td>12,219</td>
<td>18,960</td>
<td>22,531</td>
<td>28,899</td>
<td>36,513</td>
<td>37,956</td>
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<tr>
<td>Animal feeds</td>
<td>16,457</td>
<td>29,526</td>
<td>35,073</td>
<td>33,572</td>
<td>32,354</td>
<td>42,976</td>
</tr>
<tr>
<td>Olseeds</td>
<td>65,285</td>
<td>131,278</td>
<td>131,706</td>
<td>126,162</td>
<td>147,172</td>
<td>154,060</td>
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<tr>
<td>Soybeans</td>
<td>45,407</td>
<td>90,504</td>
<td>86,210</td>
<td>81,136</td>
<td>98,954</td>
<td>91,245</td>
</tr>
<tr>
<td>Oilseed products</td>
<td>84,392</td>
<td>194,605</td>
<td>181,170</td>
<td>190,460</td>
<td>226,511</td>
<td>263,181</td>
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<tr>
<td>Oils</td>
<td>57,735</td>
<td>132,241</td>
<td>114,025</td>
<td>109,807</td>
<td>123,459</td>
<td>147,148</td>
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<tr>
<td>Oliche and meal</td>
<td>29,153</td>
<td>51,455</td>
<td>54,599</td>
<td>70,248</td>
<td>90,690</td>
<td>103,277</td>
</tr>
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<td>Animals, live</td>
<td>47,161</td>
<td>97,030</td>
<td>61,261</td>
<td>88,865</td>
<td>30,161</td>
<td>56,571</td>
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<tr>
<td>Cattle</td>
<td>38,920</td>
<td>81,477</td>
<td>43,302</td>
<td>70,461</td>
<td>13,361</td>
<td>36,833</td>
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<td>Meats</td>
<td>142,823</td>
<td>186,601</td>
<td>192,439</td>
<td>335,393</td>
<td>294,841</td>
<td>331,212</td>
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<tr>
<td>Beef, veal, fresh, frozen</td>
<td>78,640</td>
<td>97,494</td>
<td>72,295</td>
<td>132,510</td>
<td>88,200</td>
<td>147,502</td>
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<tr>
<td>Pork, fresh, frozen</td>
<td>15,345</td>
<td>38,035</td>
<td>77,031</td>
<td>144,561</td>
<td>142,167</td>
<td>110,815</td>
</tr>
<tr>
<td>Mutton, lamb, fresh, frozen</td>
<td>21,311</td>
<td>20,935</td>
<td>16,474</td>
<td>18,842</td>
<td>19,181</td>
<td>25,946</td>
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<tr>
<td>Other animal products</td>
<td>95,057</td>
<td>155,313</td>
<td>144,532</td>
<td>187,223</td>
<td>199,368</td>
<td>231,050</td>
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<tr>
<td>Hides, skins, furs</td>
<td>45,258</td>
<td>76,358</td>
<td>73,104</td>
<td>102,119</td>
<td>107,316</td>
<td>131,737</td>
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<tr>
<td>Wool, raw</td>
<td>26,760</td>
<td>26,667</td>
<td>24,505</td>
<td>30,021</td>
<td>33,659</td>
<td>38,647</td>
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<tr>
<td>Dairy products</td>
<td>33,208</td>
<td>78,598</td>
<td>58,323</td>
<td>57,718</td>
<td>63,766</td>
<td>76,426</td>
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<tr>
<td>Cheese</td>
<td>22,447</td>
<td>41,375</td>
<td>47,561</td>
<td>52,243</td>
<td>58,165</td>
<td>66,024</td>
</tr>
<tr>
<td>Poultry and eggs</td>
<td>15,551</td>
<td>24,590</td>
<td>32,701</td>
<td>59,916</td>
<td>52,234</td>
<td>59,111</td>
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<tr>
<td>Shell eggs</td>
<td>6,970</td>
<td>9,817</td>
<td>12,098</td>
<td>17,386</td>
<td>16,295</td>
<td>19,553</td>
</tr>
<tr>
<td>Fruits and nuts</td>
<td>309,847</td>
<td>434,171</td>
<td>490,954</td>
<td>546,194</td>
<td>649,470</td>
<td>818,323</td>
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<tr>
<td>Citrus, fresh or processed</td>
<td>87,637</td>
<td>111,944</td>
<td>132,091</td>
<td>142,221</td>
<td>176,499</td>
<td>243,561</td>
</tr>
<tr>
<td>Bananas</td>
<td>35,566</td>
<td>41,515</td>
<td>54,436</td>
<td>59,134</td>
<td>66,631</td>
<td>74,727</td>
</tr>
<tr>
<td>Vegetables (excl. potatoes)</td>
<td>141,406</td>
<td>237,867</td>
<td>265,936</td>
<td>289,268</td>
<td>359,557</td>
<td>413,245</td>
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<tr>
<td>Fresh vegetables</td>
<td>100,979</td>
<td>142,174</td>
<td>177,065</td>
<td>207,456</td>
<td>237,536</td>
<td>278,676</td>
</tr>
<tr>
<td>Potatoes and products</td>
<td>11,259</td>
<td>25,236</td>
<td>19,185</td>
<td>29,220</td>
<td>37,095</td>
<td>32,653</td>
</tr>
<tr>
<td>Seeds for sowing</td>
<td>11,595</td>
<td>22,346</td>
<td>22,262</td>
<td>23,741</td>
<td>35,775</td>
<td>40,639</td>
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<tr>
<td>Sugar</td>
<td>112,083</td>
<td>441,979</td>
<td>504,962</td>
<td>274,783</td>
<td>230,588</td>
<td>211,375</td>
</tr>
<tr>
<td>Tobacco</td>
<td>5,303</td>
<td>9,873</td>
<td>11,590</td>
<td>7,690</td>
<td>9,031</td>
<td>10,680</td>
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<tr>
<td>Vegetable fibres</td>
<td>50,876</td>
<td>77,563</td>
<td>56,875</td>
<td>76,339</td>
<td>85,965</td>
<td>94,134</td>
</tr>
<tr>
<td>Cotton, raw</td>
<td>45,551</td>
<td>65,469</td>
<td>48,584</td>
<td>65,889</td>
<td>76,693</td>
<td>85,100</td>
</tr>
<tr>
<td>Plantation crops</td>
<td>178,908</td>
<td>258,317</td>
<td>297,504</td>
<td>405,665</td>
<td>685,516</td>
<td>715,850</td>
</tr>
<tr>
<td>Coffee and products</td>
<td>100,176</td>
<td>131,685</td>
<td>168,430</td>
<td>250,693</td>
<td>423,443</td>
<td>437,782</td>
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<td>Tea and products</td>
<td>23,506</td>
<td>29,822</td>
<td>35,094</td>
<td>35,869</td>
<td>73,289</td>
<td>58,464</td>
</tr>
<tr>
<td>Other agricultural products</td>
<td>101,037</td>
<td>180,644</td>
<td>207,532</td>
<td>218,715</td>
<td>257,183</td>
<td>295,597</td>
</tr>
<tr>
<td>Spices, flavorings and confection</td>
<td>36,489</td>
<td>62,074</td>
<td>81,791</td>
<td>78,540</td>
<td>97,949</td>
<td>110,384</td>
</tr>
</tbody>
</table>

Excludes 1978-85,251 thousand seed corn (included in Seeds for sowing).

*Excludes oilcake and meal (see Oilseed Products).

*Includes (62,635,000 pounds of butter valued at $3,446,000) 1972;
(53,765,900 pounds of butter valued at $3,237,000) 1974;
(10,063,900 pounds of butter valued at $5,897,000) 1975;
(11,120,000 pounds of butter valued at $4,989,000) 1978.

*Includes hatching eggs.

Source: International Trade Policy Division Agriculture Canada
FIGURE 1: CONTRIBUTION OF FOOD PRICES TO INFLATION

- % INCREASE CPI-FOOD
- % INCREASE CPI-ALL ITEMS
- WEIGHTED % INCREASE IN CPI-FOOD (1967 WEIGHTS) / % INCREASE IN CPI-ALL ITEMS

CHAPTER 2: REVIEW OF THEORY AND LITERATURE

PRODUCTION THEORY

Let us take the firm as the basic unit of the production organization. Typically, the firm is assumed to maximize profit subject to a set of technical and institutional constraints. The technical constraints, as represented by the production function, defines the relationship between the set of inputs used in the production process and the maximum attainable level of output for a given technology.

The production function of a representative firm can be written as:

\[ Q = F(X_1, X_2, \ldots, X_n) \]  \hspace{1cm} (1.1)

where \( Q \) is physical output and \( (X_1, X_2, \ldots, X_n) \) are the physical inputs involved in the production process. The function \( F \) is assumed twice differentiable, non decreasing and concave for \( X_i > 0 \).

Assume that the firm is faced with the output demand function given by \( P_0 = d(Q) \) where \( P_0 \) is output price and by input supply functions \( P_i = s(X_1, X_2, \ldots, X_n) \) where \( P_i \) is the price of the \( i^{th} \) input.
The firm is presumed to maximize the profit function

\[ \pi = P_0 Q - \sum_{i=1}^{n} P_i X_i \]  

(1.2)

First order functions for an extremum are:

\[ \frac{\partial \pi}{\partial X_i} = P_0 \frac{\partial Q}{\partial X_i} + Q \frac{\partial P_i}{\partial Q} \frac{\partial Q}{\partial X_i} - P_i \]

\[ \sum_{j=1}^{n} (X_j \frac{\partial P_j}{\partial X_i}) = 0 \]  

(1.3)

Alternatively,

\[ \frac{\partial Q}{\partial X_i} = P_i + \sum_{j=1}^{n} (X_j \frac{\partial P_j}{\partial X_i}) \]

(1.4)

Expressing in terms of elasticities:

\[ \frac{\partial Q}{\partial X_i} = \frac{P_i}{P_0} \left[ \frac{\sum_{j=1}^{n} \frac{E_j}{E_i} \frac{\varepsilon_{ij}}{1 + \varepsilon_{ij}}}{1 + \varepsilon_{ii}} \right] \]

(1.5)

with \( i = 1 \ldots n \) and where \( E_j = P_j X_j \) is the expenditure on input \( j \),

\[ E_{ij} = \frac{\partial X_i}{\partial P_j} \frac{P_j}{X_i} \]  

is the elasticity of input quantity (i)

.../13
with respect to input price \((j)\).

\[
\varepsilon_0 = \frac{\partial q}{\partial p_0} \cdot \frac{p_0}{q}
\]

\[
\varepsilon_i = \frac{\partial q}{\partial p_i} \cdot \frac{p_i}{q}
\]

is the price elasticity of output demand.

\[
\varepsilon_i = \frac{\partial q}{\partial p_i} \cdot \frac{p_i}{q}
\]

is the output elasticity with respect to input prices.

Given the assumptions on the production function and appropriate conditions on the input supply and output demand functions, the second order conditions for a maximum are assumed satisfied.

Note that the equation is homogenous of degree zero in prices. That is, a proportionate change in all prices will not affect the optimal conditions of production.

Moreover, the classical optimum

\[
\frac{\partial q}{\partial x_1} = \frac{p_1}{p_0} \quad \text{is obtained from} \quad (1.5) \quad \text{if and only if}
\]

\[
\frac{1}{\varepsilon_0} = \sum_{j=1}^{n} \left( \frac{E_j}{E_i \varepsilon_{ij}} \right)
\]

This condition is satisfied in the perfectly competitive case where input and output price elasticities are infinity \((\varepsilon_0 = \varepsilon_{ij} = \infty)\).

Assuming no interaction effects among inputs in the production function, the marginal product can be obtained by differentiating (1.1).

\[
\frac{\partial q}{\partial x_i} = F_i' \left( x_1, x_2, \ldots, x_n \right) ; \quad i = 1, \ldots, n
\]

and substituting (1.7) into (1.6) yields the optimal conditions for a perfectly competitive firm.

\[
F_i' \left( x_1, x_2, \ldots, x_n \right) = \frac{p_i}{p_0}
\]

where

\[
\vdots = 14
\]
$P_i$ and $P_0$ are prices determined exogenously. Expression (1.8) represents a set of $n$ equations with $n$ unknowns and can be solved for the optimal input use: $X_i^* = g_i \left( \frac{P_1}{P_0}, \frac{P_2}{P_0}, \ldots, \frac{P_n}{P_0} \right)$. (1.9)

Equation (1.9) is the resulting static input demand function which is homogenous of degree zero in prices.

Substituting (1.9) into (1.1) yields the static output supply function:

$$Q = g_1 g_2 \cdots g_n$$

which is also homogenous of degree zero in prices.

Equation (1.9) and (1.10) says that the demand for input $i$ and the supply of output $Q$ by a perfectly competitive firm is a function only of the relative prices of input $i$ to output $Q$. 

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CONSUMPTION THEORY

A consumer's ordinary demand function gives the quantity of a commodity that he will consume as a function of commodity prices and his income. These functions can be derived from the analysis of utility maximization (GREEN 1971). If a utility function that takes the specific form \( U = g_1 g_2 \) is assumed for the individual who also faces a budget constraint \( Y - p_0^1 g_1 - p_0^2 g_2 = 0 \) a lagrangian expression can be formed thus:

\[
U = g_1 g_2 + \frac{\partial U}{\partial g_1} (Y - p_0^1 g_1 - p_0^2 g_2) = 0
\]

\[
\frac{\partial U}{\partial g_1} = g_2 - \Theta p_0^1 = 0
\]

\[
\frac{\partial U}{\partial g_2} = g_1 - \Theta p_0^2 = 0
\]

\[
\frac{\partial U}{\partial \Theta} = Y - p_0^1 g_1 - p_0^2 g_2 = 0
\]

\[
\frac{g_2}{g_1} = \frac{p_0^1}{p_0^2}
\]

\[
g_2 = \frac{p_0^1 g_1}{p_0^2}
\]

\[
\frac{Y}{p_0^2} - \frac{Y^2}{2p_0^2}
\]
Similarly, \( g_1 = \frac{y}{2p_0} \) \hspace{1cm} (1.16)

The demand functions for \( g_1 \) and \( g_2 \) can therefore be written:

\[
\begin{align*}
\quad g_1 &= g_1 \left( p_0^1, y \right) \quad (1.17) \\
\quad g_2 &= g_2 \left( p_0^2, y \right) \quad (1.18)
\end{align*}
\]

These demand functions depend only on their own price and income. In other words, it is assumed:

\[
\frac{\partial g_1}{\partial p_2} = \frac{\partial g_2}{\partial p_1} = 0.
\]

To the extent that \( g_1 \) and \( g_2 \) are not independent either because they are substitutes or complements then the demand functions will be written as:

\[
\begin{align*}
\quad g_1 &= g_1 \left( p_0^1, p_0^2, y \right) \quad (1.19) \\
\quad g_2 &= g_2 \left( p_0^2, p_0^1, y \right) \quad (1.20)
\end{align*}
\]

Two important properties of demand functions can be deduced:

1. The demand for any commodity is a single valued function of own price, substitute price and income. This property follows from the convexity of the indifference curves. A single maximum and therefore a single commodity combination corresponds to a given set of prices and incomes.

2. Demand functions are homogenous of degree zero in prices and incomes, i.e., if all prices and incomes change in the same proportion, the quantities demanded remain unchanged.
This means that:

$$g_i = g_i \left( k P^1_0, k P^2_0, kY \right)$$  \hspace{1cm} (1.21)

where $i = 1, 2$.

Since $K$ is any positive number, we can set it equal to $1/P^1_0$ (or $1/Y$) and write $g_i = g_i \left( 1, P^2_0, Y \right) = g_i \left( P^1_0, P^2_0, 1 \right)$. \hspace{1cm} (1.22)

The quantity of $i$th commodity demanded is uniquely determined by the $n$ ratios formed by dividing each of the $n + 1$ independent variables by any one of them. One quotient is always unity. Alternatively, we can write:

$$g_i = h_i \left( \frac{P^2_0}{P^1_0}, \frac{Y}{P^1_0} \right) = k_i \left( \frac{P^1_0}{Y}, \frac{P^2_0}{Y} \right).$$  \hspace{1cm} (1.23)

The quantity of $i$th good demanded is a function of relative prices and real income.
INVENTORY

The previous section was concerned with the factors that determine the consumption demand for goods - a flow demand. This section would deal with the inventory demand for goods - a stock demand. Particularly, in the agricultural sector because of the periodic nature of production (harvests), stocks of goods are held to meet transactions, precautionary and speculative demand. A prime example of this would be the inventory demand for grains.

To elaborate, the transactions motive gives rise to a demand for stocks to meet various production, processing and marketing requirements between harvests. The Wheat Board, the grain trading firms, and farmers in the normal course of transacting the business of buying and selling grain, producing grain and raising livestock would have a transaction demand for stocks. The precautionary motive gives rise to a demand for stocks to meet unplanned contingencies. The return from holding such stocks are savings in costs arising from an unexpected disruption of supplies: losing an export contract because of a dock strike or a transportation bottleneck are pertinent examples. The speculative motive gives rise to a demand for stocks for capital gain reasons. The owner of a storeable food - say grain, is confronted with the decision to sell his grains now at the prevailing price or postpone his sale to a later date if he expects the price to rise. If he decides not to sell at the current price this implies that he is demanding to own the amount of grain in question. This would be determined, at the margin, by the equality of the marginal return from owning the grain which consists of the utility he derives
from the ownership of grain and the expected increase in price, and the marginal cost of owning grain - which is made up of the highest return foregone from not owning a good other than grain and the actual cost of owning grain (Stigler 1966).

Another type of stock demand that is found in the agricultural sector is the demand for a capital good such as livestock that generates an income stream through time.

An appropriate theoretical framework for the econometric analysis of the demand for livestock capital goods is taken to be the investment theory of the firm. Livestock, in the form of meat is a consumption good but livestock can also be regarded as a capital good which is held by producers as long as their capital value in production (breeding) exceeds their value in production (slaughter). Another feature of the livestock good is that, like wine or valuable timber, it is a growing capital machine so that the value of the capital good itself is a function of time. This latter aspect of the livestock capital good results in a constantly changing set of resources for the livestock firm which, at each point in time, must decide whether to hold on to the existing stock of livestock capital goods (i.e. further investing) or sell the livestock either as consumption good (i.e. slaughter) or as capital good to another investor.

Jarvis (1969) has treated cattle producers as portfolio managers seeking the optimal combination of different categories of animals to complement their non-livestock assets from current conditions and expectations of the future. Yver (1971) provides further elaboration
by classifying the decision problem of the cattle firm into three categories:

(1) How much capital to own?

(2) What the composition of the capital good should be?

(3) What shall be the rate of utilization of capital in the alternative uses of producing further capital goods and consumption goods. Decisions (1) and (2) are portfolio choices while (3) is a familiar production decision.

In the model that will be developed later livestock is treated as a composite good and disaggregation by sex, age or type is not attempted. The portfolio decision consists of choosing between the livestock capital good and other assets.

All other things being equal the higher the perceived capital price of livestock relative to their consumption price and the best alternative return from investing in other assets, the more profitable it will be to invest further thus increasing the capital stock of livestock. The livestock firm can invest further either by producing more new animals and/or by adding value to its existing stock by choosing to produce larger animals rather than sell at the current price.

Jarvis and Yver have formalized what has been said above in the following framework assuming a representative livestock firm operating in a perfectly competitive environment and motivated to maximize the net present value of the livestock capital good.
Let \( V_o(t) = P_c W(t) e^{-rt} - P_F \int_0^t F(x) e^{-rt} \, dx \)  
(1.24)

where \( V_o(t) \) = net discounted value at birth  
\( P_c \) = farm price of livestock  
\( W \) = weight of the animal  
\( t \) = age at which animal is slaughtered  
\( r \) = opportunity cost of capital  
\( F(x) \) = feed input at any point in time  
\( P_F \) = farm price of feed

Assuming that animals are fed optimally throughout their lifetime, the problem boils down to finding the \( t \) that maximizes \( V(t) \).

The first order condition for the maximum is given by:

\[
\frac{\partial V_o(t)}{\partial t} = e^{-rt}(P_c W'(t) - r P_c W(t) - P_F F(t)) \quad (1.25)
\]

The second order condition is given by:

\[
\frac{\partial^2 V_o(t)}{\partial t^2} = e^{-rt}(P_c W''(t) - r P_c W'(t) - P_F F'(t)) < 0 \quad (1.26)
\]

and shall be assumed satisfied.

These optimum conditions apply to male animals. For female animals the present value function will have to include an additional term to take account of the female's calf output and thus will lengthen the discount horizon. Otherwise the analysis for males can be equally applied to females. For the purpose of this thesis a distinction between male and female animals will not be made.
The first order conditions state that the livestock animal will be slaughtered when the percentage increase in its weight per quarter equals the rate of interest plus quarterly feed costs per dollar's worth of animal.

Formally: \[ \frac{W'(t)}{W(t)} = r + \frac{P_F F_s(t)}{P_C W(t)} \] (1.27)

Clearly then, the maximized capital value of the livestock animal at birth with respect to slaughter age is a function only of the farm price of livestock, the feed price and the opportunity cost of capital, here, represented by the rate of interest, if optimal \( F(t) \) is assumed and \( W(t) \) is given.

So far the analysis is conducted in terms of capital values at birth but it is a simple matter to rewrite the net present value function in terms of the arbitrary age \( a < t \) as follows:

\[ V_0(a) = P_C W(t) e^{-r(t-a)} \int_a^t P_F e^{r(t-x)} e^{-rt} dx \]

(1.28)

\[ = P_C W(t) e^{-rt} e^{ra} \int_0^t P_F e^{r(t-x)} e^{-rt} dx \]

\[ + P_F \int_0^a F(x) e^{-rt} e^{ra} dx \]

\[ = e^{ra} \left( V_0(o) + P_F \int_0^a F(x) e^{-rt} dx \right) \] (1.29)

From this it is clear that the slaughter age that maximizes \( V_0(o) \) will also maximize \( V_0(a) \). The relationships between the present value, market value and the capital value of a livestock animal can be illustrated with Fig. 2.
Figure 2. Determination of the optimal slaughter age of livestock.

\[ P_C \cdot W(a) \]

\[ V^*(a) \]

\[ V(a) \]

\[ t^* \]

- Market value
- Present value at age \( a \)
- Maximized capital value at age \( a \)
- Maximized capital value at birth
- Optimum slaughter age
Once $t^*$, the optimum slaughter age that maximizes the present value $V_0^*(o)$ is determined, the maximized capital value at birth $V_0^*(o)$ is the price at which the livestock firm can sell a new born calf to another firm or for slaughter. At any age $a$ the maximized capital value $V_0^*(a)$ will equal the sum of the maximized capital value at birth plus the value of the feed intake compounded at rate $r$ up to age $a$. All animals of age $a$ will be bought and sold at their maximized capital value $V_0^*(a)$. It should be noted that up to optimal age $t^*$ the maximized capital value exceeds the market value $P_W(a)$ and at $t^*$ the maximized capital value and the market value are equal. Although there is only one age at which it is optimal to slaughter the animal at its market value the livestock firm will be indifferent between selling the livestock of optimum age at market value or selling it at less than optimum age at maximized capital value.

The next step in this analysis is to indicate the direction of change in the optimum slaughter age when the relevant arguments of the present value function changes. For this purpose, the implicit function theorem is used to write the general function $V_0^*(t, r, P_c, P_f) = 0$ (JARVIS) where the variable $t$ satisfies the subsidiary condition.

$$\frac{\partial V_0}{\partial t} = \beta^*(t, r, P_c, P_f) = 0$$ (1.30)

But $t = \theta(r, P_c, P_f)$

where the $\hat{\cdot}$ signifies optimality and by substitution $V_0(t, r, P_c, P_f) = 0$ and by using the chain rule of differentiation the unknowns $\partial t/\partial r$, $\partial t/\partial P_c$, $\partial t/\partial P_f$ can be solved.
From the above using classical production theory the following signs can be deduced.

\[ \frac{\partial t}{\partial p_c} > 0 \] will hold because at the former slaughter age the percentage weight gain will exceed the sum of the interest costs and feed costs per dollar worth of animal so optimum slaughter age will increase when the farm price of livestock increases.

\[ \frac{\partial t}{\partial r} < 0 \] because as interest rates rise the interest foregone at every age increases and this will reduce the optimal slaughter age.

A rise in the expected price of livestock and/or fall in the expected feed costs and interest rates, all other things being equal, will therefore lead to a reduction in the number currently slaughtered, as more animals are retained for breeding and an increase in the weight of animals held in inventory as feeding is intensified. Given a downward sloping function for the consumption demand for meat this will raise the price of meat as a result of the supply curve of meat having shifted leftwards. On the other hand, given expected livestock, feed prices and interest rates, a rise in the meat price will shift the curve for desired demand for livestock inventories downwards increasing the current supply of meat. In general, and in the short run, the supply of meat is expected to be related negatively to expected livestock prices and positively to meat prices. In short the current supply of meat is
expected to be negatively related, in the short run, to the price of capital value of livestock relative to the consumption value.

Reutlinger (1966) was among the first authors who offered a rational explanation for the negative slaughter supply response to a rise in cattle prices that was observed in several empirical studies and baffled agriculture economists because it so clearly contradicted conventional economic theory. Yver using an annual model of the Argentinian cattle sector disaggregated into male and female sectors obtained results which showed that when cattle prices increase the initial response is for female sales to decrease but in the long run sales begin to increase as a result of the built up female herds. As for males the initial response to a rise in cattle prices is an increase in sales and this is attributed to the strong disinvestment in steers (steers are animals with the shortest economic horizon within the male sector) while the long run response of sales, as in the case of females, is positive. Tryfos (1974) estimated a model for Canada using annual data which specified separate equations for beef supply and inventory of cattle. Positive coefficients were obtained for the expected beef price variable in the inventory equation and the supply of beef was estimated as a residual. From his results one can infer an inverse relationship between current slaughter and price.

Lattimore (1974) in his study of the Brazilian beef sector found a positive sign for the coefficient of the cattle price variable in the investment equation and a negative sign in the slaughter equations thus providing empirical support for the investment-supply models developed by Jarvis and Yver.
Elam (1975) in commenting on Tryfos's paper makes a point that Tryfos used current price as a proxy for expected price and therefore ignores the fact that current price can be shown to have a negative effect upon ending inventories which is independent of any expectational effects.

Nelson and Spreen (1978) monthly steer and heifer supply model evaluated the effects of producer price expectations based on trend extrapolations. The empirical results showed strong evidence of market response to the pattern of recent prices. Even a short trending pattern apparently leads to expectations that the trend will continue and consequently a change in the current - expected price relationship.

From the cursory review of the literature on models of the livestock sector it is clear that the theoretical approach of Jarvis that treated livestock as capital goods and livestock producers as portfolio managers has taken firm root in the agriculture economics literature. Also there is now ample empirical support to validate Jarvis's contention that because cattle production can be increased only by increasing the size of the breeding herd and/or withholding animals for further fattening, producers must bid animals away from consumers to increase the capital stock which is the source of future beef production.

RELATIONSHIP BETWEEN RETAIL AND FARM PRICES

Do farm prices determine retail prices or do retail prices determine farm prices or are farm and retail prices determined simultaneously?
Alchian and Allen (1969) in a much quoted passage 1/ explains the relationship between retail meat prices and farm livestock prices very succinctly this way:

"The consumers' increased demand for meat, then, brought about a rise in the price of meat to consumers. This rise appeared to be the result of a rise in costs because the first price effect of the increased demand occurred at the cattle raisers' end of the line. The demand increase pulled up the price in the first stages of the production and distribution channels. The first rise in price could have occurred in the butcher shops and then have been transmitted back step by step to the farmers. But butchers' inventories are usually adequate to cushion the changes in demand temporarily until the impact of increased sales go all the way through the productive processes. This explains the common illusion that increases in costs are responsible for higher prices."

Heien (1977) following this line of reasoning argues that since processor inventories are relatively constant and supplies of agriculture products are relatively fixed in the short run changes in retail prices are determined by factors that shift the retail demand curves.

Another approach is to explain the retail price spread rather than the retail price or the farm price itself. Several studies undertaken by the Economic Research Service, U.S. Department of Agriculture belong to this genre (see Barr and Gale (1973) and Scott and Badger (1972)).

Of the studies that take explicit account of the demand and supply for marketing services in a simultaneous model that integrates the three markets - retail, farm and marketing services, Gardner (1975) examines the consequences of competitive equilibrium in product and factor markets for the relationship between farm and retail food prices and deserves special mention. Gardner considers a food marketing industry that uses two factors of production - purchased agricultural commodities and other marketing inputs to produce food at retail under constant returns to scale production conditions. Using this production function and its assumed classical properties, the demand functions for the two inputs are derived. Together with the output demand function and the two input supply functions a system of six equations in six endogenous variables are set up to yield a unique equilibrium values for given values of the exogenous variables.

Using this theoretical framework Gardner concludes that "no simple mark-up pricing rule...can in general accurately depict the relationship between the farm and retail price. This is so because these prices move together in different ways depending on whether the events that cause the movement arise from a shift in retail demand, farm supply or the supply of marketing services."

However, when retail food demand shifts to the right the ratio of retail to farm price will remain unchanged if the input supply elasticities are equal or if the elasticity of substitution between the two inputs in the production function for retail food is very high. In such cases then a fixed percentage mark-up rule used by marketing firms is viable because competitive forces will not require the mark-up to change when retail food demand shifts.
This result is relied upon to model the farm to retail price transmission equations in the model. Since all the farm inputs considered in the model are available to the food marketing industries at a fixed price either because they happen to be regulated as in the case of poultry, eggs, milk and milling wheat for domestic consumption or because they are available in sufficient quantities at the prevailing world prices and because the food marketing industry is assumed to be a price taker in the national labour and capital markets the percentage mark-up pricing rule for food retailers is considered appropriate.

**EXPECTATION FORMULATION**

Work related to the theoretical development of the Phillip's curve in the macro-economic literature has generated considerable empirical testing of the expectations hypothesis. However, the employment of expected variables predates even Phillip's original paper. Among the early contributors (Ezekiel, 1938) assumed a simple extrapolative hypothesis where the price expected in the current period is equal to the price that prevailed in the last period. Algebraically

\[ p_t^* = p_{t-1} \]

where the asterisk denotes expectation. This formulation also implies that expected price change is zero i.e. \( E(p) = p_{t-1} - p_t = 0 \).

(1.32)

Goodwin (1947) improved upon the naive extrapolations hypothesis by proposing the extrapolation formula:

\[ p_t^* = p_{t-1} + \Theta (p_{t-1} - p_{t-2}) \]

(1.33)

which asserts that expected price is equal to the price last period and a correction that allows for the trend in the inflation rate.
over the previous period. If $\theta > 0$, the price forecaster extrapolates these trends expecting them to continue. If, on the other hand, $\theta < 0$, he expects past trends to reverse themselves and expectations in this case are said to be regressive. If $\theta = 0$ then this expectation hypothesis becomes equivalent to the naive extrapolative hypothesis.

Another expectations hypothesis that is widely used in the literature is the adaptative expectations hypothesis which asserts that the expected price is corrected by an amount proportional to the most recently observed forecast error. Cagan (1956) and Nerlove (1958) are the original proponents of this hypothesis which can be expressed as follows:

$$ p^*_t = p^*_{t-1} + \theta (p_{t-1} - p^*_{t-1}). $$

(1.34)

The reduced form of this difference equation can be expressed as a distributed lag model:

$$ p^*_t = \theta \sum_{i=0}^{\infty} (1-\theta)^i p_{t-1-i} $$

(1.35)

which implies that:

$$ E(p) = p^*_{t+1} - p_t = (\theta-1) p_t + \sum_{i=1}^{\infty} (1-\theta)^i p_{t-1-i} $$

(1.36)

i.e. changes in price expectations depend on a weighted average of current and past levels of prices.

The simple expectation hypotheses outlined above are sometimes referred to as autoregressive hypotheses because the expected variable is determined by past values of the variable being...
predicted. These hypotheses which allow linkages between unmeasurable economic variables with their observable counterparts have not escaped criticism which has been mainly directed at the considerable loss of information entailed in forecasting an endogenous variable using only its past values. Particularly, the information provided by the economic structure is ignored and this is considered lamentable because the structure, in the first place, was designed to provide predictions for the endogenous variable and secondly, it is quite conceivable that the predictions from the autoregressive scheme will be quite inconsistent with those implied by the model. It is therefore argued that if forecasters are aware of the structure of the relevant economic model, the rational way to form their expectations will be to base them upon the predictions of the economic model. This hypothesis, which originated with Muth (1951), is known as the rational expectations hypothesis. Formally, it means that \( P_{t+i}^* = \mathbb{E} \left( P_{t+i} / t \right) \), where \( P_{t+i}^* \) is the expectation formulated at time \( t \) about prices expected at time \( t+i \) and \( \mathbb{E} \left( P_{t+i} / t \right) \) is the statistical expectation of \( P_{t+i} \), as predicted by the econometric model, conditioned on the information available at time \( t \).

In constructing the Canadian agricultural sector model no attempt has yet been made to use rational expectations. This is partly because of the availability of futures price data the use of which will counter some of the criticisms directed against autoregressive hypotheses. However, as will be explained later futures prices have not performed as well as expected in the estimation phase except in a few cases and resort had to be made to autoregressive hypotheses discussed above to generate observable expected prices in the model.
AGGREGATION PROBLEM

Aggregation theory is concerned with the transformation of individual micro relations to a relation for the group as a whole. To give a very simple illustration let there be two relations:

\[ Y_1 = \delta_1 + \beta_{11} x_{11} + \beta_{12} x_{12} \]  \hspace{1cm} (1.37)

\[ Y_2 = \delta_2 + \beta_{21} x_{21} + \beta_{22} x_{22} \]  \hspace{1cm} (1.38)

Adding \((Y_1)\) and \((Y_2)\) and taking the simple average and assuming:

\[ \beta_{11} = \beta_{21} ; \beta_{12} = \beta_{22} \]  \hspace{1cm} (1.39)

\[ \bar{Y} = \bar{\delta} + \beta_1 \bar{x}_1 + \beta_2 \bar{x}_2 \]  \hspace{1cm} (1.40)

If assumption (1.39) is not met the coefficients in (1.40) will suffer from aggregation bias and the use of (1.37) and (1.38) will make a difference to the results of the analysis of the problem at hand. In short, (1.40) does not represent a consistent aggregation of (1.37) and (1.38).

The requirements for consistent aggregation are actually much more rigid than the simple example above will indicate. Theil (1954) investigated the implications of aggregation for statistical estimation of linear models and he concludes that, in general, a macro-parameter is a weighted average of all (corresponding and non-corresponding) micro-parameters, and is not necessarily equal to an unweighted average of the corresponding micro-parameters. According to Theil, the perfect aggregation is where there is no contradiction between the macro-relation...
and the micro-equations corresponding to it. In practice, however, aggregation is generally done on an ad hoc basis where an attempt is made to strike a fine balance between the costs associated with using a large number of variables and the costs associated with the imprecision in using too few variables.
CHAPTER 3: STATISTICAL, POLICY, INSTITUTIONAL AND ECONOMIC BACKGROUND

This chapter, together with the previous one lays the groundwork for the specification of the agricultural sector model that will be undertaken in the next chapter. The chapter is organized as follows: For each of the three major sectors that are modelled, namely, the grains and oilseeds sector, the livestock sector and the regulated sector a description of the statistical trends, the institutions important to the sector, recent policy shifts and the economic structure of the sector will be given.

SECTION 3.1: GRAINS AND OILSEEDS

Statistical Trends:

In terms of share of farm cash receipts the grains and oilseeds sector rank first with 31 percent when averaged over the period 1967-1977. A look at the historical trend in production, feed use, inventory holdings and exports in the grains and oilseeds sector reveals the following. The statistics are averages taken over the 1968/69 to 1977/78 and are expressed in million tonnes. Available supplies of food grains (production and opening inventories) of all wheat and rye averaged 17.13 m.m.t. Exports accounted for 38 percent of supplies, food use was 11 percent and closing inventories 46 percent. Clearly an overwhelming proportion of food grain supplies was thus accounted for by exports and closing inventories.
The supplies of feed grains (oats, barley and corn) averaged 25.1 m.m.t. out of which 13 percent was exported, 51 percent was used for feed and 5.7 percent was accounted for by closing inventories.

Oilseeds supplies (rapeseed and soybeans) averaged 4.2 m.m.t., 20 percent of which was exported, and closing inventory demand accounted for 11 percent and food and feed use accounted for approximately 33 percent of supplies. It should be pointed out that for soybeans, imports are 1.13 times production.

Canada, together with the U.S., France and Argentina ranks as one of the leading exporters of wheat in the world. Taking a ten-year average over the period 1966/67 - 1975/76 Canada's wheat exports constituted 20 percent of the world's exports of wheat including flour. However, the U.S., Canada's major competitor in wheat exports had a 41 percent share, double that of Canada. The U.S. is clearly the dominant exporter of wheat in the world. In feed grains, Canada exported 2.8 m.m.t. - 6 percent of world's exports whereas the U.S. exported 23 m.m.t. capturing 49 percent of the share of world's total exports. Corn is the major feed grain used around the world and the U.S. share of world corn exports is 40 percent. The overwhelming dominance of the U.S. in the world's feed grain market is evident from these statistics.

In oilseeds, Canada is a net importer of soybeans, soybean meal and soy products, but a major exporter of rapeseed. However, production and world trade in soybean dwarfs that of rapeseed with production being 20-30 times as large and exports being 10 to 20 times higher in recent years. Experts in the industry contend that it is soybean, rather than rapeseed stocks and supply that determine world oilseed prices. Here
again the U.S. is the major producer and exporter of soybeans and soybean products (64 percent of the world's soybean oil production is in the U.S.).

INSTITUTIONS

The premier institution in the Canadian grains sector is the Canadian Wheat Board. The amended Canadian Wheat Board act of 1949 gives the Wheat Board sole authority to market, wheat, oats, barley, rye, flaxseed and rapeseed interprovincially and internationally. The control of interprovincial trade in feed grains has however been taken out of Wheat Board jurisdiction between 1974 and 1979. A major function of the board is to promote the sale of Canadian wheat in world markets at the best possible price and to provide price stability to producers. To carry out this function the Wheat Board has to coordinate the delivery of grain to elevators, manage the inventory and arrange transportation of grain to shipping points.

The cornerstone of the Wheat Board grain marketing system is the price pooling arrangement whereby all the monies received by the Wheat Board from the sale of a particular kind of grain, wheat for example, are placed or pooled in a single fund out of which the expenses of the Wheat Board are deducted. Prices received throughout the year from the sale of each grade are averaged to form the basis of per bushel payment to producers.

Producers do not wait for payment until the Wheat Board has sold the entire crop. An advance payment, called an initial payment is paid at the time the producer delivers his grain to the primary elevator. Initial price levels are fairly constant from year to year
and thus reflects only in a general way current world and CWB asking prices in the international grains market. The intended role of the initial prices is to provide an advance to the producer on his expected receipts from marketed grain. This initial payment based upon initial prices announced before seeding time in March - April is in effect a government guaranteed minimum floor price. To elaborate, if the money in the pool after the crop has been sold is insufficient to cover the total amount paid to producers in initial payments plus the costs the Wheat Board has incurred in selling the grain, the Canadian Government pays the deficit. In recent years, the wheat or barley pools have been subsidized by the government on only two occasions which indicates that the initial prices have been set well below world prices.

If there is a net surplus in the pool after the crop is sold an additional payment - in the form of an interim and/or final payment, is paid to producers based on the number of bushels of each grade delivered. In effect, part of the total price received by the farmer for the grain that he has already delivered is deferred to the extent that there is a subsequent payment. On the other hand, the grain producer enjoys the benefits of receiving a price for his grain that is averaged over the length of the pool rather than a price that is current at the time of delivery. Since grain prices are usually at their minimum during the delivery time this advantage is not insignificant.

Next in importance to price pooling is market sharing through the delivery quota system which is the other principal feature of the Wheat Board system. The delivery quota is a major element in the
Wheat Board's inventory management system; it is a control lever which potentially provides the Wheat Board with a flexibility to respond to the market's demand for a particular kind and grade of grain. The optimal use of the limited grain storage space and the equalization of delivery opportunities for producers independent of location and timing of delivery can be said to be the two principal objectives of the Wheat Board's delivery quota system.

Under the present system the producer's deliveries of each grain are based on assigned acreage which is defined as follows:

1) Land seeded to wheat, oats, barley, rye, rapeseed and flaxseed;
2) Land in summerfallow;
3) Land in miscellaneous crops;
4) Land seeded to perennial forage up to a maximum of 1/3 of total land included under classification 1-3.

After the assigned acreage is determined and the delivery quota per assigned acre of a particular crop is announced the producer can reallocate his aggregate delivery quota between different crops by revising his assigned acreage. Only one revision is permitted per crop year. It should be noted that the quota limits marketings, not production and this is the major reason why in a model that aggregates seven grains (six of which are quota grains) and farm and commercial inventories the delivery quota system will not be considered as a relevant variable.

Among the major policy initiatives taken by the Federal Government with respect to the grain sector of the Canadian agriculture industry the following three are considered to be of direct relevance to the model.
1) **Two Price Wheat System**

Since 1968, the price of wheat used for domestic human consumption has been set by the Federal Government. The $1.95 price which prevailed over the 1969-71 period was higher than the Wheat Board's selling prices. In effect then the difference between the world price and domestic price represented a tax on domestic consumption of wheat.

In January 1972 the two price system for wheat introduced by the government converted the consumption tax into a consumption subsidy. This was done by setting the quoted price at Thunder Bay to be $3 and the domestic milling price to be $1.95 (the price paid by the miller) with the Federal Government making up the $1.05 to the producer.

In recent years leading up to its modification in 1979 the Two-Price Wheat System worked in the following manner: the miller pays $3.25 per bushel for No. 1 CWRS at Thunder Bay. If the export price is above $3.25 the Federal Government pays up to a maximum of $1.75 into the CWB wheat pool. The $1.75 was therefore the maximum subsidy by the government to the consumer whenever the world price was above the based quoted price of $3.25. When the world price was above $5 say $6, then there is an implicit $1 export tax borne by the producer which constitutes part of the $2.75 subsidy to the consumer ($1 from the producer and $1.75 from the government).

2) **Lower Inventories for Tomorrow (LIFT)**

The large build-up of wheat stocks (LIFT) in Canada during the later 60's owing to consistently good crops around the world induced the enactment of the Lower Inventories for Tomorrow program in the crop year 1970/71.
The program was designed as a one year program to sharply reduce wheat acreage and lower inventories. Under the program diversion payments were made for taking land out of wheat production with increased payments being made if that land was seeded to perennial forage. In 1970/71 as a direct result of the program wheat acreage fell by half and beginning stocks for 1971/72 were down 40 percent from the year before.

3) The New Feed Grains Policy

Prior to the new feed grains policy in 1974 there were essentially two markets for feed grains - one for Eastern Canada and another for Western Canada. The CWB then had full control over interprovincial trade in feed grains which means that surplus feed grains in the Prairies cannot be marketed interprovincially except through the CWB. In the Eastern markets the CWB priced its feed grains at the price that is competitive with the landed price of U.S. corn in Montreal after taking into account an eight cent per bushel tariff on U.S. corn and fifteen cent per bushel feed freight assistance subsidy on domestic feed grains to that point.

In the Prairies feed grains marketed through CWB faced competition from the "off-board" market - the selling of grain between farmers, feed mills and feedlot operators. Prices in the off-board market was determined freely by excess demand conditions for feed grains intra-provincially and the CWB control was limited to controlling access to transportation facilities and to a lesser extent elevator services. It was usually the case that the off-board market price was lower than the CWB selling quotation and the final realized prices.
The new feed grains policy, brought into existence on August 1, 1974 in effect "expanded the off-board market for utility wheats, oats and barley to include Eastern Canada as well as Western Canada" (see Jolly 1976), by removing interprovincial trade in feed grains from CWB control. Consequently, the Western Canadian off-board price should be equalized with Montreal prices, except for transportation and handling costs.

Economic Structure

A small percentage of the world's grain production that is traded combined with the very large percentage share of the world's grain trade gives the U.S. a dominating influence in the pricing of grain and oilseeds that is internationally traded. Canada, because of her substantial share in world's exports of wheat may in the short run have some influence in the pricing of wheat that is internationally traded. However, because of the commanding position in all the interrelated markets of wheat, feed, grains and oilseeds, it is doubtful that the leadership of the U.S. in the international grains market can be questioned. A contrasting oligopolistic view of the world market for wheat with Canada as a member of the oligarchy can be found in papers by McCalla (1966), Taplin (1969) and Alphonze, Watson and Sturgess (1978). It should be pointed out that these studies, as will become apparent from the short review that follows, do not deny the fact of the U.S. market power in the international grains market. However, they suggest that because of considerations other than economic, foreign policy being mentioned as one, the U.S. may not choose to exercise that power. McCalla, for example, says:

"Canadian price leadership arises primarily because the U.S. is willing to let Canada..."
lead. In terms of production capacity, available stocks and production resources the U.S. is in the position to be the dominant price leader. The U.S. chooses to allow Canada to lead, first because of the U.S. domestic agricultural policy and second because of U.S. foreign policy.

Taplin, on the other hand, conjectures that since export revenues as a proportion of farm income is far greater in Canada than in the U.S. he expects Canada to act as a pure monopolist setting price to maximize revenue with the U.S. following downward price changes. In the case of upward price changes initiated by Canada which the U.S. does not follow Taplin suggests that Canada will react by revising its prices downwards.

Alaonze; Watson and Sturgess suggest that the world wheat market is characterized by a triopoly with Australia, U.S., Canada as members. Canada is presumed to be the price leader primarily because the function of the CWB is supposed to be simply one of maximizing revenue. Little supporting evidence exists, however, for such simplicity.

Given the fact that cash and futures trading in grains in the major international grain trading centres located in the U.S. such as Chicago and Kansas is practically unrestricted and almost epitomizes the concept of a free market, the oligopoly view of the world wheat market, it is contended, does not detract in any way the view that Canada is a price taker in the international grains market than is taken in this thesis.

* The Russians contracted to buy 15 million tons of wheat and 6 million tons of feed grains from the U.S. in 1972 representing respectively 4 percent and 1 percent of world production of wheat and coarse grains and it was months before the identity of the buyer was known.
SECTION 3.2: LIVESTOCK SECTOR

STATISTICAL TRENDS

The livestock sector as it is defined in the model encompasses cattle (including calves) and hogs. Sheep and lamb was excluded because it is such a minor segment of the livestock sector (3 percent). The dairy cattle although important as a supplier of low grade beef was excluded because it is considered that the dairy sector operates under constraints that are significantly different from the cattle and hog sectors.

The average contribution of the livestock sector to farm cash receipts was $2 billion over the 11 year period 1967-77 which represented 30 percent of total farm cash receipts.

Slaughter, processing and marketing of meat is a major segment of the food industry. The meat packing industry employs about 32,000 workers.

The number of livestock on farms have averaged 20.2 million heads (13.8 million cattle and calves and 6.4 million hogs). Slaughter of animals have averaged 13.5 million (4.4 million cattle and calves and 9.1 million hogs).

From the consumption side 23 percent of weekly expenditures on food at home by all income classes is spent on beef and pork [(1974 survey data) - Hassan and Karanchandani]]. The historical trends of meat consumption is seen in Fig: 3.
The average per capita consumption of meat (1967-1977) is broken down as follows: 91.9 lbs of beef and 56.8 of pork, annually. Beef is the leading meat consumed by Canadians by an almost 2 to 1 margin with pork ranking second.

Canada exported $197.7 million worth of meat (averaged over 1975-77) and imported $274 million registering a deficit of $76.3 million. Exports of live animals, mainly cattle in the same period averaged $108.5 million and imports averaged $60 million so there was a $48.5 million surplus in live animal trade. Exports of live cattle and beef has on average represented about 14 percent of farm cash receipts from cattle and calves and exports of live hogs and pork have averaged about 12 percent of farm cash receipts from hogs.

INSTITUTIONS

Beef is marketed domestically in an open system with no marketing boards. Marketing of Canadian hogs is through provincial marketing boards except in Quebec (30 percent of national market) but as reported by the task force on the Orientation of Canadian Agriculture "Canadian pork prices are established by the much larger U.S. market". Compared to the grains and oilseeds sector, marketing institutions do not play a significant role in the livestock sector.
Policy Shifts - A major disruption to normal trade flows took place in March 1973 when the U.S. Government imposed price ceilings on food products. Of particular interest is the impact of U.S. meat price freeze on the Canadian farm and retail prices of meat.

"Since price ceilings were not applicable to imported beef by late July 1973, normal U.S. - Canadian trade relationships for both cattle and beef became distorted by a movement of U.S. slaughter cattle into Canada accompanied by a backflow of beef to U.S. markets."
(Marshall, 1974)

These abnormal trade flows were mainly due to the reduction in U.S. slaughter that resulted from the expectation that the controls would be removed soon. This led to reduced supplies in the U.S. and hence upward pressure on the price of beef. The effective price imposed by the ceiling was however below the market clearing price for domestic beef.

Consequently, this excess demand at the ceiling price spilled over to the Canadian market which increased the demand for slaughter raising the Canadian slaughter cattle prices above the U.S. price. The end result was that Canadian imports of U.S. slaughter cattle rose while at the same time increasing the export of Canadian beef to the U.S.

The widespread and lingering impacts of the "Nixon Price Freeze" are therefore considered a significant exogenous shock on the Canadian livestock and meat system over the 1973-75 period.

Economic Structure - Fifty percent of Canada's meat trade (imports plus exports) and 88 percent of live animal trade is with the
U.S. Given 1) the relative size of the U.S. market - 10 times larger than Canada, and 2) free trade in live animals under normal circumstances and relatively more restrictive trade in meat (quotas and tariffs on beef and tariffs on pork), the North American market for livestock can be considered as an integrated market with market conditions in the U.S. having a direct and large influence on Canadian farm level prices and indirectly Canadian retail prices of meat.

The close alignment of U.S. and Canadian farm level livestock prices through trade is seen in Figs: 4 and 5. Fig: 6 shows the close correspondence of Canadian and U.S. livestock cycles.

One dominant feature that has characterized the cattle sector is the recurring cattle cycles with the consequence that prices tend to be volatile. A ten year average of average livestock prices at principal stockyards in Calgary is $34.98 whereas the standard deviation of these prices is $8.57. The ratio of the standard deviation to the average of .25, indicates that on average the A1 steer prices deviate 25 percent from their mean during the period in question.

Similarly, in the hog sector, a ten year average of index 100 hog prices at principal stockyards in Calgary is $38.75 and the standard deviation is $15.5 so the ratio of standard deviation to the mean is 40 percent. On average, then, hog prices deviate 40 percent from its mean during the period in question. Finally, the simple correlation coefficient between hog and cattle prices is .79 reflecting the close substitutability in consumption between beef and pork.
DOMESTIC DISAPPEARANCE OF BEEF, PORK AND VEAL IN CANADA (cold, dressed carcass weight), 1947-76

Disappearance (lb/capita/year)

120
110
100
90
80
70
60
50
40
30
20
10
0


BEEF

PORK

VEAL
FIGURE 4

CALGARY-OMAHA PRICE DIFFERENCE FOR CHOICE SLAUGHTER STEERS, 1960-76

NET TRADE (IMPORTS-EXPORTS) IN SLAUGHTER CATTLE BETWEEN CANADA AND THE UNITED STATES

Net flow of cattle into Canada (000 head)
FIGURE 5

TORONTO-U.S. PRICE DIFFERENCES FOR HOGS, SEVEN MARKETS, 1959-76

PRICE DIFFERENCE
($ Can / cwt)

1959 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76

NET TRADE (EXPORTS-IMPORTS) IN PORK BETWEEN CANADA AND THE UNITED STATES, 1959-76

(mil lb) Canada's Net Exports

1959 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76

.../51
FIGURE 6

CATTLE AND CALVES ON FARMS AT JANUARY 1 IN CANADA AND THE UNITED STATES

- Canadian data from 1940-76 apply to December 1 of the previous year.
SECTION 3.3: THE REGULATED SECTOR

Statistical Trends

The regulated sector as it is defined in the thesis encompasses the Dairy, Poultry and Egg sectors of the Canadian agriculture. The dairy industry in Canada comprises the production of milk, processing into fluid milk, butter, skim milk powder, cheeses, ice cream, cream, evaporated milk and other products. Skim milk powder and some cheeses are exported. Commercial sales of milk and cream accounted for almost 13 percent of farm cash receipts averaged over 1967-77.

The average per capita production of dairy and dairy products (in milk equivalent) is 809.93 lbs. On the demand side, consumer expenditures on milk and dairy products accounted for almost 14 percent of weekly food expenditures which is second only to expenditures on beef. Taking the milk production and processing sectors together, the dairy industry contributed nearly two billion dollars (or approximately 1 percent) to Canadian GDP in 1977 and accounted for some 97 percent of total Canadian milk requirements.

Dairy production is divided into two major sectors, fluid milk and manufacturing milk. The former is characterized by high production in larger sized herds, the latter by generally smaller herds, fed primarily on grass with more seasonal production. Capital investment per cow has increased dramatically since 1970. In Ontario, it was $1,720 in 1970 and $4,358 in 1975, a 69 percent increase in constant dollars.

The contribution of the poultry and eggs sector to farm cash income is approximately 8 percent. Taking the average over the 1966-76
period 847.36 million pounds of poultry meat was produced. Per capita consumption of poultry meat was 30 lbs annually and accounted for 5 percent of weekly food expenditures of all income classes.

Eggs accounted for 3 percent of farm cash receipts. Average production of eggs stood at 456 million dozens and per capita consumption was 30.4 lbs; 2 percent of weekly food expenditures of all income classes was spent on eggs.

Canada is a net importer of poultry and eggs and the net annual imports averaged over 1975-77 was $30 million. Trade (total imports and exports) represent about 18 percent of farm cash receipts and 80 percent of trade in poultry and eggs is with the U.S.

INSTITUTIONS

The Dairy industry in Canada is probably the most regulated industry in the Canadian agriculture sector. The marketing of fluid milk in Canada is under the jurisdiction of provincial authorities while industrial milk marketing is controlled by the Canadian Dairy Commission, a federal agency. Table 3.1 which lists the principal instruments with which Canadian dairy sector is regulated will give some idea about the extent of government intervention in the sector.

In the poultry sector the marketing of broilers are controlled by provincial marketing boards which regulate volume and price. A National Broilers Marketing Agency has come into existence since December 1978 but it has not yet become operational. The success of the broiler supply management program is a direct function of how tightly lower priced imports from the U.S. can be controlled.
With regard to supply management in turkey, the Task Force on Orientation of Canadian Agriculture reports as follows:

"The Canadian Turkey Marketing Agency (CTMA) became a reality in 1974 with limited authority over the inter-provincial and export trade in turkeys. In addition, it was given some control over inter-provincial movement which was allowed through delegation of limited provincial authority to the federal government. In its second year of operation, the CTMA achieved a workable balance between production, consumption and stocks with storage inventories amounting to 21.4 million kilograms."

In the egg sector, the major regulatory institution is the Canadian Egg Marketing Agency (CEMA), a national marketing board established in 1972 with powers to set production quotas and producer prices. Prior to the establishment of CEMA provincial marketing boards introduced programs that set minimum prices, surplus removal and marketing quotas. However, lack of control over inter-provincial and international trade rendered ineffective the provincial marketing boards' attempts to stabilize the Canadian egg industry. With the establishment of CEMA which allocates production quotas for each province and sets farm level egg prices in each province using a pricing formula that includes costs for feed, pullets, labour, depreciation, overhead and profit. In the International trade front, since July 1975 there has been an annual import quota of three million dozen.

However, additional quotas may be authorized if CEMA is unable to fill requests for eggs.

Economic Structure

The regulated sector, deserves separate treatment because the quantity produced and the pricing of its products are determined primarily by provincial and national marketing agencies rather than
by market forces. This, however, does not mean that production and pricing decisions are completely divorced from market forces. As it will become clearer later the regulated sector is distinguished by the fact that market forces, rather than being the final determinants of economic decision making in this sector, serve the role of economic signals and indicators upon which the provincial and national marketing agencies base their production and pricing decisions.

Walker (1968) provides a good rationalization of the proliferation of marketing boards in Canada:

"Since the first economic depression, Canadian farm operations have always emphasized the need to strengthen their bargaining position in the market place. Basically, farm operators believe that the individual farmer is in no position to bargain effectively in a product market with a few large firms.

Legislators have responded to the wishes of farm operators by enacting legislation which provides for the formation of compulsory marketing boards controlled by producers."

This has led in actual practice to supply management programs with the following objectives:

1) To encourage a viable, stable and growing domestic industry that will develop a potential to be internationally competitive.

2) Procuring for efficient Canadian producers price stability and a level of real returns that include reasonable compensation for management, labour and capital invested.

Although particular practices vary between different regulatory
agencies the actual implementation of these objectives have involved
the following steps:

1) Import quotas to insulate the domestic market from
foreign competition;

2) Price setting on the basis of cost of production
formulas combined with an estimate of a fair return
to producer;

3) An estimate of consumer demand at the set price levels;

4) Selection of a combination of quota levels, penalties
for over quota production that will induce supplies
approximately sufficient to meet domestic requirements
estimated above;

5) A resetting of the levels of the instruments of supply
when there are significant divergences between supply
and demand.

In summary, this chapter has attempted to provide a statistical,
institutional and policy background for the three major sectors of the
Canadian agricultural industry. The information provided in this
chapter will be relied upon to justify the departures from the particular
specification of the equations in the model that strict and exclusive
adherence to economic theory would have dictated.
<table>
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<th>Dairy Sector</th>
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<td>Shipment Quotas</td>
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<td></td>
<td>Discriminatory Pricing</td>
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</table>
| Industrial                   | Shipment Quotas            | 1967 -           | Control Milk Supply               | Federal-
| Milk and Cream Production   | Over-Quota Penalties      | 1969 -           | Income Support Stabilization      | Provincial       |
|                             | Discriminatory Pricing    | 1962 -           | Income Support                      | Federal          |
|                             | In Quota Holdback          | 1966* - 1967     | Export Disposal of Surplus         | Provincial       |
| Processing of Industrial     | Offers to Purchase         | 1946 -           | Wholesale Price Support for Selected Processed Products | Federal |
| Milk Products                | Minimum Prices             |                  |                                    |                  |
| Domestic Retail Demand for   | Consumer Subsidies         | 1962 - 1966      | Retail Price Reduction            | Federal          |
| Butter                       |                            |                  | or Moderation of                   |                  |
|                             | - Fluid Milk               | 1973 - 1975      |                                    | Federal          |
|                             | - Skim Milk Powder         | 1973 - 1978      |                                    | Federal          |
| International Trade          | Import Tariffs             | 1906 -           | Domestic Market                    | Federal          |
|                             |                            |                  | (Price and Quantity)               |                  |
|                             | Import Embargos            | 1951 -           | Protection                          | Federal          |
|                             | Import Quotas              | 1975 -           |                                    |                  |
|                             | Export Subsidies           | 1964 -           | Export Disposal of Surplus         |                  |

* Ontario; for Quebec these policy instruments were introduced in 1971.

Source: Canadian Farm Economics, Vol. 14, Feb-April, 1979
CHAPTER 4: SPECIFICATION OF THE MODEL

In this chapter, the structure of the Canadian agricultural sector, based on a priori information obtained from published, unpublished sources, economic theory, knowledge of the institutions and major policy shifts affecting the agricultural sector, will be specified. The modelling framework for each of the three economic sectors, data sources, and description of the data together with the methods of aggregating data will also be undertaken at the same time.

Model Outline

First of all, the model contains thirty-four equations made up of 19 stochastic equations, 1 market clearing equation, and 14 definitional and identity relationships. A linear specification is chosen for the model for its simplicity. Altogether there are 3 economic sectors - namely, the grain and oilseeds sector, the livestock sector and the regulated sector (composed of dairy, poultry and egg sub-sectors) and one accounting sector. There are 12 equations in the grains sector, 8 stochastic and 4 identities. The livestock sector has 12 equations, 4 stochastic, 1 market clearing equation and 7 identities. The regulated sector has 8 equations, 7 of which are stochastic and 1 is an identity. The accounting sector has 2 equations - 1 is a definitional equation and the other is an identity.

DATA SOURCES

The primary sources for the data utilized in the model are the following:

.../59
1) The Food and Agriculture Regional Model (FARM) data bank maintained by the Market Analysis and Trade Policy Directorate, Agriculture Canada;

2) The CANSIM data bank maintained by Statistics Canada;

3) Trade tapes obtained from the External Trade Division, Statistics Canada;

4) Chicago futures prices for live cattle and hogs obtained from the Yearbooks of the Chicago Mercantile Exchange.

Modelling Framework: GRAINS

Two issues encountered in modelling the grain and oilseeds sector of Canadian agriculture relate to commodity coverage, and level of aggregation. This sector covers five principal grains (wheat, oats, barley, rye, corn) and two principal oilseeds (soybeans and rapeseed). In terms of volume these cover 50 percent of total crop production in Canada.

The second issue in the modelling of the grain sector is the perennial aggregation problem and it must be admitted that no attempt has been made to treat it theoretically. Rather the results obtained from published theoretical work has been noted and using a priori reasoning buttressed by simple correlation tests, an effort was made to minimize the aggregation bias. From the production side no distinction is drawn between an acre of grain and an acre of oilseed or for that matter an acre of wheat and an acre of barley. Grain acreage is simply a total of the acreages of all the selected grains.
On the demand side, the five grains considered in the model have been aggregated into two groups namely food grains consisting of wheat and rye and feed grains consisting of corn, barley and oats. This is admittedly not an ideal split because some wheat is also used as feed but feed wheat which is low quality wheat is a small proportion of total wheat produced in Canada. The two oilseeds considered in the model rapeseed and soybeans are treated as a separate group-oilseeds. This disaggregation permits the separation of domestic consumption demand for grain and oilseeds into three distinct types namely food demand, feed demand and oilseed demand while at the same time allowing inventory demand and export demand to be considered as an aggregate commodity - grains and oilseeds.

In Canada, wheat is the dominant grain relative to rye in food use and the simple correlation coefficient between changes in wheat and rye prices is very high. On this basis wheat prices will be taken as the representative price for food grains with the objective of economizing on data.

On the same basis the corn price is used as a representative price for feed grains. This is so because among the many factors that determine Canadian feed grain prices the following two are considered dominant: 1) the price of corn at Chicago; 2) the feeding value relationships between the feed grains.

Prior to 1974 when the Canadian Wheat Board was responsible for setting grain prices outside the Prairie region it tended to set feed grain prices in relation to U.S. corn competitive prices in Montreal. The price for feed grains in off board market which competed with the CWB however, tended to be lower. The prairie feed grains market, in this sense, was dualistic in nature. Now that interprovincial trade in feed grains has been removed from...
CWB control the Western Canadian free market price should be equalized with the U.S. corn price in Montreal after adjustment for transportation and handling costs.

The relative prices between different feed grains is determined by the relative feeding value of each grain and this depends on whether the feed is being used for cattle, hogs or poultry. Crompton and Harris (1969) has calculated the following feeding value relationships on a per bushel basis: corn = 100, oats = .5082 and barley = .7643.

On this basis the price of barley and oats, per bushel at the same location should be priced respectively at 76.4 percent and 51 percent the price of corn.

In the oilseeds group, soybeans and rapeseed are important because their meal is used for animal feed and their oil is used in the food industry. In both its uses soybeans and rapeseed are highly substitutable and the fact that there is a well developed futures market for soybeans dictated the choice of soybeans price to be the representative price for the oilseeds group.

In the grains and oilseeds sector (from here on grains shall be interpreted to include oilseeds) three types of demand - namely feed demand by the livestock and regulated sectors, inventory demand by the Wheat Board, private grain companies and the farmers and food demand by the bakery and cereals and fats and oils industries are distinguished. On the supply side grain production is treated as identically equal to acreage multiplied by yield. Another identity then expresses a relationship between grain supply, grain production and opening inventories.
Canada is presumed to be a price taker in the international grains market and Chicago futures prices are presumed to best represent "world prices". This implies that Canada faces a perfectly elastic world demand curve in grains.

This "view" of the grain sector is illustrated with Fig. 7.
Figure 7. Small country representation for the grains and oilseeds sector.
Let AA be the food demand curve for grains. BB is the feed demand curve for grains and CC is the inventory demand curve for grains and DD is the downward sloping total domestic demand curve for grain obtained by summing the three demand curves horizontally. Let II be the opening grain inventories. PP is the upward sloping grain production curve and SS is the upward sloping grain supply curve obtained by the horizontal summation of II and PP. Assuming instantaneous commodity arbitrage and abstracting from transaction costs the following relationship will hold: 

\[ P = P^* e \]  

(3.1)

where \( P \) = domestic grain price; \( P^* \) = world grain price (Chicago); e = price of U.S. dollar (in Canadian currency). Assuming Canada to be a price taker in the international grains market \( P^* \) is exogenous.

Since \( e \) is given to the agricultural sector, (3.1) determines the domestic price of grains, \( P \). Because of the small country assumption, at price \( P \) the export demand curve for grains EE is perfectly elastic. At price \( P \) grain supply is EF and domestic grain demand is EG so GF the residual must represent net exports.

Algebraically: 

\[ NTGR = GPRD + INVDT(-1) - INVDT - FEGD - FOGD - BAGD \]  

(3.2)

where

- NTGR = Net exports of grains
- INVDT(-1) = Opening grain inventories
- GPRS = Available grain supply
- INVDT = Closing inventory demand for grain
- FEGD = Feed demand for grains
- FOGD = Demand for grain. By fats and oils industry
- BAGD = Demand for grain by bakery and cereal industry
The Specification of the Grain Sector Equations

EQ 1: Grain Acreage Equation

\[ \text{GRACQ} = (\text{GRACQ.0} + \text{GRACQ.1} \times \text{FCGDQ}) \]
\[ + \text{GRACQ.2} \times \text{FMIPQ} + \text{GRACQ.3} \times \text{FCLDQ} \]
\[ + \text{GRACQ.4} \times \text{LIFTQ}) \times \text{DUM3} \]

Seeding of grain and oilseeds in Canada takes place in March-April and the harvesting is carried out over the August-October period. There is therefore only one observation on yield and acreage which determines production. The problem of constructing a quarterly simulation model with one annual relationship was resolved in the following way:

Instead of estimating the annual linear equation \( Y_t = X_t \beta_t + \epsilon_t \)
where \( Y_t \) = annual grain acreages; \( X_t \) = vector of explanatory variables; \( \epsilon_t \) = error term, a transformed quarterly linear equation,

\[ Y^*_t = X^*_t \beta^*_t + \epsilon^*_t \] was estimated with

\[ Y^*_t = Y_t \times \text{DUM 3} \]
\[ X^*_t = X_t \times \text{DUM 3} \]
\[ \epsilon^*_t = \epsilon_t \times \text{DUM 3} \]

\( \text{DUM 3} = 0 \) in 1st, 2nd and 4th quarters and 1 in the 3rd quarter.
The parameter estimates in the quarterly specification of the grain average equation would of course be identical to the normal specification so the transformation will have no impact on the simulation. In estimation, however, because the quarterly specification contains "dummy" observations the parameter estimates with the quarterly model will appear much more efficient and the goodness of fit statistic $R^2$ too will be inflated. Consequently, the $R^2$ and T statistics in the grain acreage equation must be interpreted with caution.

Quarterly grain acreage (GRACQ = GRACA * DUM3) is specified as a function of the first quarter average of December Chicago grain futures price, (FCGDQ). The farm input price index (FMIPQ), the first quarter average of Chicago livestock futures prices (FLDQ) and a dummy variable for Lower Inventories for Tomorrow Program (LIFTQ). Both sides of the equation are multiplied by DUM3 a dummy variable that takes the value 1 in the 3rd quarter and 0 otherwise. This is necessary to imbed an annual relationship into a quarterly simulation model.

The inclusion of FCGDQ is rationalized on the premise that farmers' anticipations of receipts from grain delivered to the Wheat Board which acts as their selling agent is based on futures prices considered as an unbiased estimate of market expectations of alternate spot prices. The choice of the December contract is suggested by the September-October harvesting time and the several months that it takes for the grain to move from the elevators to the shipping points. Since livestock production and grain production compete for land and other capital resources the FCLDQ represents the expected opportunity cost of grain production.
FMIPQ represents an index of costs of producing grain. The LIFT program, which was applied to the 1970-71 crop year and which resulted in a substantial reduction in grain acreage is taken into account with a dummy variable LIFTQ.

The expected signs on the grain acreage equation are GRACQ.1>0; GRACQ.2<0; GRACQ.3<0; GRACQ.4<0.

Quarterly grain acreage (GRACQ) is a simple aggregate of wheat, oats, barley, corn, rye, soybeans and rapeseed, multiplied by a third quarter dummy variable.

The first quarter average of Chicago December futures prices of grain (FCGDQ) is calculated as follows: Firstly, Chicago December futures price for wheat, corn and soybeans is averaged over the period January to March (e.g. 1976 Chicago weekly December contract prices for wheat, soybeans and corn prevailing in the period 1976 January to March is averaged). Secondly, a price index (weighted average of price relatives) with current share in either exports or imports according to grain used as weights is constructed for these quarterly wheat, corn and soybean futures prices.

The formula used to calculate the price index is given below:

\[\text{Price index} = \frac{\sum_{i=1}^{n} P_{i,t} \cdot P_{i,0}^{it}}{\sum_{i=1}^{n} P_{i,0}^{it}}\]

\[P_{i,t} = \text{Price of the } i^{th} \text{ commodity in quarter } t \text{ where } i = \text{wheat, corn or soybeans and } t = 1 \ldots \ldots n.\]
\[ P_{i,0} = \text{Price of } i^{th} \text{ commodity in the base period which is taken to be the simple average of the } i^{th} \text{ commodities price between 1967-1 and 1969-4.} \]

\[ Q_{i,t} = \text{Quantity of imports or exports, as the case may be, of the } i^{th} \text{ commodity in quarter } t. \]

This indexing method was applied uniformly throughout the model to calculate all farm level price indices. Henceforth, all farm level price indices should be understood to have been calculated in exactly the same manner except for the fact that the weights used in each specific case may be different.

The quarterly farm input price index (FMIPQ) is obtained from the Statistics Canada Cansim data bank.

The first quarter average Chicago futures price of livestock (FCLDQ) is calculated in exactly the same fashion as (FCGDQ) except for the fact that the share in total current value of cattle and hog inventories both inventories expressed in grain consuming animal units, are used as weights. Grain consuming animal units reduces the different types of livestock into a common unit - that of milk cows. The conversion factors were obtained from Lafarge (1974).

The Lower Inventories for Tomorrow Program which was applicable for the specific crop year 1970-71 and designed to reduce grain acreage particularly wheat is taken into account by the dummy variable LIFT which takes the value of 1 in the 3rd quarter of 1970 and zero otherwise.
EQ.2: Identity for Grain Production

\[ \text{GPRDQ} = \text{GRAYQ} \times \text{GRACQ} \]

Grain yield (GRAYQ) is largely a function of such factors as the amount and distribution of rainfall and technology - and is therefore treated as an exogenous variable because it is assumed that it is determined in a way which is independent of the process described by the equations in the model. From the statistical viewpoint, the yield variable is presumed to be stochastically independent of the disturbances of the system.

GRAIN PRODUCTION (GPRDQ) is therefore treated as identically equal to grain acreage multiplied by yield which assumes that planted acreage and harvested acreage are equal and there is no compelling reason to assume otherwise.

Grain production (GPRDQ) is a simple total of the seven grains, grain yield (GRAYQ) is weighted average of yield with share in total acreage used as weights and grain acreage is a simple total of the acreages of the seven grains.

EQ.3: Feed Grain Demand

\[ \text{FEGD} = \text{FEGD.0} + \text{FEGD.1} \times \text{LIVPX} + \text{FEGD.2} \times \text{FEGPX} + \text{FEGD.3} \times \text{TLIVD}(-1) + \text{FEGD.4} \times \text{DUM2} + \text{FEGD.5} \times \text{DUM3} + \text{FEGD.6} \times \text{DUM4} \]

Feed grain demand (FEGD) is specified as a function of livestock price (LIVPX), feed grain price (FEGPX), opening inventories of livestock (TLIVD(-1)), and three seasonal dummies (DUM2, DUM3, DUM4). The demand for feed grain is derived from the demand for livestock which is a stock demand that can be satisfied by increasing the number of livestock and/or the weight of the livestock. In other words, the amount of feed grain demanded depends on the number of .../70
livestock on hand and the average quantity of feed per unit weight of livestock. As livestock prices rise (fall) or feed grain prices fall (rises), the marginal value product of feed in producing an additional pound of livestock rises (falls) relative to its alternative use (inventories or exports) and one would expect the average amount of feed fed per unit weight of livestock to rise if livestock numbers are given. On the other hand, given the amount of feed demanded per unit weight of livestock the higher the livestock numbers on hand the higher would be the demand for feed grains. The livestock price variable should therefore capture the short run effects while the longer run effects on feed demand should be captured by the livestock numbers variable. Three seasonal dummies included to account for the seasonal nature of grain feeding relative to forage feeding completes the specification.

It should be pointed out that feed grain is demanded by both the livestock sector and the regulated sector and that is why the variable TLIVD(-1) includes, in addition to cattle and hogs, dairy cows and poultry.

The expected signs are - FEGD.1 > 0; FEGD.2 < 0; FEGD.3 > 0.

Feed grain demand (FEGD) is calculated as a simple total of feed use of wheat, feed use of oats, feed use of barley and feed use of corn. There is no independent data available for feed use of corn so it was calculated as a residual from the balance sheet for corn. Data points for 1977, 3rd and 4th quarters were not available.
at the time the simulations were run so the informed estimate of the commodity specialist was relied upon for these two quarters. Since the equation was estimated to 1976-4, this has no impact on the regression estimates.

The livestock price (LIVPX) was calculated as a price index of the average price of choice slaughter steers Toronto and Calgary and price of index 100 hogs Toronto and Calgary ($ per cwt) with share in total current value of cattle inventories and hog inventories converted to grain consuming animals units basis used as weights.

Feed grain price (FEGPX) is the unit value import price of corn, in Canadian dollars.

Total farm livestock inventories at beginning of quarter (TLIVD(-1)) consists of beef cattle and hogs, calves, chicken and turkey and dairy cows expressed in grain consuming animal units.

**EQ.5: Grain Inventory Demand**

\[ INVDT = INVDT.0 + INVDT.1 \times (FCPG - GRAPX) + INVDT.2 \times AGEX + INVDT.3 \times DUM1 + INVDT.4 \times DUM2 + INVDT.5 \times DUM3 + INVDT.6 \times LIVPX + INVDT.7 \times BCOP + INVDT.8 \times INVDT(-1) \]

Grain inventory demand (INVDT) is hypothesized as a function of the change in expected prices (FCPG - GRAPX), a 4 quarter moving average of grain exports (AGEX), three seasonal dummies, livestock price (LIVPX), bumper crop variable (BCOP) and a lagged dependent variable (INVDT(-1)).
Grain inventories are held by the Wheat Board, the farmers and private transactors (grain companies, elevator companies, agents). The uncertain nature of the forces determining demand and supply in the international grain market and the complex process through which grain is collected from the farms, transported to grain elevators and stored and then transported to ports and shipped is reflected in the high ratio of grain inventories to production which seems to be directly linked to the ratio of exports to production. For example, 80 percent of wheat production in Canada is exported. The average ratio of wheat inventories to production is about 99 percent. Approximately, 28 percent of barley and 24 percent of oats production is exported and it is interesting to see that barley inventories as a proportion of production is higher than oat inventories but less than wheat inventories. It would seem not unreasonable to assume that part of the grain inventories are held for transactive purposes mainly exports.

This explains the presence of AGEX as a measure of the level of transactions, a proportion of it is hypothesized to be held as inventories for transactive purposes.

The Wheat Board does not publicize information surrounding its modus operandi in the international grains market and any statements about how the Wheat Board actually operates in the grains market is necessarily speculative. One is told when talking to Wheat Board officials that the Wheat Board does not "speculate" - neither on its grain or on
its exchange rate transactions. It is also known that the Wheat Board does not use the futures market to hedge its sales commitments. In the sense that the Wheat Board, with sole authority to market as much grain as possible at the best possible prices, has at any point in time grain that it owns but has not yet been sold one is led to hypothesize that part of that grain is awaiting better prices. In other words, part of the inventories held by the Wheat Board is presumed to be for speculative purposes. As for inventories of grain held by private transactors (e.g.: international grain companies) it would be simply asserted that part of it is held for speculative purposes. It is therefore hypothesized that the demand for inventories for speculative purposes would be a function of the change in expected prices as measured by the variable (FCPG - GRAPX).

Available statistics show that 30 percent of Canadian grain production is used as feed domestically. Use of grains in livestock production therefore represents a significant alternative to inventory holding and the livestock price (LIVPX) would therefore measure the opportunity cost of holding inventories of grain.

Further because of production, transportation and institutional lags the adjustment of actual inventories to desired inventories would take in most cases longer than 3 months to be realized it is further hypothesized that actual changes in inventories in any quarter represent only a fraction of the desired change.
i.e. \( \text{INVDT} - \text{INVDT}(-1) = \alpha(\text{INVDT}^* - \text{INVDT}(-1)) \) \hspace{1cm} (3.2)

\[
\text{INVDT} = \alpha \text{INVDT}^* + \text{INVDT}(-1) - \alpha \text{INVDT}(-1) \\
= \alpha \text{INVDT}^* + (1 - \alpha) \text{INVDT}(-1) \hspace{1cm} (3.3)
\]

But the maintained hypothesis is that desired inventory demand for grain is a linear function of the variables (FCPG - GRAPX), AGEX, LIVPX.

i.e. \( \text{INVDT}^* = a_0 + a_1 (\text{FCPG} - \text{GRAPX}) + a_2 \text{AGEX} \hspace{1cm} (3.4) \)

\[+ a_3 \text{LIVPX} \]

substituting (3.4) in (3.3)

\[
\text{INVDT} = \alpha (a_0 + a_1 (\text{FCPG} - \text{GRAPX}) + a_2 \text{AGEX} \\
+ a_3 \text{LIVPX}) + (1 - \alpha) (\text{INVDT}(-1)) \\
= \alpha a_0 + \alpha a_1 (\text{FCPG} - \text{GRAPX}) + \alpha a_2 \text{AGEX} \\
+ \alpha a_3 \text{LIVPX} + (1 - \alpha) (\text{INVDT}(-1)) \hspace{1cm} (3.5)
\]

\[
+ \beta_0 + \beta_1 (\text{FCPG} - \text{GRAPX}) + \beta_2 \text{AGEX} \\
+ \beta_3 \text{LIVPX} + \beta_4 \text{INVDT}(-1) \hspace{1cm} (3.6)
\]

where \( \beta_0 = \alpha a_0; \beta_1 = \alpha a_1; \beta_2 = \alpha a_2; \beta_3 = \alpha a_3 \)

\[
\beta_4 = (1 - \alpha)
\]

This specification takes care of the intended component of inventory demand. However, given the seasonal nature and unpredictable element in grain production due to weather conditions there is, one can surmise, an unintended component to grain inventories. Specifically, inventories would be highest in the third and fourth quarters because
of the harvest and lowest in the first and second quarters. If there is a bumper crop, inventories would be higher than intended until the market adjusts to higher than expected levels of production. The grain inventory equation therefore needs to be supplemented by DUM1, DUM2, DUM3 and BCOP.

The expected signs in the fully specified inventory demand equation are as follows:

$$\text{INVDT.1}>0; \quad \text{INVDT.2}>0$$

$$\text{INVDT.6}<0; \quad \text{INVDT.7}>0$$

Grain inventory demand (INVDT) is the total of farm and commercial inventories (including those held by the Canadian Wheat Board) of rapeseed, soybeans, rye, durum (only commercial), wheat, oats and barley.

Chicago near futures price (FCPG) of grain is a price index of wheat, soybeans and corn near futures prices with the share of export/import value used as weights.

Index of domestic grain prices (GRAPX) is a price index of wheat, corn and soybeans export/import unit value prices with the share in total export/import value used as weights.

Average grain exports (AGEX) is a 4-quarter moving average of total grain exports.

The bumper crop variable (BCOP) is calculated in the following manner: In the first and second quarters when there is no current production BCOP is calculated as the deviation of the last crop from average production. In the third and fourth quarters it is the sum of the deviation of the last crop from average production and the deviation of the current crop from average production.
EQ.6: Identity for Net Exports of Grains

\[
\text{NTGR} = \text{GPRS} - \text{INVDT} - \text{FOGD} - \text{BAGD} - \text{FEGD} + \text{RESD}
\]

Net exports of grain (NTGR) is identically equal to grain supply minus closing grain inventories minus grain demand by fats and oils industry and bakery and cereals industry, minus feed demand for grain and a residual item (RESD) to close the identity.

Net exports of grain (NTGR) is total exports minus total imports of the following items all expressed in terms of million metric tonnes of grains - wheat, wheat flour, oats, barley, rye, corn, soybeans, soybean oil, soybean meal, rapeseed, rapeseed oil, rapeseed meal.

Grain demand by fats and oils industry (FOGD) is calculated by converting the production of soybean and rapeseed oil by crushing plants into million metric tonnes of soybeans and rapeseed by using conversion factors given in the booklet "Weights and Conversion Factors for Canadian Agricultural Products" published by the Canadian Department of Agriculture in September, 1962.

Grain demand by bakery and cereal industry (BAGD) is calculated by converting the domestic disappearance of grain products (wheat flour, oatmeal, rolled oats, barley pot and pearl, rye meal and flour, corn flour and meal, buckwheat flour) into million metric tonnes of grain by using conversion factors contained in the booklet quoted above.

EQ.7: Retail Price of Bakery and Cereals

\[
\text{BACP} = \text{BACP.0} + \text{BACP.1} \times \text{DOMP} + \text{BACP.2} \times \text{FCPR} + \text{BACP.3} \times \text{WAGF} + \text{BACP.4} \times \text{BACP}(-1)
\]
The retail price of bakery and cereal products is specified as a function of the domestic milling price (DOMP), the interest rate (FCPR), the wage rate (WAGF) and a lagged dependent variable. Price at the retail level is presumed to be determined by a constant mark-up on the input prices. This is defended on the following grounds. The supply of wheat to the bakery and cereal industry is perfectly elastic at the price (DOMP) determined by the two-price wheat policy and also since it would be reasonable to assume that demands imposed by the bakery and cereal industry in the capital and labour markets would not be large enough to affect the interest rate and the wage rate, the supply of these two inputs are also perfectly elastic. Shifts in retail demand for bakery and cereals (which would be negligible in any case) would therefore not affect the equilibrium BACP/DOMP, BACP/FCPR, BACP/WAGF ratios. Hence a simple mark-up formulation of the retail price determination mechanism is considered adequate for the bakery and cereal industry.

A lagged dependent variable is included as an additional explanatory variable on the assumption that retail prices of cereals and bakery products do not adjust completely within one quarter. Not having any apriori information on the specific lag structure the infinite geometrical lag structure that the introduction of a lagged dependent variable imposes is accepted.

The expected signs on the coefficients are:

BACP.1>0; BACP.2>0; BACP.3>0

The domestic milling price (DOMP) is that decreed by the two-price wheat system which was explained in the previous chapter.
The interest rate (FCPR) is the 90-day finance company paper rate. Among a multiplicity of interest rates that is available to measure the costs of inventory holdings and as a general measure of the best alternative return available to those who have invested in agricultural activities, FCPR was chosen because it is readily available, widely used and reasonably appropriate. FCPR is retrieved from CANSIM data bank.

EQ.8: Farm Price of Food Grains

    FGRPX = FGRPX.0 + FGRPX.1 * SWFPX(-1)
    * + FGRPX.2 * EXCHI(-1)

The domestic price of food grains (FGRPX) is specified as a function of the world price of wheat lagged one quarter (SWFPX(-1)) and the exchange rate lagged one quarter (EXCHI(-1)).

The theoretical motivation for this specification is that since Canada is presumed to be a price taker in the world market for grains and Chicago near futures price is taken as the representative world price, the Canadian price for food grains is determined by the world price times the exchange rate, assuming zero transaction costs and absence of tariffs. (There is actually an 8 cent per bushel tariff on corn, but it has remained unchanged for so long that it has been ignored.)

    i.e.: FGRPX = SWFPX * EXCHI

A linearized form of this identity which ignores the residual term would be FGRPX = FGRP.0 + FGRPX.1 * SWFPX + FGRPX.2 * EXCHI.

However, the Chicago near futures price and the exchange rate
variable has been lagged one quarter to account for the fact that this
is approximately the time that it takes for CWB quoted export prices
to be recorded as Statistics Canada export unit values.

The expected signs on the coefficients are $FGRPX.1 > 0$;
$FGRPX.2 > 0$.

The domestic price of the food grains (FGRPX) is an export
unit value of wheat.

Chicago near-futures price for grain (SWFPX) is taken as the
representative world price for food grains and the near futures is
defined as the nearest contract that is at least one month ahead of the
present quarter. Closing mid-month prices for May contract in January-
March are averaged for the first quarter, July contract prices in April-
June are averaged for the second quarter, October contract prices in
July-September are averaged for third quarter and February contract
prices in October-December are averaged for the fourth quarter. All
the Chicago near futures prices used in the model SWFPX, SSFPX and
FCOP are defined in the same way.

The exchange rate is the price of U.S. dollars in Canadian
funds and this is available on the CANSIM data bank.

EQ.9:  Farm Price of Oilseeds

\[ OILPX = OILPX.0 + OILPX.1 \times SSFPX(-1) + OILPX.2 \times EXCHI(-1) \]

The domestic price of oilseeds (OILPX) is specified as a
function of the world price of oilseeds lagged one quarter (SSFPX(-1))
and the exchange rate lagged one quarter.

The expected signs are: $OILPX.1 > 0$; $OILPX.2 > 0$. 

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The domestic oilseed price is the unit value import price of soybeans.

The world price of soybeans is the Chicago near futures price for soybeans.

**EQ.10: Identity for Index of Grain Prices**

\[
\text{GRPX} = \left( \frac{\text{FEKPX}}{\text{FEKPX}} \right) \times \text{VALUE OF Feed Grain Imports} \\
+ \left( \frac{\text{OILPX}}{\text{OILPX}} \right) \times \text{VALUE OF Oilseed Imports} \\
+ \left( \frac{\text{FGRPX}}{\text{FGRPX}} \right) \times \text{VALUE OF Food Grain Exports}
\]

Total value of feedgrain, oilseeds and food grain imports and exports.

The bar (\(-\)) denotes base year (1967-\(\bar{\} 1969-4\)).

Equation 10 is a constructed aggregate price index for grains. Each of the price relatives for the three representative grains - wheat, soybeans and corn is weighted by their share in the total current value of exports and imports.

**EQ.11: Retail Price of Fats and Oils**

\[
\text{FAOP} = \text{FAOP\_0} + \text{FAOP\_1} \times \text{OILPX} + \text{FAOP\_2} \times \text{WAGF} \\
+ \text{FAOP\_3} \times \text{FCPR} + \text{FAOP\_4} \times \text{FAOP\_(-1)}
\]

The retail price of fats and oils is specified as a function of the farm price of oilseeds (OILPX), the wage rate (WAGF), the interest rate (FCPR) and the lagged dependent variable (FAOP\_(-1)).

The expected signs on the coefficients are: FAOP\_1 > 0; FAOP\_2 > 0; FAOP\_3 > 0.
The retail price of fats and oils (FAOP) is the CPI - fats and oils and the data series is retrieved from the CANSIM data bank.

The farm price of oilseeds (OILPX) is the import unit value of soybeans.

EQ.12: Farm Price of Feed Grains

\[ \text{FEGPX} = \text{FEGPX}.0 + \text{FEGPX}.1 \times \text{FCOP}(-1) + \text{FEGPX}.2 \times \text{EXCHI}(-1) \]

Farm price of feed grains is specified as a function of Chicago near futures price of corn lagged one quarter (FCOP(-1)) and the exchange rate lagged one quarter.

The expected signs on the coefficients are FEGPX.1 > 0; FEGPX.2 > 0.

The domestic farm price of feed grains (FEGPX) is the import unit value price of corn.

The world price of feed grains (FCOP) is the Chicago near futures price of corn.

Modelling Framework: THE LIVESTOCK SECTOR

Three characteristics of the livestock sector which have been given special emphasis in modelling shall be mentioned from the outset.

(1) Livestock by its nature is simultaneously a capital good as well as a consumption good. As a capital good it is capable of converting inputs - for example, feed grain into a marketable product of another form, meat, but at the same time, depending primarily, it is maintained, on the price of the livestock capital good relative to the
consumption good, the capital good itself can be transformed into a consumption good by being slaughtered.

(2) Owing to the long lead time required to increase the given stock of the livestock capital good, the supply of the consumption good (meat) at any point in time is limited by the excess supply of capital goods (livestock).

(3) Trade in live animals, almost all which is between Canada and U.S., under normal circumstances, is free from tariff and non-tariff barriers while trade in meat is quite frequently restricted by non-tariff barriers particularly quotas. Consequently, it is maintained that the Canadian livestock prices are directly influenced and largely determined by the larger U.S. market while domestic demand and supply conditions have relatively more influence, especially in the short run, in determining domestic meat prices.

The livestock sector is modelled with 12 equations, 4 of which are stochastic, one is an equilibrium condition with definitional and identity relationships accounting for the rest.

The direct influence played by U.S. prices is taken into account in the equation determining the Canadian livestock price which is specified as a function of the U.S. livestock price in Canadian dollars and the domestic excess demand for livestock. Price expectations which are presumed to be formed based on past and recent trends in Canadian livestock prices then determine investment holdings in livestock.

Once the investment decision is made the portion of current stock of livestock that is available for slaughter also becomes simultaneously determined. This current supply of meat then is available
to satisfy the consumption demand and the price of meat will then adjust to clear the retail market for meat. On the other hand, if meat demand increases, meat prices will tend to rise and this will induce increased slaughter reducing livestock inventories and consequently livestock and meat imports will have to rise.

Given this conceptualization of the processes which operate within the livestock sector an exogenous rise in U.S. livestock prices or a fall in feed grain prices or a fall in interest rates will, to the extent that they are extrapolated into the future (extrapolative expectations), have the following consequences (assuming ceteris paribus conditions). Firstly, the expected capital value of livestock will rise and this will raise the desired investment holdings in livestock. Secondly, with a given stock of livestock, the excess supply of livestock and hence the current supply of meat will fall. Thirdly, if the demand curve of meat is negatively sloped then the price of meat will rise. In the short run, a rise in the livestock capital good price will therefore lead to reduced supplies of meat and an increase in the consumption good price. In the long run, however, the rise in the current meat price will restrain consumption, increase imports while reducing the incentive to increase investment holdings (the relative price of the capital good falls as the price of the consumption good rises) and this will increase the supply of meat. Furthermore, with a larger capital stock the flow supply of meat too will increase thus arresting and quite possibly reversing the rise in the consumption price of beef. Obviously, consequences opposite to those described above will ensue if the capital good prices fall.
The process of adjustment that is triggered in the livestock sector when exogenous shocks are imposed on it can be illustrated with a flow chart diagram (FIG. 8).
Figure 8. Flow chart of the adjustment process in the livestock sector.

Retail Meat Price

Investment Holdings of Livestock at the Close of Current Period

Expected Capital Value of Livestock

Expected Canadian Livestock Price

Expected Feed Price

Available Supplies of Livestock and Meat

Change in Investment Holdings of Livestock

Meat Demand

Meat Supply

U.S. Livestock Price

Exchange Rate
Specification of the Livestock Sector Equations

EQ.13: Definition for U.S. Price of Steers in Canadian Dollars

\[ \text{CANPSS4} = \text{PSS4} \times \text{EXCH1} \]

EQ.14: Definition for U.S. Price of Hogs in Canadian Dollars

\[ \text{CANPHG4} = \text{PHG4} \times \text{EXCH1} \]

These two equations define the U.S. price of steers and hogs in Canadian dollars as a preliminary step towards constructing the index of the U.S. livestock price expressed in Canadian dollars.

U.S. price of steers (PSS4) is the price of choice slaughter steers (900-1100 lbs.), Omaha ($/cwt.).

U.S. price of hogs (PHG4) is the average price of barrows and gilts at seven markets, U.S.A. ($/cwt.).

EQ.15: Definition for Index of U.S. Livestock Price in Canadian Dollars

This is a price index of U.S. steer and hog prices expressed in Canadian dollars weighted by share in total value of inventories where inventories are defined in terms of grain consuming animal units.

EQ.16: Identity for Total Farm Inventories of Livestock

\[ \text{TLIVD} = \text{LIVD} + \text{POVDT} + \text{DCVDT} \]

This identity is an aggregate of farm inventories of beef cattle, calves, hogs, chicken, turkey and dairy cows all expressed in terms of grain consuming animal units.
EQ.17: Imports of Livestock and Meat

MTIM = MTIM.0 + MTIM.1 * CANUSLP + MTIM.2 * LDUM +
    MTIM.3 * LIVM(-1) + MTIM.4 * YCOM
    + MTIM.5 * (MTIM(-1))

Livestock and meat imports are specified as a function of the index of U.S. livestock prices in Canadian dollars (CANUSLP), a dummy variable for the Nixon price freeze (LDUM), personal disposable income (YCOM), opening inventories of livestock expressed in terms of pounds of meat (LIVM(-1)), and the lagged dependent variable (MTIM(-1)).

The simplest import demand function one can specify will have to include the price of imports, the price of the domestic substitute good and personal disposable income. If one imposes the absence of money illusion the three variables can be reduced to two by deflating with say the price of the substitute good.

The basic import demand function for livestock and meat would look as follows:

MTIM = f(CANUSLP, LIVPX, YCOM)

However, the presence of two prices in the import function implies that the substitution between the imported good and its
domestic counterpart is imperfect. If, on the other hand, the substitution between these two goods is very high, so that relative prices are constant and in the case of Canadian and U.S. livestock and meat products there are a priori grounds to assume this to be the case, one can use a common price rather than two separate prices to avoid estimation problems.

In the form of specification suitable for the imperfect substitute case the shifts in domestic supply affect the demand for imports through the medium of domestic prices (See Leamer and Stern 1970). However, in the case where the substitution between the import good and the domestic good is perfect or near perfect, which is the one that is relevant here, shifts in domestic supply are not observed in price changes because prices change very little if at all when substitution is very high and only import demand will change. This calls for including variables that will shift the supply curve for livestock and meat in the import demand function for livestock and meat production. The form of the meat supply equation (EQ.20) immediately suggests the inclusion then of \( LIVM(-1) \) which is positively related to meat supply.

On March 29, 1973 the U.S. Government imposed price ceilings on beef among other food products and this led to serious distortions in trade in livestock and livestock products and by extension to Canadian cattle and beef prices (See Chapter 3). This shift away from the normal pattern of trade is taken into account by a dummy variable \( LDUM \) which takes the value of 1 in the third and fourth quarters of 1973 and 0 otherwise.

The expected signs on the coefficients are \( MTIM.1 < 0; MTIM.2 > 0; MTIM.3 < 0; MTIM.4 > 0. \)
Imports of livestock and meat products (MTIM) is the aggregate of meat imports and cattle and hog live animal imports converted into pounds of meat, through multiplying by the average carcass weight.

Per capita income (YCOM) is retrieved from the CANSIM data bank.

EQ.18: Identity for Net Exports of Livestock and Meat

\[ NTMT = MTEX - MTIM. \]

Exogenously determined exports of livestock and meat (pork, beef, veal, live hogs, live cattle - MTEX) minus imports of livestock and meat (MTIM) determine net trade.

EQ.19: Inventory Demand for Livestock

\[ LIVM = LIVM.0 + LIVM.1 \times LIVPX(-2) + LIVM.2 \times FEGPX(-2) + LIVM.3 \times FCPR(-2) + LIVM.4 \times LIVM(-1) + LIVM.5 \times LIVM(-2) \]

\[ + LIVM.6 \times DUM3 + LIVM.7 \times DUM4 + LIVM.8 \times LIVM(-3) + LIVM.9 \times (FEGPX(-2) - FEGPX(-3)) + LIVM.10 \times (FCPR(-2) - FCPR(-3)) \]

\[ + LIVM.11 \times LVPP \]

It was demonstrated in the theoretical section that if livestock is treated as a capital good the problem of choosing the optimum slaughter age boils down to maximizing net present value of the livestock capital good. Further, it was shown that the optimum slaughter age is a function of the expected prices of livestock, feed price and the opportunity cost of capital given the behavioral postulate.
of profit maximization. A positive monotonic relationship is therefore implied between the optimum slaughter age and the desired farm inventory holdings of livestock (LIVM*). Hence, LIVM* can be written as a linear function of expected price of livestock (LIVPX*) expected price of feed grains (FEGPX*), and the expected rate of interest (FCPR*) which measures the expected opportunity cost of capital.

However, because of biological lags and adjustment costs it will be reasonable to assume that livestock producers cannot instantaneously adjust their current holdings of livestock inventories to desired levels as exogenous factors change. It will therefore be hypothesized that the change in livestock inventory levels in each quarter which will be defined as realized investment in livestock inventories is a proportion of the difference between the desired livestock inventory level and the current (opening) inventory level. Algebraically,

\[ I_L = LIVM - LIVM(-1) = \phi(LIVM^* - LIVM(-1)) \]  
\[ \text{where } I_L \text{ = Realized investment in livestock inventories} \]
\[ \phi = \text{Proportional adjustment factor} \]
\[ \text{LIVM}^* = \text{Desired level of livestock inventories} \]

Since \( LIVM^* \) = \( f(LIVPX^*, \text{FEGPX}^*, \text{FCPR}^*) \)

Substituting in (3.7)

\[ LIVM = \phi f(LIVPX^*, \text{FEGPX}^*, \text{FCPR}^*) + (1-\phi) \{LIVM(-1)\} \]  
\[ \text{(3.9)} \]

Alternatively,

\[ LIVM = g(LIVPX^*, \text{FEGPX}^*, \text{FCPR}^*, LIVM(-1)) \]
\[ \text{(3.10)} \]
A preliminary experiment to represent (LIVPX*) and (FEGPX*) with the Chicago long futures price (December contract in the first quarter of the year) and Chicago corn futures price proved unsuccessful as the signs on the coefficients were inconsistent with the maintained hypothesis and the variables proved to be insignificant. The possible explanation among many is that, the data, particularly for live hogs in the early years 1967-69 when the futures market for live hogs was in its infancy, are less than reliable as a representation of market expectations.

Consequently, an autoregressive hypothesis of expectations formation in the form of extrapolative expectations was adopted to represent the expected variables in the equation. The observed long and sharp cycles in the Canadian livestock sector, particularly for cattle, will lend support to the contention that expectations are formed through extrapolating recent past trends.

To elaborate, when price expectations are hypothesized to be formed by geometric lag structures expected prices will be below current observed prices when prices are on a rising trend. In other words, forecasters will regard the current high (low) prices as unsustainable. In contrast, with the extrapolative hypothesis, however, the current high (low) prices will be expected to continue to remain so. In the present case it is hypothesized that forecasters form price expectations not only on the basis of past price levels but also takes into consideration recent changes in prices. Given the level of prices an upward trend in prices will reinforce bullish expectations whereas
a downward trend will tend to temper it. More formally, if:

$$LIVM^* = \alpha_1 + \beta_1 LIVPX^*$$  \(3.11\)

With extrapolative expectations:

$$LIVPX^* = LIVPX(-1) + \theta(LIVPX(-1) - LIVPX(-2))$$  \(3.12\)

Substituting \((3.12)\) in \((3.11)\)

$$LIVM = \alpha_1 + \beta_1 LIVPX(-1) + \beta_1 \theta(LIVPX(-1) - LIVPX(-2))$$  \(3.13\)

The coefficient of adaptation can be estimated directly from the above question.

However, in preliminary testing much higher \(t\) values were obtained with \(LIVPX(-2)\) than with \(LIVPX(-1)\). The same holds true for the two other expected variables in the equation \(FEGPX^*, FCPR^*\), so this information was utilized by specifying the equation with two quarter lags on the price level.

Livestock inventories in the model serve the dual role of capital stock as well as a stock of consumable goods from which current meat supplies are met and to which future supplies of meat are added. In the extreme, given the capital value of livestock, if the current meat price is high enough, the capital stock would be depleted (all livestock will be slaughtered); alternatively given current meat prices, if the capital value of livestock is high enough, the current supply of meat will be zero (zero slaughter). In short, the demand for livestock inventories is, therefore, a function of the capital value of livestock relative to the consumption value of meat. The better it is maintained, is reflected in the retail price of meat which is, therefore, included as a separate variable in the livestock inventory equation.
Finally, the net returns from holding livestock inventories are expected to vary with the seasons (costs are higher in cold weather) so the inventories themselves will be expected to be seasonal and that is why seasonal dummies are added to the equation.

The expected signs are LIVM.1 > 0; LIVM.2 < 0; LIVM.3 < 0; LIVM.9 > 0; LIVM.10 < 0; LIVM.11 < 0.

Farm inventories of livestock (LIVM) includes the number of cattle and hogs on farms expressed in terms of millions of grain consuming animal units multiplied by average carcass weight. The average carcass weight is calculated by dividing the aggregate of estimated dressed production (1000 lbs cold dressed carcass weight basis) of beef, veal and pork by the number of cattle and hogs slaughtered—expressed in terms of thousands of grain consuming animal units.

The retail price of meat (LVPP) is the weighted average of CPI—beef, CPI—pork, and CPI—veal with the 1967 CPI weights used as weights.
EQ.20: Meat Supply
\[ \text{DMTSY} = \text{BDRE} + \text{LIVM(-1)} - \text{LIVM} + \text{MTIM} - \text{MTEX} \]

Meat supply is expressed as identically equal to millions of net births of animals (expressed in million pounds of meat by conversion through average carcass weight) plus opening farm inventory holdings of livestock, minus closing farm inventories of livestock plus imports of livestock and meat products (expressed in terms of million pounds of meat).

Meat supply (DMTSY) is slaughter of cattle and hogs (grain consuming animal unit basis) multiplied by average carcass weight plus net imports of livestock and meat (MTIM-MTEX).

Net births of animals in pounds of meat (BDRE) is derived residually from the identity.

EQ.21: Per Capita Retail Demand for Meat
\[ \text{PCLVPD} = \text{PCLVPD.0} + \text{PCLVPD.1} \times \text{LVPP} + \text{PCLVPD.2} \times \text{PCYCOM} + \text{PCLVPD.3} \times \text{PLCPI} + \text{PCLVPD.4} \times \text{PCLVPD(-1)} \]

The per capita retail demand for meat is specified as a function of the retail price index of meat (LVPP), per capita income (PCYCOM), the price of the substitute - retail price of poultry and (PLCPI), and the lagged dependent variable (PCLVPD(-1)). Admittedly, this specification can be criticized for not using relative prices but the desire to avoid non-linearities in a simulation model proved to be an overriding concern.
The expected signs are \( PCLVPD.1 < 0; PCLVPD.2 > 0; PCLVPD.3 > 0 \).

Per capita retail demand for meat (PCLVPD) is the aggregate of domestic consumption of beef, pork and veal divided by population of Canada. The retail prices of poultry PLCPI is the weighted average of CPI - chicken and CPI - turkey weighted by 1967 CPI weights.

EQ.22: Market Clearing Function for Retail Meat

\[
PCLVPD \times \frac{POPC}{1000} = DMTSY
\]

This is an equilibrium condition for the retail meat market. The equation determines the retail price of meat that will clear the retail market for meat.

The variable \( POPC \) is the population of Canada and the term \( \frac{POPC}{1000} \) was necessary to convert per capita meat consumption in thousands of pounds to total consumption of meat in millions of pounds.

EQ.23: Farm Price of Livestock

\[
LIVPX = LIVPX.0 + LIVPX.1 \times CANUSLP + LIVPX.2 \times LIVPX(-1) + LIVPX.3 \times (LIVM(-1) - LIVM(-2))
\]

Canadian farm price of livestock (LIVPX) is specified as a function of the U.S. price of livestock in Canadian dollars (CANUSLP) the lagged dependent variable \( LIVPX(-1) \) and the change in farm inventory holdings of livestock \( LIVM(-1) - LIVM(-2) \).

Trade in live animals is essentially between Canada and the U.S. and except for infrequent restrictions in the form of tariff and non-tariff barriers, there is free trade. Given that the U.S. livestock
market is many times larger than the Canadian market and given the proximity of two markets and the trade between them the U.S. livestock price will have a strong and direct effect on the Canadian prices. In the short run, however, owing to information lags and transaction costs there can be divergences between the prices in the two markets and domestic excess demand and other factors can determine the domestic price within these limits. Marshall in the study prepared for the Food Price Review Board has observed that Calgary and Omaha choice slaughter steer prices can differ by as much as $5 per hundredweight in the short run. As a result, a measure of the lagged investment excess demand for livestock (LIVM\((-1) - LIVM\((-2)\)) was included in the equation. A lagged dependent variable (LIVPX\((-1)\)) was also included because it was expected that the adjustment to U.S. livestock prices and domestic excess demand would not be completed within one quarter. Delays can be expected because of shipping arrangements, health restrictions, etc.

It should be noted, that in defining CANUSLP (Index of U.S. livestock prices in Canadian dollars) as a weighted average of U.S. cattle prices in Canadian dollars and U.S. hog prices in Canadian dollars, changes in CANUSLP is made equivalent to changes in USLP (index of U.S. livestock prices in U.S. dollars) times the change in exchange rate. (This is necessary if simulated changes in exchange rates are to be reflected in CANUSLP.) In other words, the coefficient on CANUSLP measures the change in an index of domestic livestock price (LIVPX) as a result of a small change in the variable which is a multiple of USLP and the exchange rate given the other variables included in eq: 23.

The multiplicative form for CANUSLP therefore presumes
that domestic livestock prices respond to the total change in the Canadian dollar equivalent of U.S. livestock prices and it is immaterial how that total change is allocated between changes in U.S. livestock prices in U.S. dollars and changes in exchange rates.

The argument in favour of this specification is further strengthened by the fact that the alternative specifications with USLP and the exchange rate entered as separate variables (functionally additive) resulted in a negative coefficient on the exchange rate variable. This is attributed to mis-specification although multicollinearity with other included variables particularly LIVPXL(-1) is not ruled out.

MODELLING FRAMEWORK: The Regulated Sector

The regulated sector of the Canadian agriculture industry comprises the dairy, poultry (chickens and turkeys) and egg sub-sectors. The basic objective of the federal and provincial regulation of these sectors has been to encourage long-term viability of the industry and self-sufficiency. Towards this end the sectors are insulated from exposure to external influences by import quotas. The price for these sectors are then set by the provincial and national regulatory agencies on the basis of cost of production formulas and the agencies' perception of the rate of return that will encourage efficient sized enterprises and the adoption of cost saving technology. An estimate of domestic demand that will result at these prices is made and the production quotas are then set to achieve a balance between demand and supply.
Given that the main thrust of the thesis is to make an empirical analysis of macro policy impacts on food prices, interest in the regulated sector centres on the determination of farm and retail level prices and not on the economic welfare aspects of regulation. Consequently, the modelling of the regulated sector is considerably simplified. The determination of the regulated sector prices is modelled with eight equations, seven of which are stochastic and the remaining one being an identity. The components that enter the price determining process of the regulatory agencies are generally known although the precise application of these formulas is far from mechanical with varying discretionary powers being exercised by various regulatory authorities.

Consequently, it was decided to use the following modelling strategy. Each sub-sector of the regulated sector is modelled with two stochastic equations. One equation is used to endogenize the regulated farm price by regressing the farm price on variables known to enter the price setting decision making process of the regulatory authorities. The second equation is then used to determine the retail prices of the sub-sector's products by a simple mark-up equation. An identity is then used to construct a composite weighted price index of all the retail prices in the regulated sector. An equation to link the feed price considered more appropriate for the poultry sector with the feed price used in the rest of the model completes the specification of the regulated sector.
EQ. 25: Specification of the Regulated Sector Equations

The Retail Price for Dairy Products

\[ DPRP = DPRP.0 + DPRP.1 \times GTRM + DPRP.2 \times WAGF + DPRP.3 \times FCPR + DPRP.4 \times DPRP(-1) \]

The retail price of dairy products (DPRP) is specified as a function of gross target returns on milk (GTRM), the wage rate, the interest rate, and the lagged dependent variable DPRP(-1).

The rationalization for this specification, as also for the other retail price equations in the regulated sector, is identical to one that was used to specify the retail price equations in the grain sector.

The expected signs are:

\[ DPRP.1 > 0; DPRP.2 > 0; DPRP.3 > 0. \]

The dairy product price (DPRP) is the CPI - Dairy Products.

Gross target returns for industrial milk (GTRM) is calculated by the Canadian Dairy Commission by applying a returns adjustment formula with a 35 percent weight on CPI (1971 = 100) - a proxy for imputed labor earnings, 45 percent weight on dairy cash input price index and a 20 percent weight on judgement factors (world prices, stock levels, etc.) to the target returns established for the base period, $25.05 per lb. of milk on April 1, 1975. The formula calculates the changes in cash inputs and CPI components for each three month period. More precisely, the formula given above is only an indicated target return as judgemental factors can act as a counterweight to the components of the formula. STONEHOUSE (1979) provides a detailed discussion of the formula.
EQ.26: Regulated Farm Price for Milk

\[ GTRM = GTRM.0 + GTRM.1 \ast FEGPX(-1) + GTRM.2 \ast CPIAQ(-1) + GTRM.3 \ast GDST(-1) \]

The gross target returns for milk (GTRM) which is in effect the regulated farm price of milk is a function of the feed grain price lagged one quarter, the consumer price index lagged one quarter CPIAQ(-1), and opening stocks of dairy products GDST(-1).

Quite clearly, this equation is an attempt to endogenize the exogenous policy variable, the target returns for industrial milk. This is done through using variables which are known to affect the formula for setting target returns as regressors.

The expected signs are:

\[ GTRM.1 > 0; GTRM.2 > 0; GTRM.3 < 0. \]

Government dairy stocks (GDST) is the closing stocks of butter and skim milk powder owned by the government regulatory agency.

EQ.27: Retail Price for Poultry

\[ PLCPI = PLCPI.0 + PLCPI.1 \ast POFP + PLCPI.2 \ast WAGF + PLCPI.3 \ast FCPR + PLCPI.4 \ast LVPP + PLCPI.5 \ast PLCPI(-1) \]

The retail price of poultry (PLCPI) is specified as a function of the regulated farm price of poultry (POFP), the wage rate, the interest rate, the retail price of meat (the price of substitute good) and the lagged dependent variable.
The expected signs are:

\[ PL_{CPI.1} > 0; \quad PL_{CPI.2} > 0; \quad PL_{CPI.3} > 0; \quad PL_{CPI.4} > 0. \]

The retail price of poultry is the weighted average of CPI - chicken and CPI - Turkey with CPI weights used as weights.

**EQ.28: Retail Price for Eggs**

\[ EC_{PI.1} = EC_{PI.0} + EC_{PI.1} \times REGGP \]
\[ + EC_{PI.2} \times WAGF \times EC_{PI.3} \times FCPR \]
\[ + EC_{PI.4} \times EC_{PI.(-1)} \]

The expected signs are:

\[ EC_{PI.1} > 0; \quad EC_{PI.2} > 0; \quad EC_{PI.3} > 0. \]

The retail price for eggs (ECPI) is specified as a function of the regulated farm price of eggs (REGGP), the wage rate, the interest rate and the lagged dependent variable.

The regulated farm price of eggs (REGGP) is the average prices to producers at registered stations (for GRADE A) - (cents per dozen). The data was extracted from the Agriculture Canada data bank.

**EQ.29: The Regulated Farm Price of Poultry**

\[ PO_{FP.1} = PO_{FP.0} + PO_{FP.1} \times EGGFP(-1) \]
\[ + PO_{FP.2} \times CPIAQ(-1) + PO_{FP.3} \times POLS \]
\[ + PO_{FP.4} \times CHUS(-1) \times EXCHI(-1) \]

The regulated farm price of poultry (POFP) is specified as a function of the poultry feed price lagged one quarter EGGFP(-1),
the consumer price index lagged one quarter (CPIAQ(-1)), the opening stocks of poultry (POLS), the U.S. chicken price in Canadian dollars lagged one quarter CHPUS(-1) * (EXCHI(-1)) and the lagged dependent variable.

The specification of this equation follows the common form of specification for all the regulated sector farm prices except for the inclusion of the variable CHPUS(-1) * EXCHI(-1). This step was considered necessary because unlike in the case of turkey there were until recently only provincial marketing boards for chicken and no national marketing board agency and since Canada's trade with U.S. is relatively free in chickens, the provincial marketing boards in setting chicken prices have to take U.S. chicken prices into serious consideration.

The expected signs for the coefficients are:

POFP.1 > 0; POFP.2 > 0; POFP.3 < 0; POFP.4 > 0.

The regulated farm price of poultry is the price index of average producer price for chicken and turkey at registered stations weighted by share in total value of inventories with inventories expressed in terms of grain consuming animal units.

The poultry feed price (EGGFP) is the simple average of the import unit value of corn and soybeans.

The opening poultry stocks (POLS) is the stocks of poultry meat held by retailers.

The U.S. chicken price is the U.S. wholesale price of broiler chicken.
EQ.30: Feed Price for Poultry Industry

\[
\text{EGGFP} = \text{EGGFP}_{0} + \text{EGGFP}_{1} \times (\text{FEGPX} + \text{OILPX}/2)
\]

This equation links the feed price that is considered more appropriate for the poultry industry with the feed price that is used in the rest of the model.

The poultry feed price is therefore regressed on the simple average of the domestic feed grain price and the domestic oilseed price.

The expected signs are:

\[
\text{EGGFP}_{1} > 0.
\]

The feed price for poultry (EGGFP) is the retail price of laying mash in Ontario, index 1971=100 and the data is obtained from Statistics Canada.

EQ.31: Regulated Farm Price of Eggs

\[
\text{REGGP} = \text{REGGP}_{0} + \text{REGGP}_{1} \times \text{EGGFP}(-1)
+ \text{REGGP}_{2} \times \text{EGST}(-1) + \text{REGGP}_{3} \times \text{CPIAQ}(-1)
+ \text{REGGP}_{5} \times \text{CMDUM1}
\]

The regulated farm price of eggs (REGGP) is specified as a function of the poultry feed price lagged one quarter, the opening inventories of egg stocks (EGST(-1)), the consumer price index lagged one quarter and a dummy variable for the structural break caused by the establishment of the Canadian Egg Marketing Agency (CEMA).

The expected signs are:

\[
\text{REGGP}_{1} > 0; \text{REGGP}_{2} < 0; \text{REGGP}_{3} > 0.
\]

The opening inventories of egg stocks EGST(-1) are those
held by retailers and does not include CEMA's stocks which were not available.

The dummy variable for CEMA (CMDUM1) takes the value of 1 for the period before the establishment of CEMA i.e. up to 1973-2 and takes the value of zero thereafter.

EQ.32: Retail Price of Regulated Sector Products

\[
\text{RSCP} = \frac{(33328 \times \text{DPRP} + 0.617 \times \text{ECPI} + 0.9053 \times \text{PLCPI})}{4.8551}
\]

The regulated sector price index is constructed as a weighted average of the CPI - dairy products, CPI - eggs, CPI - poultry using CPI weights as weights.

MODELLING FRAMEWORK: The Accounting Sector

The accounting sector consists of two equations - 1 definition and 1 identity. The price index of non-traded goods has to be defined and constructed because no index as such is published and it is constructed in a manner that would make it reflect any changes in exchange rates. The CPI - Food Index, of course, is the premier variable in the model since it is this variable on which the thesis is focused. It is therefore appropriate that these two variables - CANPASH and CPIFG, as they do not rightfully belong to any of the three economic sectors in the model, be collected in the accounting sector.
Specification of the Accounting Sector Equations

EQ.33: Definition for Unit Value of Non-Competing Imports in Canadian Dollars

\[ \text{CANPASH} = \text{USPASH} \times \text{EXCHI} \]

This is actually an empirical construct to incorporate the impact of exchange rate changes on non-competiting agriculture imports such as fruits and vegetables, sugar and coffee, etc., into the CPI - Food. A weighted average of price and quantity relatives (price and quantity index) of 82 items of agriculture imports which are considered non-competiting either in the seasonal sense (e.g. fresh lettuce in January) or in the production sense (e.g. mangoes, coffee) is constructed using share in total import value as weights. In the second step the total import value of these imports was converted into U.S. dollars by dividing with the exchange rate. In the third step this value of non-competiting agriculture imports was divided by the quantity index of non-competiting agriculture goods to define the price index of non-competiting agriculture imports (a composite good) in U.S. dollars (USPASH).

The price index of non-competiting agriculture products in Canadian dollars (CANPASH) is therefore identically equal to USPASH times the exchange rate.

EQ.34: The Retail Index for Food at Home

\[ \text{CPIFQ} = (\text{FAOP} \times 0.3795 + \text{LVPP} \times 5.9249 + \text{FCPI} \times 0.394 + \text{DPRP} \times 3.3328 + \text{ECPI} \times 0.617 + \text{PLCPI} \times 0.9053 + \text{CANPASH} \times 3.9908 + \text{BACP} \times 2.6251)/18.1694 \]
This index brings together all the retail price indices which are treated as endogenous in the model except for the CPI-FISH (FCPI) which is exogenous to the model and has been included only for the sake of completeness.

The retail price index for food at home (EPIFQ) is a weighted average of CPIF - fats and oils, CPIF - meat, CPIF - fish, CPIF - dairy products, CPIF - eggs, CPIF - poultry, CPIF - bakery, and cereal products and the price index of non-competing agriculture imports - weighted by CPI weights.
CHAPTER 5: THE ESTIMATION OF THE MODEL

Section 5.1: Approach

The Canadian agricultural sector model in its entirety can be treated as a simultaneous block and by using two and three stage least squares, limited and full information maximum likelihood methods consistent and efficient estimates can be obtained.

However, with limited sample data and a large number of predetermined variables in the model the application of these methods on a system wide basis has not been feasible. Instrumental variable techniques such as principal components and generalized inverses are available for simultaneous equation estimation but they too have been found to yield inconsistent estimations unless applied very selectively (Ayemiya (1966), Fisher (1969)). Recently, more sophisticated instrument variable methods have been developed to overcome problems associated with the estimation of structural parameters of large scale systems with limited sample data. The principal method involved is iterated instrumental variable (Dutta and Lytkens (1974), Brundy and Jorgenson (1974)) and although this method is being more widely used the full properties of this method are still in the process of development.

Consequently, two principal methods of estimation were used to obtain the structural parameters of the model. In the first step the whole model was estimated using the OLS method. This might be called the "naive" approach. Certain equations were, respecified in the light of the OLS results and the model re-estimated. Primary importance
was attached to obtaining signs on the coefficients which conform to
economic theory and a priori reasoning and also to obtaining significant
coefficients. In cases where autocorrelation was judged to be present
it was carefully noted but correctional methods available in the
literature such as Orcutt and Cochrane and Hildreth-Lu methods were
not used.

The structure of the model, up to this stage was considered
provisional. The model was then dynamically simulated over the period
1968-1 to 1977-4 and simple shocks were experimented on the model.
These simulation experiments carried out on the provisional structure
of the model estimated by OLS provided a "feel" for the simulation
performance of the model. On the basis of the model's tracking ability
as measured by the root mean squares absolute and percentage errors and
turning point errors and the model's conformity, when it is shocked, to
prior expectations engendered by knowledge of the underlying economic
structure of the model, the structure of the model was accordingly
revised. Specifically, certain structural equations were respecified,
some endogenous variables were made exogenous, one identity became a
stochastic equation and one stochastic equation became an identity.
Using the OLS estimation method and information obtained from simulation
experiments the final structure of the model was thus chosen.

In the second step, with the assistance of a TROLL program,
the block structure of the model, which is reproduced as Appendix A, is
analyzed. It is seen that the model which consists of 31 blocks is
block triangular, i.e. the solution of the equations in any block
depends, if at all, on equations in lower level blocks and not on
equations in higher level blocks.
If it can be further assumed that the variance-covariance matrix of disturbances is block diagonal then the estimation of the model will become much simplified as the model can then be classified as block recursive. OLS can under these conditions give consistent and indeed efficient estimates for all the blocks that contain stochastic equations except block 26, which is simultaneous. TSLS will give consistent estimates for the equations in block 26 and a system estimation method such as three stage least squares will give consistent and efficient estimates if the disturbances across these 4 equations are not independent.

Among consistent estimators the Three Stage Least Squares advantage over Two Stage Least Squares is that it can take into account correlation between the disturbance terms across equations and therefore tend to be more efficient. On the other hand the three stage, because it estimates the parameters in the equation system simultaneously requires a large number of observations if the degrees of freedom are not to be exhausted. In practice, especially when the size of the model is large this requirement is difficult to meet.

Cragg (1967) after making an extensive study of the properties of different estimation methods suggest that because consistent estimators do not differ greatly and their relative performances are sensitive to the data and structure, TSLS may be the best estimator to choose since it is the cheapest and the easiest method to compute.

Following this lead, TSLS was applied to those stochastic equations in the model which have endogenous variables as one or the explanatory variables. For those stochastic equations that do not have current endogenous variables as explanatory variables OLS was used. To the
extent that the disturbance terms are correlated across equations this
approach, admittedly, would be less efficient than if a system estimation
method was used. However, in a simulation model this loss in efficiency
was considered a small price to pay for the considerable gain in convenience
and economy of using TLSL.

Of the 31 blocks in the model not all of them contain stochastic
equations as some blocks are identities or definitions. Among blocks that
contain stochastic equations, blocks 1, 4 and 5 were regarded as self-
contained since they do not contain endogenous variables as explanatory
variables and the left hand side variables in these blocks do not appear
as right hand side explanatory variables in a stochastic equation in any
other block. The stochastic equations contained in these three blocks
(equations 1, 7, 8) were therefore estimated using OLS.

Blocks 6 (eq: 9) and 7 (eq: 11) were treated as part of one
system and equation 9 whose explanatory variables are all exogenous was
estimated with OLS while eq: 11 was estimated with TLSL with the following
instruments (lagged endogenous and lagged and current exogenous variables
in blocks 6 and 7): SSFPX(-1), EXCHI(-1), FCPR, FAOP(-1).

Since the errors in the feed demand and grain inventory equations
are expected to be correlated because of the link through the net grain-
exports identity Blocks 8 (eq: 12), 12 (eq: 15), 14 (eq: 23), 15 (eq: 4),
16 (eq: 5) are treated as one system and consequently eqs: 12, 23 were
estimated with OLS while Eqs: 4 and 5 were estimated using TLSL using
the following instruments: CANUSLP, LIVPX(-1), LIVM(-2), LIVM(-3), FCOP(-1),
EXCHI(-1), TIME, TLIVD(-1), DUM 2, DUM 3, DUM 4, GRAPX(-1), TGREX, AGEX,
INVDT(-1).

Blocks 13 (eq: 17), 19 (eq: 29), 25 (eq: 18), 26 (eqs: 19, 20):
21, 22) and 28 (eq: 27) are treated as a system because of the simultaneity between Canadian livestock and meat market equations and also because of the close substitution between the poultry and red meats in the consumer's food budget. Equations 17, 29 were estimated with OLS and equations 19, 21, 27 were estimated using TSLS. The following instruments were used for the TSLS: LIVPX(-2), LIVPX(-1), FEGPX(-2), FEGPX(-1), FCPR(-2), FCPR(-1), DUM 2, DUM 3, DUM 4, LIVM(-1), PCYCOM, BDRE, MTEX, CANUSLP, LDUM, DMTSY(-1), POPC, MTIM(-1), WAGF, PLCPI(-1), POLS, EGGFP(-1), WAGF(-1), CHPUS(-1), EXCHI(-1), PCLVPD(-1).

Blocks 17 (eq: 26) and 18 (eq: 25) are treated as one system because of the presumed close interrelationships between GTRM and the omitted variables from eq: 25. Equation 26 was estimated using OLS while equation 25 was estimated with TSLS using WAGF, DPRP(-1), FEGPX(-1), CPIAQ(-1), GDST(-1), GTRM(-1) as instruments.

Blocks 20 (eq: 30), 21 (eq: 31), 22 (eq: 28) were treated as a system. However, because block 20 depends on blocks 8 and 6, the exogenous variables in these two blocks were used as instrument variables in addition to those in blocks 20, 21 and 22 to estimate equations 28, 30 and 31. Alternatively blocks 6, 7, 8, 14, 15, 16, 20, 21, 22 can be treated as one system and equations 4, 5, 11, 23, 28, 30, and 31 can be estimated with TSLS using the following instruments: TLIVD(-1), DUM 2, DUM 3, DUM 4, GRAPX(-1), TGREX, AGEX, INVDT(-1), SSFPX(-1), EXCHI(-1), FCPR, FAOP(-1), FCOP(-1), TIME, CANUSLP, LIVPX(-1), LIVM(-2), LIVM(-3), WAGF, ECPI(-1), EGST(-1), LMDUM 1. The difference in statistical results between the two alternative approaches proved to be insignificant and for the record the simulation of the model utilized the estimates from the first approach.
Section 5.2: Estimation Results

The OLS and Two Stage Least Squares results are provided below. The original form of the equation is given first and the final form of the equation together with the OLS estimates is given next. The standard errors in round brackets and the t statistics in square brackets are given directly below the corresponding coefficients. The $R^2$, the Durbin-Watson, the F statistic and the estimation range are also presented. The letter O refers to the original statistical specification of the equation and F refers to the form of the equation that is finally selected on the basis of the OLS results. In those cases where the original specification is the final specification neither O nor F is used.

The presentation of Two Stage Least Squares results (TSLS) follows the OLS results. One additional statistic - the h statistic considered more appropriate as a test statistic for serial correlation when a lagged dependent variable is present, is provided where necessary.

Also, in some cases, the OLS final results and the TSLS results are not directly comparable because as much as one would like the TSLS and OLS to have the same estimation range, the variable with the shortest data range among the selected instrument variables determines the maximum range of estimation for the equation estimated with TSLS. This range, of course, does not necessarily coincide with the range used for OLS estimation. Efforts were made whenever possible to make the estimation range coincident between different specifications of the equation but owing to unnsurmountable difficulties they were less than completely successful.

The numbering system of the equations follow that of the complete model which of course includes stochastic as well as non stochastic equations.
To avoid repetitive narration, the TSLS results are discussed only when they differ significantly from OLS results. Otherwise, the results are allowed to speak for themselves.

**GRAIN ACREAGE**

\[
1: \text{GRACQ} = (54.269 + 6.257 \text{ FCGDQ} - .003 \text{ FMIPQ}) \\
(1.24) (1.13) (01) \\
[43.59] [5.51] [- .34] \\
- 12.012 \text{ FCLDQ} - 9.386 (\text{LIFTQ}) \ast \text{ DUM 3} \\
(1.80) (6.61) \\
[15.66] [15.39] \\
R^2 = .99 \\
\text{D.W.} = 2.00 \quad 1967-1 \text{ to } 1976-4
\]

All the coefficients of the explanatory variables have the hypothesized correct signs and are significant except the farm input price index coefficient which has the expected negative sign but is insignificant. The elasticity of aggregate grain acreage with respect to an index of Chicago futures grain prices is .18 which is less than the .32 negative elasticity with respect to an index of Chicago livestock futures prices. Apparently grain acreage responds more to expected livestock prices than to expected grain prices, a result not expected but not altogether surprising given that grain and livestock production are competing activities for a large percentage of Canadian farms especially in the Prairies. The elasticity of grain acreage with respect to farm input price index is - .01 which is considered reasonable. As expected the dummy variable for the lower inventories for tomorrow program is highly significant.

.../114
FEED GRAIN DEMAND

4:  $\text{FEGD} = \text{FEGD.0} + \text{FEGD.1} \times \text{LIVPX} + \text{FEGD.2} \times \text{FEGPX}$

$\text{FEGD.3} \times \text{TLIVD(-1)} + \text{FEGD.4}$

$\text{DUM2} + \text{FEGD.5} \times \text{DUM4} + \text{FEGD.6} \times \text{DUM3}$

$\begin{bmatrix}
4.632 & 0.535 & 0.015 & \text{FEGPX} & (1.93) & (0.45) & (0.04) \\
+0.595 & \text{TLIVD(-1)} & +0.846 & \text{DUM2} & -0.292 & \text{DUM4} & +1.368 & \text{DUM3} \\
(1.17) & (1.18) & (1.18) & (2.21) \\
\end{bmatrix}$

$R^2 = 0.90$

D.W. = 1.89  
1967-3 to 1976-4

4(TSLS): $\text{FEGD} = -1.018 + 0.114 \times \text{TLIVPX} - 0.14 \times \text{FEGPX} + 0.548 \times \text{TLIVD(-1)}$

$\begin{bmatrix}
1.87 & 0.44 & 0.004 & 0.16 \\
-0.824 & \text{DUM2} & -0.271 & \text{DUM4} + 1.488 & \text{DUM3} \\
(1.17) & (1.17) & (2.0) \\
[-4.75] & [-1.6] & [7.31] \\
\end{bmatrix}$

$R^2 = 0.91$

D.W. = 2.06  
1967-4 to 1976-4

The signs on the estimated coefficients conform to prior expectations. The equation is explained well by the selected variables as indicated by a 0.91 $R^2$. The Durbin-Watson (D.W.) value of 2.06 permits the acceptance of the null hypothesis of no serial correlation.
The coefficient on the livestock price index is insignificant but the elasticity of .22 can be compared with the .4 elasticity of corn demand with respect to hog price that Reimer and Kulshreshtha (1974) obtained. The demand for feed grains by the livestock sector is explained partly by the livestock price which is designed mainly to capture the short run impact on feeding rates and partly by livestock numbers which is intended to account for the longer run impact on feed demand. It may be that the livestock numbers variable possibly is doing most of the work of explaining feed demand which will explain why the coefficient on the livestock price variable is insignificant. The signs and significance of the coefficients on the seasonal dummies confirm the view that feed grain demand has a distinct seasonal pattern. The coefficient on feed grain price is significant with an elasticity of -.38. This compares with the -.13 elasticity of Kulshreshtha and Holub (1973) for the Canadian feed demand and the -.62 elasticity of U.S. feed grain demand with respect to the U.S. price of corn obtained for the grain component of the Agriculture Canada's FARM model. The feed demand elasticity with respect to the opening livestock inventories is 2.6. The flow demand for feed grain is very responsive to changing stock levels of livestock animals and this is probably due to the fact that the major input other than feed to livestock production is land, a relatively fixed input.

When the equation is estimated with TSLS, the size of the coefficient on LIVPX was reduced by about 5 per cent while the coefficients on TLIVD(-1) and FEGPX remained virtually unchanged.
GRAIN INVENTORY DEMAND

5(0): \( INVDT = INVDT.0 + INVDT.1 \cdot (FCPG - GRAPX) + INVDT.2 \cdot AGEX + INVDT.3 \cdot DUM1 + INVDT.4 \cdot DUM2 + INVDT.5 \cdot DUM3 + INVDT.6 \cdot LIVPX + INVDT.7 \cdot BCOP + INVDT \cdot INVDT(-1) \)

\[
\begin{align*}
\beta_{0} & = 4.318 \quad (6.74) \\
\beta_{1} & = .912 \quad (1.02) \\
\beta_{2} & = 1.312 \quad (.63) \\
\beta_{3} & = -1.750 \quad [.64] \\
\beta_{4} & = 3.551 \quad [.89] \\
\beta_{5} & = -2.03 \quad [-2.09] \\
\beta_{6} & = 5.045 \quad (1.51) \\
\beta_{7} & = .873 \quad (2.62) \\
\beta_{8} & = -1.750 \quad (-1.16) \\
\beta_{9} & = 3.551 \quad [1.15] \\
\beta_{10} & = -2.03 \quad [8.56] \\
R^2 & = .97 \\
h & = .54 < 1.64 \\
D.W. & = 1.86 \quad 1967-4 \text{ to } 1976-4
\end{align*}
\]

5(TLS): \( INVDT = 4.106 + .883 \cdot GRAPX(-1) - 1.311 \cdot (TGREX-AGEX) - 1.730 \cdot DUM1 - 3.522 \cdot DUM2 + 30.408 \cdot DUM3 - 4.922 \cdot LIVPX + .875 \cdot INVDT(-1) \)

\[
\begin{align*}
\beta_{0} & = 4.106 \quad (6.80) \\
\beta_{1} & = .883 \quad (1.03) \\
\beta_{2} & = -1.311 \quad (.63) \\
\beta_{3} & = 1.730 \quad [-1.15] \\
\beta_{4} & = 3.522 \quad [1.75] \\
\beta_{5} & = 30.408 \quad (2.63) \\
\beta_{6} & = -4.922 \quad (2.21) \\
\beta_{7} & = .875 \quad (-2.01) \\
\beta_{8} & = 4.922 \quad [11.57] \\
\beta_{9} & = .875 \quad [-2.23] \\
\beta_{10} & = INVDT(-1) \quad (1.10) \\
R^2 & = .97 \\
D.W. & = 1.86 \quad 1967-4 \text{ to } 1976-4
\end{align*}
\]
\[ R^2 = 0.97 \]

D.W. = 1.86 1967-4 to 1976-4

This equation was, without doubt, the most difficult equation to estimate. The estimation of the originally specified equation was unsatisfactory. Except for the livestock price variable coefficient no other coefficients of the economic explanatory variables was significant. Moreover, the coefficient of the variable representing transaction demand (AGEX) had the wrong sign. Substantial experimentation using different lags and using different explanatory variables was carried out with mixed results. The equation that was finally chosen is not perfect but comes closest to the original conception of the equation.

Comparing this equation to the original equation the following differences are noted: the expected change in grain prices has been replaced by the grain price lagged one quarter (GRAPX(-1)), the 4 quarter moving average of grain exports has been replaced by a new variable (TGEX-AGEX) which is current grain exports minus average grain exports and the bumper crop variable, which rarely was significant during the course of the experimentation, has been dropped. The lagged grain price is a proxy for expected grain price which is presumed to be generated by the simple extrapolative process.

Throughout the experimental phase it was impossible to obtain the correct signs for various variables that were used to represent export demand and feed grain demand, i.e. transactions demand. Quarter specific averages (averages of quarter i where i = 1 to 4), moving averages, simple averages of grain exports were used to represent normal transactions demand in the grain inventory equation but invariably
the sign on the coefficient was negative which was contrary to what was expected. Different lags on levels of grain exports too were tried but they failed to yield a positive sign. The relationship between grain inventories and the transaction demand variable was overwhelmingly negative and this was so because production was added to inventories once a year whereas various demands for grain which were met out of grain inventories was continuous throughout the year. To overcome this problem it was hypothesized that since actual inventories include both intended and unintended inventories it is the intended portion of total inventories that would be expected to have a positive relationship with the transactions variable. If a moving average of exports represents the level of normal transactions and to the extent that actual exports exceed it this unexpected element in exports would reduce inventories.

In short a negative relationship would be expected between grain inventories and the variable defined as total exports minus moving average of exports (TGREX - AGEX).

In summary, the rationale underlying the grain inventory equation that was used as the final equation for simulation is that grain inventory demand has a speculative element that responds positively to expected prices, a transactive element that responds positively to a moving average of exports, a buffer stock element that absorbs supply and demand shocks, an investment element that responds negatively to the alternative return from investing in livestock and finally seasonal elements. The explanatory power of the equation is very good with $R^2 = .97$. Without exception all the coefficients have signs which are consistent with this reasoning. The elasticity of inventory demand with respect to the expected grain price, the above average exports...
and the livestock price are, respectively, .04, -.01, -.18 respectively which can be regarded as within the bounds of reason.

However, the lagged grain price variable - GRAPX(-1), which was used as a proxy for expected prices was insignificant and so was the first quarter seasonal dummy. All other variables are significant at the 1 percent level. The lack of significance of GRAPX(-1) was disappointing but the presence of the livestock price variable LIVPX, with which it should be strongly correlated may have taken away some of its explanatory power. The high standard errors associated with GRAPX(-1) and the low elasticity of INVDT with respect to GRAPX(-1) = .035 calls for caution in using this equation. The h statistic is presented in addition to the Durbin-Watson statistic as the presence of the lagged dependent variable makes the latter an unreliable statistic to test for serial correlation (Johnston 1972). The .54 value of the h statistic which is less than 1.64 permits the acceptance of the hypothesis of no serial correlation. Evidently, the TSLS results are almost identical to OLS.

**RETAIL PRICE OF BAKERY AND CEREALS**

7(0): \[ BACP = BACP.0 + BACP.1 \times DOMP + BACP.2 \times FCPR + BACP.3 \times WAGF + BACP.4 \times BACP(-1) \]

7(F): \[ BACP = .885 + .094 \times DOMP + .473 \times FCPR \]

\[ (4.00) \quad (.03) \quad (.24) \]

\[ [.22] \quad [3.04] \quad [1.99] \]

\[ -.029 \times BACS + .941 \times BACP(-1) \]

\[ (.02) \quad (.02) \]

\[ [-1.58] \quad [40.81] \]
The explanatory power of the original equation is very good. But the coefficient of the wage rate variable is negative and insignificant and the interest rate variable is positive but insignificant.

After experimenting with several variants of this equation it was decided to leave the wage rate variable out of the equation. Further, it became necessary to introduce an additional explanatory variable, bakery and cereal stocks. The rationale is that if opening stocks of bakery and cereal products held by retailers are high this might act as a restraint on the mark up. The expected sign on the coefficient of the selected equation is very good, the coefficients on all variables have correct signs and with the exception of the bakery and cereal stocks variable, significant at the 1 percent level. However, the h statistic indicates the presence of serial correlation which taken together with the presence of a lagged dependent variable leads to biased and inconsistent estimates as the error term is no longer independent from the explanatory variable (in this case, the lagged dependent variable).

\[
8(0): \text{FGRPX} = \text{FGRPX.0} + \text{FGRPX.1} \times \text{SWFPX}(-1) \\
+ \text{FGRPX.2} \times \text{EXCHI}(-1)
\]

\[
8(F): \text{FGRPX} = -260.048 + 1.084 \text{ SWFPX}(-1)
\]

\[
(105.39) (0.07)
\]

\[
[-2.47][16.32]
\]

\[
+ 240.844 \text{ EXCHI}(-1) + 0.744 \text{ TIME}
\]
(95.11)  (.36)
[2.53]  [2.04]
R² = .94
D.W. = 1.64  1966-2 to 1976-4

It would be noticed that the equation determining food grain
prices was not estimated in the multiplicative form FGRPX = \delta f(SWFPX \times EXCHI)
+ e₁ as suggested by the theoretical specification. This is because of
the desire to let the data determine the coefficients on each of the two
variables within the brackets rather than impose the assumption of uniform
coefficients which the above specification would imply. Also, because
the selling price of grain is recorded as unit value data from customs
documents only some months later all the explanatory variables are lagged
by one quarter.

Since the period over which the equation was estimated covers
both the fixed and flexible exchange rate regimes for the Canadian dollar
it is expected that the relationship between FGRPX, SWFPX and EXCHI could
be changing over time. For this reason, the food grain price was there-
fore first estimated without the time variable and then with the time variable.

In the equation without the time variable, the R² was .94 and
the D.W. statistic does not indicate the presence of serial correlation.
The world grain price and the exchange rate variables are correctly signed
and the former is significant but the latter is not.

The inclusion of the time variable increases the value of R² and
improves the D.W. Statistic. Without exception the three explanatory
variables are significant and the signs consistent with prior expectations.
The elasticity of food grain prices with respect to world wheat prices and the exchange rate is calculated at .92 and 2.39 respectively. The high elasticities on the exchange rate is probably due to changes in exchange rates generating expectations of further exchange rate changes in the same direction - which are then incorporated into domestic grain prices. The same supposition is much less applicable to world grain prices because they are measured by futures grain prices so "expectations" are already embodied in them.

**FARM PRICE OF OILSEEDS**

\[ g(0): \text{OILPX} = \text{OILPX}.0 + \text{OILPX}.1 \times \text{SSFPX}(-1) + \text{OILPX}.2 \times \text{EXCHI}(-1) \]

\[ g(F): \text{OILPX} = 11.946 + .921 (\text{SSFPX}(-1)) \times \text{EXCHI}(-1) \]

(6.89) (.04)

[1.79][21.75]

\[ R^2 = .92 \]

D.W. = 1.97 1966-1 to 1976-4

The domestic oilseed price equation was estimated like the domestic food grain price equation with and without the time variable. In both cases, the coefficient on the exchange rate variable turned negative, and this of course was contrary to prior expectations.

Consequently, the equation was estimated in its theoretical form which imposes the same coefficients on the two variables - the world soybean price and the exchange rate. The equation performs very well with a high value of \( R^2 \) and the D.W. statistic close to the value of 2. The
elasticity of domestic oilseed price with respect to the world oilseed price in Canadian dollars is .92.

The choice of the above specification for the oilseed equation introduces an inconsistency between it and the two other farm level price equations in the grains and oilseeds sector namely FGRPX and FEGPX. The choice actually boils down to estimating all the three price equations in the form that the theory suggests (the form chosen for OILPX) which as already mentioned imposes a restriction that the farm price reacts in like manner to the Chicago futures price as it does to the exchange rate or to accept the inconsistency in specification and remove the restriction in two equations one of which happens to be the important feed grain price (FEGPX) equation. Consequently, it was decided to accept the inconsistency.

RETAIL PRICE OF FATS AND OILS

11(o): \( FAOP = FAOP + FAOP.1 \times OILPX + FAOP.2 \times WAGF + FAOP.3 \times FCPR + FAOP.4 \times FAOP(-1) \)

\[
\begin{align*}
11(f): FAOP &= -3.468 + 1.285 \times FCPR + .074 \times OILPX + .868 \times FAOP(-1) \\
(3.13) &\quad (.48) &\quad (.02) &\quad (.03) \\
\end{align*}
\]

\[ R^2 = .98 \quad h = 2.88 > 1.64 \]

D.W. = 1.15 1966-1 to 1976-4
11(TSL3): FAOP. = -3.024 + 1.156 FCPR + .087 OILPX
(3.16) (.49) (.02)
[-.96] [2.38] [4.19]
+ .854 FAOP(-1)
(.03)
[25.92]

$R^2 = .98 \quad F(3/40) = 722.449$

D.W. = 1.19 1966-1 to 1976-4

The explanatory power of the equation is very good judged by the $R^2$ value of .98. However, the coefficient of the wage rate variable was insignificant and negative which was contrary to what was expected. Several alternative specifications were tried but the negative sign of the coefficient of the wage variable continued to plague the equation. Consequently, the wage variable was dropped from the equation. The resulting equation is explained well by the selected explanatory variables. The Durbin-Watson statistic is low but since there is a lagged dependent variable present the h statistic is calculated and it indicates the presence of serial correlation. The presence of a lagged dependent variable when serial correlation is present invalidates the notion that lagged endogenous variables are predetermined.

These problems are therefore noted as the interpretation of the results proceed. The regression coefficients, without exception, are significant and the signs conform to prior expectations. The elasticity of the retail price index of fats and oils with respect to the interest rate and the oilseed price index is, respectively, .08 and .09.
There is nothing remarkable about the TSLS results which are almost identical to OLS results.

**FARM PRICE OF FEED GRAINS**

12(0): \( FEGPX = FEGPX.0 + FEGPX.1 \times FCOP(-1) + FEGPX.2 \times EXCHI(-1) \)

\[
\begin{align*}
12(F): FEGPX &= -150.194 + 0.854 \times FCOP(-1) + 142.605 \times EXCHI(-1) \\
&\quad (54.44) (0.06) (49.01) \\
&\quad [-2.75][14.76] [2.91] \\
&\quad + 0.807 \times TIME \\
&\quad (0.23) \\
&\quad [3.56] \\
R^2 &= .96 \\
D.W. &= 2.26 \\
&1967-1 to 1976-4
\end{align*}
\]

The feed grain price was estimated in the same form as the food grain price equation and it is rationalized in exactly the same manner. The equation without the time variable is flawed only because the coefficient of the exchange rate variable is insignificant.

With the addition of the time variable all the three regression coefficients are significant and have positive signs as expected. The \( R^2 \) value is .96 and the D.W. value of 2.26 does not indicate the presence of serial correlation.

As in the case of food grains, the elasticity of the domestic feed grain price with respect to the world corn price (.76) is less than the elasticity with respect to the exchange rate.
IMPORTS OF LIVESTOCK AND MEAT

17(0): \[ MTIM = MTIM.0 + MTIM.1 \times \text{CANUSLP} + MTIM.2 \times LDUM \]

\[ + MTIM.3 \times \text{LIVM}(-1) + MTIM.4 \times (\text{PCYCOM} \times \text{POPC/1000}) \]

\[ + MTIM.5 \times MTIM(-1) \]

\[
\begin{array}{ccc}
(50.75) & (19.30) & (11.76) \\
[1.61] & [-2.34] & [2.52] \\
-0.096 \text{ DMTSY}(-1) + .005 (\text{PCYCOM} \times \text{POPC/1000}) \\
(.07) & (.0009) \\
[-1.33] & [5.12] \\
+ .465 MTIM(-1) \\
[1.15] \\
[3.14] \\
\end{array}
\]

\[ R^2 = .84 \quad h = 4.91 > 1.64 \]

D.W. = 1.73 \quad 1966-2 to 1976-4

The explanatory power of this equation is good: All the coefficients have signs consistent with prior expectations. The Nixon price freeze dummy coefficient is significant, the price variable coefficient is negative and significant but the coefficient of the lagged livestock inventories representing supply-capacity although having the expected sign was insignificant.

On the grounds that DMTSY (net supply) which is calculated as net available supply perhaps measure the tightness in the market better, LIVM(-1) was replaced by DMTSY. This led to an insignificant and positive sign on DMTSY. Consequently, assuming that excess supply
is perhaps not reflected in imports during the same quarter DMTSY was
lagged one quarter and this resulted in a correct negative sign, although
the variable remained insignificant at the 5 percent level. The explana-
tory power of this equation is good judged by the $R^2$ value of .84. All
the signs on the coefficients are consistent with prior expectations and
except for the supply variable the remaining explanatory variables are
highly significant. Consequently, this was chosen as the final equation.
It is perhaps worth noting that the equation was also estimated after adding
LIVPX as an additional explanatory variable and deflating all the three nominal
variables - CANUSLP, PCYCOM and LIVPX with CPIAQ. The coefficient on the deflated
CANUSLP was insignificant and the coefficient on the deflated LIVPX variable
was, contrary to expectations, negative.

**INVENTORY DEMAND FOR LIVESTOCK**

19(O): $LIVM = LIVM.0 + LIVM.1 \times LIVPX(-2) + LIVM.2 \times FEGPX(-2)$

$+ LIVM.3 \times FCPR(-2) + LIVM.4 \times LIVM(-1) + LIVM.5 \times DUM2$

$+ LIVM.6 \times DUM3 + LIVM.7 \times DUM4 + LIVM.8$

$\times (LIVPX(-2) - LIVM(3)) + LIVM.9 \times (FEGPX(-2) - FEGPX(-3))$

$+ LIVM.10 \times (FCPR(-2) - FCPR(-3)) + LIVM.11 \times LVPP$

19(F): $LIVM = 666.965 + 1383.950 LIVPX(-2) - 3.819 FEGPX(-2)$

<table>
<thead>
<tr>
<th>Coefficient</th>
<th>Standard Error</th>
<th>t-Statistic</th>
<th>p-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>190.99</td>
<td>382.86</td>
<td>1.65</td>
<td>[3.49]</td>
</tr>
<tr>
<td>-24.77</td>
<td>10.86</td>
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<td>[-.67]</td>
</tr>
<tr>
<td>(13.08)</td>
<td>(.07)</td>
<td>(49.29)</td>
<td>(.54.46)</td>
</tr>
<tr>
<td>[-1.87]</td>
<td></td>
<td>[-.34]</td>
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<tr>
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<td></td>
<td>[-5.69]</td>
</tr>
<tr>
<td>745.613</td>
<td></td>
<td></td>
<td>[2.20]</td>
</tr>
</tbody>
</table>
\[
\begin{align*}
&= 128 \\
&= 3.086 (FEGPX(-1) - FEGPX(-2)) - 41.978 (FCPR(-1) - FCPR(-3.08)) \\
&\quad - 8.808 [LNP(1.000)] \\
&\quad - 1.82 \\
&= 8.808 [LVPP] \\
&\quad (4.45) \\
&\quad [-1.98] \\
R^2 = .98 &\quad h = -.73 < 1.64 \\
D.W. = 2.21 &\quad 1967-2 to 1976-4 \\
\end{align*}
\]

\[19(TSLS):LIVM = 875.006 + 1546.520 LIVPX(-2) - 3.014 FEGPX(-2)\]

\[
\begin{align*}
&\quad (235.67) \quad (403.17) \quad (1.78) \\
&\quad [3.71] \quad [3.83] \quad [-1.69] \\
&= 29.370 FCPR(-2) + .794 LIVM(-1) - 15.346 DUM2 \\
&\quad (13.9) \quad (0.08) \quad (51.58) \\
&\quad [-2.11] \quad [9.91] \quad [-0.30] \\
&= 35.248 DUM3 - 317.231 DUM4 + 891.652 (LIVPX(-1) - LIVPX(-59.84)) \\
&\quad (58.71) \quad (362.42) \\
&\quad [-0.59] \quad [5.40] \quad [2.46] \\
&= 3.241 (FEGPX(-1) - FEGPX(-2)) - 37.764 (FCPR(-1) - FCPR(-3.21)) \\
&\quad (24.54) \\
&\quad [-1.01] \quad [-1.54] \\
&= 11.451 LVPP \\
&\quad (4.87) \\
&\quad [-2.35] \\
\]

\[
\begin{align*}
R^2 = .97 \\
D.W. = 2.36 &\quad 1968-2 to 1976-4 \\
\end{align*}
\]
The explanatory power of the original specification of the equation was very good \((R^2 = .97)\). The coefficients of the lagged prices of livestock and feed grains had the expected signs and were also significant at the 1 percent level. The coefficients of the lagged interest rates and the retail price of meat variables although having the correct signs were not significant. On the other hand, the lagged changes in livestock and feed grain price coefficients had not only incorrect signs but were insignificant. The lagged change in interest rates and the retail price of meat coefficients were correctly signed but insignificant.

Consequently, the equation was respecified with last quarter's changes in the prices of livestock and feed grains and in interest rates instead of changes that took place two quarters ago as was the case in the original equation. Expectations it is now hypothesized are formed in the following manner: livestock feed grain prices and interest rates that prevailed two quarters ago are expected to continue to prevail until and unless these prices and interest changes changed in the last quarter. When this happens the original expected level of prices and interest rates will be adjusted in the same direction and by some proportion of the change in prices and interest rates.

In spite of the large number of explanatory variables in this crucial equation all coefficients except those of two seasonable dummies and the change in feed grain prices were significant at least at the 5 percent level and the \(R^2\) value of \(.98\) was very high (the corrected \(R^2\) was \(.97\)). The \(h\) statistic did not indicate the presence of serial correlation.
The TSLS estimates of this equation, are substantially different from the OLS estimates. Subject to the qualification that TSLS had 4 less observations than OLS, the TSLS resulted in increasing the absolute size of the coefficients of the following variables which have positive signs: LIVPX(-2), LIVPX(-1) - LIVPX(-2), and decreased the absolute size of the coefficients of the following variables which have negative signs: FEGPX(-2), FCPR(-1) - FCPR(-2). Upward movements in these variables will therefore lead to higher livestock inventories when TSLS is used.

On the other hand, the absolute size of the negative coefficients on the variables FCPR(-2), FEGPX(-1) - FEGPX(-2), LVPP increased which would lead to greater reduction in livestock inventories when these variables increased.

The reduction in the absolute size of the coefficient in the lagged dependent variable with TSLS will help quicken the process of adjustment of livestock inventories to changes in the dependent variables.

With TSLS, the ratio of the coefficient to the standard error which measures the statistical significance of the coefficients of the respective variables is increased in the following variables: LIVPX(-2), FCPR(-2), LIVPX(-1) - LIVPX(-2), FEGPX(-1) - FEGPX(-2) and LVPP while decreasing the ratios of the variables FEGPX(-2), FCPR(-1) - FCPR(-2). Furthermore, the variable FEGPX(-2) which was significant at the 1 percent level with OLS is now significant only at the 5 percent level with TSLS and it is the reverse for FCPR(-2). The more important change however, is the variable FCPR(-1) - FCPR(-2) which was significant at the 5 percent level with OLS but with TSLS it is no longer significant at that level (t statistic - 1.54).
The elasticities of livestock inventories with respect to livestock prices, feed grain prices and interest rates - lagged two quarters, is respectively .45, -.05, .05. The elasticity with respect to the retail meat price is -.31. The elasticity with respect to changes in livestock lagged livestock prices, lagged feed grain prices and lagged interest rates is, respectively .003, -.001, -.0007.

PER CAPITA RETAIL DEMAND FOR MEAT

21(0): PCLVPD = PCLVPD.0 + PCLVPD.1 * LVPP
+ PCLVPD.2 * PCYCOM + PCLVPD.3 * PLCPI
+ PCLVPD.4 * PCLVPD(-1)

21(F): PCLVPD = 17.901 - .056 LVPP + .008 PCYCOM
(4.48) (.02) (.002)
[3.99][-2.53][3.69]
+ .540 PCLVPD(-1)
(1.21)
[4.45]

\[ R^2 = .76 \quad h = -1.23 < 1.64 \]
D.W. = 2.22 1966-1 to 1976-4

21(TLS): PCLVPD = .25.265 - .064 LVPP + .008 PCYCOM
(6.24) (.02) (.002)
[4.05][-2.69][3.63]
+.371 PCLVPD(-1)
(.16)
[2.37]

\[ R^2 = .64 \]
D.W. = 2.10 1968-2 to 1976-4
The explanatory power of the equation is acceptable. The income coefficient is significant and the sign is positive but the coefficients on the meat price (LVPP - direct price) and the retail price of poultry (PLCPI - substitute price) are insignificant and the coefficient of the latter variable has a negative sign contrary to a priori expectations. The equation was also estimated using relative prices: the right hand side nominal variables were deflated by CPI - all items but there was no improvement in the result.

The source of the problem in the originally specified equation is multicollinearity between LVPP and PLCPI since poultry is a close substitute for red meats. Consequently, PLCPI was dropped from the equation. The selected equation has a negative sign on the own price variable, a positive sign on the income variable and a positive on the lagged dependent variable and all three coefficients are significant at the 5 percent level. The h statistic does not indicate the presence of serial correlation. The own price elasticity of meat demand is -.16 and the income elasticity is .15. These elasticities can be put into perspective by comparing them with those of previous studies summarized in Table 5.1. It should be noted that the lower elasticities of this study are to be expected as they relate to the aggregate commodity meat (beef and pork) which therefore assumes perfect substitutibility between beef and pork.

The TSLS results led to a larger negative coefficient on LVPP and a much lower coefficient on the lagged dependent variable and the $R^2$ fell from .76 to .64. The own price elasticity and income elasticity of meat demand is calculated to be .2 and .19 respectively which is slightly higher than the elasticities obtained from OLS.
FARM PRICE OF LIVESTOCK

23(0): LIVPX = LIVPX.0 + LIVPX.1 * CANUSLP
           + LIVPX.2 * LIVPX(-1) + LIVPX.3 * LIVM(-1) - LIVM(-2)
           (.04) (.06)           (.05)
           [ -2.90] [ 10.65]      [ 9.76]
           .00008 (LIVM(-2) - LIVM(-3))
           (.00005)
           [ 1.61]

R² = .97  \ h = 1.34 < 1.64.
D.W. = 1.62  1966-1 to 1976-4

The explanatory power of the equation is very good and the signs on the coefficients conform to prior expectations. Except for the excess demand coefficient, the remaining coefficients are highly significant.

This equation was therefore re-estimated after lagging the excess demand variable by one quarter on the assumption that domestic excess demand does not impact on Canadian prices immediately. This resulted in a small improvement in the R² and a substantial increase in the t statistic on the coefficient of the excess demand variable which is now almost significant at the 5 percent level. The calculated h statistic does not indicate the presence of serial correlation. On this basis, the re-estimated equation was chosen as the preferred equation.

The elasticity of the Canadian livestock price index with respect to the U.S. livestock price index and the excess demand variable
was calculated as .6 and .0025 respectively. The view that U.S.
livestock prices have a large and direct influence on Canadian livestock
prices seems to be strongly supported by the data.

**RETAIL PRICE OF DAIRY PRODUCTS**

\[
25(0): \quad \text{DPRP} = \text{DPRP.0} + \text{DPRP.1} \times \text{GTRM} + \text{DPRP.2} \times \text{WAGF} \\
+ \text{DPRP.3} + \text{FCPR} + \text{DPRP.4} \times \text{DPRP(-1)} \\
\]

\[
\begin{align*}
(2.65) & \quad (.67) & \quad (0.4) \\
[5.54] & \quad [7.05] & \quad [.77] \\
+ & \quad .572 \text{ DPRP(-1)} \\
(.06) & \quad [8.71]
\end{align*}
\]

\[R^2 = .99, \quad h = 2.28, > 1.64\]

\[D.W. = 1.29 \quad \text{1968-2 to 1976-4}\]

\[
25(\text{TSLS}): \quad \text{DPRP} = 13.113 + 4.301 \times \text{GTRM} + .044 \times \text{WAGF} + .594 \times \text{DPRP(-1)} \\
\]

\[
\begin{align*}
(2.82) & \quad (.74) & \quad (0.04) & \quad (0.07) \\
[4.64] & \quad [5.78] & \quad [1.18] & \quad [0.62]
\end{align*}
\]

\[R^2 = .99\]

\[D.W. = 1.29 \quad \text{1968-1 to 1976-4}\]

The explanatory power of the equation is very good, but
the wage and interest rate coefficients are insignificant and the signs
are negative which is contrary to apriori expectations.
Several variants of this equation was estimated but the interest rate variable invariably had negative coefficients. Consequently, the interest rate variable was dropped from the equations. The wage rate variable in the final equation is still insignificant but it now has a positive sign. The h statistic indicates the presence of serial correlation. The elasticity of the retail price index of dairy products with respect to the gross target returns is .28 and with respect to the wage rate is .04 which is considered acceptable.

The TSLS with one extra observation resulted in a small decrease in the size of the coefficient on GTRM and the lagged dependent variable and a large increase in the coefficients on WAGF. The $R^2$ and the D.W. however remained unchanged.

REGULATED FARM PRICE OF MILK: GROSS TARGET RETURNS FOR MILK

26(0): $\text{GTRM} = \text{GTRM.0} + \text{GTRM.1} \cdot \text{FEGPX(-1)}$

$\quad + \text{GTRM.2} \cdot \text{CPIAQ(-1)} + \text{GTRM.3} \cdot \text{GDST(-1)}$

$(.66) \quad (.004) \quad \quad (.01)$

$[-1.62] \quad [2.79] \quad [1.61]$

$.001\ \text{GDST(-1)} + .773\ \text{GTRM(-1)}$

$(.0006) \quad \quad (.11)$

$[-2.17] \quad [6.20]$

$R^2 = .99 \quad h = -.08 < 1.64$

D.W. = 2.02 \ 1968-1 to 1976-4
When the equation was estimated as originally specified the explanatory power of the equation was very good ($R^2 = .98$) but the Durbin-Watson statistic was low (1.05). More seriously, the government dairy stock variable (GDSI(-1)) had a positive coefficient which was contrary to prior expectations.

It will be recalled that in Chapter 3 it was mentioned that the target returns formula was not applied automatically but judgemental factors which has a 20 percent can postpone or forestall the change indicated by the formula. A partial adjustment formulation therefore seems appropriate. On these grounds, a lagged dependent variable was introduced and the equation is re-estimated.

The new equation, judged by accepted statistical standards is very good. The explanatory power of the equation is very high, all the coefficients on the explanatory variables are significant at least at the 5 percent level with the exception of CPIAQ(-1) and the signs on these coefficients conform to prior expectations. The $h$ statistic does not indicate the presence of serial correlation. The elasticity of gross target returns for milk with respect to the feed grain price, CPIAQ, and government dairy stocks - all lagged one quarter is respectively, .14, .32 and -.03.

**RETAIL PRICE OF POULTRY**

27(O): \[\text{PLCPI} = \text{PLCPI}_0 + \text{PLCPI}_1 \times \text{POFP} + \text{PLCPI}_2 \times \text{WAGF} \]
\[\text{PLCPI}_3 \times \text{FCPR} + \text{PLCPI}_4 \times \text{PLCPI}(-1)\]

(4.63) (8.26) (.05) (.11)

\([-4.09] \ [3.80] \ [1.39] \ [3.31]\)
\[ + 0.439 \text{PLCPI}(-1) - 0.028 \text{POLS} \]
\[ (0.08) \quad (0.04) \]
\[ [5.62] \quad [-72] \]

\[ R^2 = 0.99 \quad h = 1.57 < 1.64 \]

D.W. = 1.54 \quad 1968-1 to 1976-4

27(TSLS): PLCPI = -21.696 + 29.804 POPFP + 0.081 WAGE
\[ (4.86) \quad (8.37) \quad (0.05) \]
\[ [-4.46] \quad [3.56] \quad [1.63] \]
\[ + 0.424 \text{LVPP} + 0.416 \text{PLCPI}(-1) - 0.025 \text{POLS} \]
\[ (0.12) \quad (0.08) \quad (0.04) \]
\[ [3.62] \quad [5.34] \quad [-65] \]

\[ R^2 = 0.99 \]

D.W. = 1.63 \quad 1968-2 to 1976-4

The explanatory power of the equation is very good. However, the wage rate, and the interest rate coefficients in this equation were insignificant.

The interest rate variable was consequently dropped from the equation. Two new variables were introduced into the equation namely: opening stocks of poultry meat and the meat price index (which does not include poultry price). The rationalization is that when retailers opening stocks (POLS) are high this acts as a restraint on the mark-up and when the price of a substitute food (LVPP) in this case red meat is high, there is room for imposing a higher mark-up. The coefficient on POLS is therefore expected to be negative and the coefficient on the variable LVPP is expected to be positive.

The explanatory power of the equation that was finally chosen is very good. All the explanatory variables have signs which are consistent
with prior expectations. However, the wage rate coefficient remains insignificant and the poultry stock coefficient is also insignificant. The $h$ statistic does not indicate the presence of serial correlation. Although there is very little to choose between the two forms of specification on statistical grounds the respecified equation was selected because it provides a linkage with the livestock sector through the variable LVPP which the original equation does not. From the simulation aspect this equation was considered more interesting.

The elasticity of retail price index of poultry with respect to the farm price of poultry, the wage rate, the retail price of meat, and retailers poultry stocks are, respectively, .03, .08, .34, -.01. The cross price elasticity of retail price of poultry with respect to the retail meat prices (pork, beef, and veal) can perhaps be put into perspective by comparing it with the cross price elasticity of retail price of broiler chickens with respect to pork (.09) that Holliday (1976) obtained and the .18 cross price elasticity between chicken and beef that Hassan and Johnson (1976) obtained with an annual model.

TSLS led to some changes in the size of the coefficients with marked changes observed on the coefficients on WAGF and LVPP.

RETAIL PRICE OF EGGS

28: \[ ECPI = 27.678 + 1.409 \text{REGGP} + .078 \text{WAGF} + .439 \text{FCPR} + .225 ECPI(-1) \]

\[ (2.54) \ (0.07) \ \ (.03) \ \ (.54) \ \ (.05) \]

\[ R^2 = .99 \quad h = 1.26 \times 1.64 \]

D.W. = 1.60 \hspace{1cm} 1968-1 to 1976-4

28(TSLS): ECPI = 27.819 + 1.423 REGGP + .083 WAGF

(2.86) (12.52) (3.06)

[9.73] [12.52] [3.06]

+ .546 FCPR + .208 ECPI(-1)

(.52) (.05)

[1.05] [3.88]

R^2 = .99

D.W. = 1.63 \hspace{1cm} 1967-2 to 1976-4

The explanatory power of the equation is very good. All the coefficients except the interest rate variable is significant. The signs on the coefficients conform to prior expectations. The elasticity of retail price index of eggs with respect to interest rate is .02, which is considered not unreasonable, and therefore this variable has been retained in the regression equation. The h statistic does not indicate the presence of serial correlation. The elasticity of the egg retail price index with respect to the regulated farm price of egg and the wage rate is .47 and .08 respectively.

The TSLS led to some changes in the size of the coefficients particularly the coefficients on WAGF and FCPR.

**Regulated Farm Price of Poultry**

29(0): POFP = POFP.0 + POFP.1 * EGGFP(-1) + POFP.2 * CPIAQ(-1)

+ POFP.3 * POLS + POFP.4 [CHPUS(-1) * EXCHI(-1)]
29(F): POFP = -0.057 + .005 EGGFP(-1) + .002 WAGF(-1)
   (.09) (.001) (.0008)
   [-.64] [5.44] [2.16]
+ .065 DUM 1 + .044 DUM 2 + .098 DUM 3
   (.04) (.04) (.04)
   [1.45] [1.03] [2.29]
+ .010 (CHPUS(-1) * EXCHI(-1))
   (.004)
   [2.40]

R^2 = .95

D.W. = .90 1968-1 to 1976-4

The explanatory power of this equation is very good as indicated by an R^2 value of .94. However, the coefficients on the imputed returns variable [(CPIAQ(-1)] and the U.S. broiler chicken price variable are insignificant and the Durbin-Watson statistic indicates serial correlation.

To improve the equation, the imputed returns on labour and capital variable was replaced with the wage rate (WAGF) and the interest rate variable. Although the explanatory power of this new equation remains very good, the coefficients on the wage rate and the U.S. chicken price remain insignificant and moreover the coefficient on the interest rate variable had the incorrect negative sign.

Consequently, the interest rate variable was dropped and the equation re-estimated with three seasonal dummies on the assumption that seasonality may have been introduced into the price setting mechanism through U.S. chicken prices.
The explanatory power of the equation is very good as indicated by a .95 $R^2$ value but the low D.W. statistic of .9 indicates the presence of positive serial correlation. The pattern of residuals provides further confirmation of positive serial correlation as there was long strings of positive and negative residuals. The standard error of the regression is therefore biased downwards. Although there are well known methods of correcting for serial correlation (Cochrane - Orcutt and Hildreth-Lu) no attempt has yet been made to employ them at this stage.

All the regression coefficients have signs which conform to prior expectations. With the exception of the first and second quarters, dummies all the coefficients are significant. The elasticity of the regulated farm price of poultry with respect to the lagged regulated sector feed price, wage rate, and the U.S. broiler chicken price in Canadian dollars is calculated, respectively, as .55, .19 and .26 which is what one would expect given the importance of feed costs in the poultry industry and the relative unimportance of labour costs.

POULTRY FEED PRICE

30:  \[ EGGFP = 28.402 + .868 \left( FEGX + OILPX \right)/2 \]

\[
(4.34) \quad (0.03)
\]

\[
[6.55] \quad [25.12]
\]

\[ R^2 = .94 \]

\[ D.W. = 1.15 \quad 1967-1 \text{ to } 1976-4 \]
30(TSLS):  $\text{EGGFP} = 26.955 + .881 \left( \text{FEGPX} + \text{OILPX}/2 \right)$

\[(4.52) \; (.04)\]

\[ [5.96] [24.56] \]

$R^2 = .94$

D.W. = 1.18  \(1967-2\) to 1976-4

The feed price used in the poultry equations is explained well by the average of feed grain price used in the rest of the model and the oilseed price. This is a simple price linkage equation and no economic meaning is attached to the equation.

**REGULATED FARM PRICE OF EGGS**

31(0):  $\text{REGGP} = \text{REGGPOP} + \text{REGGP.1} \times \text{EGGFP}(-1)$

$+ \text{REGGP.2} \times \text{EGST}(-1) + \text{REGGP.3} \times \text{CPIAQ}(-1)$

$+ \text{REGGP.4} \times \text{CMDUM} 1$

\[(27.43) \; (.12) \quad (-.00006) \quad (.06)\]

\[ [-1.59] [2.83] \quad [-.12] \quad [1.67] \]

$+ 2.967 \text{FCPR} + 13.151 \text{CMDUM} 1$

\[(1.07) \quad (10.47)\]

\[ [2.76] \quad [1.26] \]

$R^2 = .86$

D.W. = .97  \(1967-4\) to 1976-4
\[ 31 \times \text{TSLS}: \] \[ \text{REGG}\text{P} = -44.909 + .359 \text{EGGFP} - .00004 \text{EGST}(-1) + .092 \text{WAGF} \]

\[ (31.56) \quad (.16) \quad (.0006) \quad (1.63) \]

\[ [-.42] \quad [2.26] \quad [-.06] \quad [1.09] \]

\[ + 2.921 \text{FCPR} + 13.870 \text{CMDUM1} \]

\[ (1.01) \quad (12.66) \]

\[ [2.89] \quad [1.09] \]

\[ R^2 = .87 \]

D.W. = .97 1967-2 to 1976-4

Given the drastic structural changes that took place in the Canadian egg industry it was somewhat surprising to see that the CEMA dummy coefficient is not significant which seems to indicate that the impact of structural change has perhaps not been adequately taken into account by a simple shift in the intercept term. This would also explain the low value for D.W. statistic. The elasticity of the regulated egg price with respect to the poultry feed price, opening egg stocks, the wage rate and the interest rate is, respectively, .98, -.01, .32, .47. The capital intensive nature of and the importance of feed costs in egg production is reflected by these elasticities.

However, the size of the above elasticities seem to be on the high side and would seem to indicate, given that the sum of the elasticities of the cost components are greater than one, that CEMA overreacted to changes in costs when setting egg prices. A possible explanation for this is that since CEMA became operational in mid 1973 it has been overzealous in protecting the interests of the egg producers.
TABLE 5.1: PRICE AND INCOME ELASTICITIES, REPORTED IN RELATED STUDIES OF THE DEMAND FOR MEAT

<table>
<thead>
<tr>
<th>Source</th>
<th>Period</th>
<th>Method of Estimation</th>
<th>Functional Form</th>
<th>Dependent Variable</th>
<th>Direct Price Elasticity</th>
<th>Income Elasticity</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Beef</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yeh (1961)</td>
<td>1929-1958</td>
<td>OLS</td>
<td>DL</td>
<td>quantity</td>
<td>-.535</td>
<td>.495</td>
</tr>
<tr>
<td></td>
<td>1929-1939</td>
<td>OLS</td>
<td>DL</td>
<td>quantity</td>
<td>-1.81</td>
<td>.206</td>
</tr>
<tr>
<td></td>
<td>1947-1958</td>
<td>OLS</td>
<td>DL</td>
<td>quantity</td>
<td>-1.64</td>
<td>.393</td>
</tr>
<tr>
<td>Holmes (1968)</td>
<td>1935-1964</td>
<td>ILS</td>
<td>DL</td>
<td>price</td>
<td>-.77</td>
<td>1.5 to 3.4</td>
</tr>
<tr>
<td>Yankowsky (1970)</td>
<td>1949-1969</td>
<td>OLS</td>
<td>DL</td>
<td>quantity</td>
<td>-.74</td>
<td>.88</td>
</tr>
<tr>
<td>Kulshreshtha &amp; Wilson (1972)</td>
<td>1949-1969</td>
<td>TSLS</td>
<td>L</td>
<td>quantity</td>
<td>-.801</td>
<td>1.044</td>
</tr>
<tr>
<td>Tryfos &amp; Tryphonopoulos (1973)</td>
<td>1954-1970</td>
<td>SUR</td>
<td>L</td>
<td>quantity</td>
<td>-.521</td>
<td>.835</td>
</tr>
<tr>
<td><strong>Pork</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yeh (1961)</td>
<td>1929-1958</td>
<td>OLS</td>
<td>DL</td>
<td>quantity</td>
<td>-.343</td>
<td>-.438</td>
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<tr>
<td></td>
<td>1929-1399</td>
<td>OLS</td>
<td>DL</td>
<td>quantity</td>
<td>-.278</td>
<td>-.652</td>
</tr>
<tr>
<td></td>
<td>1947-1958</td>
<td>OLS</td>
<td>DL</td>
<td>quantity</td>
<td>-.651</td>
<td>-.258</td>
</tr>
<tr>
<td>Holmes (1968)</td>
<td>1935-1964</td>
<td>ILS</td>
<td>DL</td>
<td>price</td>
<td>1.69</td>
<td>10 to 2</td>
</tr>
<tr>
<td>Yankowsky (1970)</td>
<td>1949-1969</td>
<td>OLS</td>
<td>DL</td>
<td>quantity</td>
<td>-.47</td>
<td>.005</td>
</tr>
<tr>
<td>Tryfos &amp; Tryphonopoulos (1973)</td>
<td>1954-1970</td>
<td>SUR</td>
<td>L</td>
<td>quantity</td>
<td>1.049</td>
<td>-.004</td>
</tr>
<tr>
<td><strong>Veal</strong></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tryfos &amp; Tryphonopoulos (1973)</td>
<td>1954-1970</td>
<td>SUR</td>
<td>L</td>
<td>quantity</td>
<td>1.801</td>
<td>-2.909</td>
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<td><strong>Chicken</strong></td>
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<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Tryfos &amp; Tryphonopoulos (1973)</td>
<td>1954-1970</td>
<td>SUR</td>
<td>L</td>
<td>quantity</td>
<td>-1.40</td>
<td>.455</td>
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<tr>
<td><strong>Poultry</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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a OLS: Ordinary Least Squares; ILS: Indirect Least Squares; TSLS: Two Stage Least Squares; SUR: Zellner's Seemingly Unrelated Regressions.

b DL: Double Logarithmic; L: Linear.

c 1940-1946 omitted.
SECTION 5.3: THE FINAL STRUCTURE OF THE MODEL

MODEL: ORICMOD

A MACRO POLICY SIMULATION MODEL OF THE CANADIAN AGRICULTURAL SECTOR

SYMBOL DECLARATIONS

ENDOGENOUS:

BACP  -  Bakery and Cereal Product Price, CPIF  -  Bakery and Cereals
CPIFQ  -  CPIF  -  Food at Home
DTSY  -  Total Supply of Meat
DPRP  -  Retail Price of Dairy Products, CPIF  -  Dairy Products
ECPI  -  Retail Price of Eggs, CPIF  -  Eggs
EGGFP  -  Feed Price for Poultry Industry
FAQP  -  Retail Price of Fats and Oils, CPIF  -  Fats and Oils
FCPG  -  Near Futures Price of Grain
FEGD  -  Feed Grain Demand
FEGPX  -  Feed Grain Price
FGRPX  -  Food Grain Price
GPRDQ  -  Grain Production
GRS  -  Grain Supply
GRACQ  -  Grain Acreage
GRAX  -  Price Index for Grains
CTR  -  Gross Target Returns for Milk
INVD  -  Grain Inventory Demand
LIVD  -  Livestock Inventory Demand (Millions of Animals)
LIVM  -  Livestock Inventory Demand (Millions of Pounds of Meat)
LVPP  -  Index of Farm Price of Livestock
MTNM  -  Imports of Livestock and Livestock Products (In Million Pounds of Meat)
NTC  -  Net Trade in Grains
NTM  -  Net Trade in Livestock and Livestock Products (In Million Pounds of Meat)
OILPX  -  Oilseeds Price
PCLVDP  -  Per Capita Meat Demand
PLCP  -  Retail Price of Poultry Product, CPIF  -  Poultry
RFFP  -  Regulated Farm Price of Poultry
REGP  -  Regulated Farm Price of Eggs
RSCP  -  Retail Price Index of Regulated Sector Products
TLIVD  -  Total Livestock Inventories (Millions of Animals)
MODEL: ORIGMOD

A MACRO POLICY SIMULATION MODEL OF THE CANADIAN AGRICULTURAL SECTOR

SYMBOL DECLARATIONS

DEFINITION:

CANPASH - Unit Value (C$) of Non-Competing Agriculture Imports
CAPHG4 - U.S. Price of Hogs in Canadian Dollars
CAPPSS4 - U.S. Price of Cattle in Canadian Dollars
CANSLP - Index of U.S. Livestock Price in Canadian Dollars
GRAPX - Index of Domestic Grain Prices

EXOGENOUS:

AGEX - A Four Quarter Moving Average of Grain Exports
ARCWL - Average Carcass Weight of Livestock
BACS - Bakery and Cereal Opening Stocks
BAGD - Grain Demand by Bakery and Cereal Industry
BCOP - Bumper Crop Variable
BDRE - Net Births of Livestock Animals (In Million Pounds of Meat)
CHPUS - U.S. Broiler Chicken Price (U.S. $)
CIED - Closing Cattle Inventories
CMDUM1 - Dummy for Period Prior to Establishment of Canadian Egg Marketing Agency
CPAQ - Quarterly Consumer Price Index - All Items
DCVD1 - Dairy Cow Inventories (Millions of Animals)
DUM1 - First Quarter Seasonal Dummy
DUM2 - Second Quarter Seasonal Dummy
DUM3 - Third Quarter Seasonal Dummy
DUM4 - Fourth Quarter Seasonal Dummy
EGST - Closing Stocks of Eggs
FCDQ1 - Chicago Futures Price for Grain - December Contract in the First Quarter
FCLDQ - Chicago Futures Price for Livestock - December Contract in the First Quarter
FCOP - Chicago Near Futures Price for Corn (U.S. $)
FCPI - Retail Price for Fish, CPI - Fish
FMIPQ - Quarterly Farm Input Price Index
FOGD - Grain Demand by Fats and Oils Industry
GDST - Government Dairy Stocks (Closing)
GRAYQ - Grain Yield (Weighted Average)
MODEL: ORIGMOD

A MACRO POLICY SIMULATION MODEL OF THE CANADIAN AGRICULTURAL SECTOR

SYMBOL DECLARATIONS

EXOGENOUS (Cont.):

GREX1 - Exports of Wheat
GRIM13 - Imports of Corn
GRIM28 - Imports of Soybeans
HINVDQ - Closing Hog Inventories
LDUM - Dummy for U.S. Meat Price Freeze
LIFTQ - Dummy for Lower Inventories for Tomorrow Program
MTEX - Exports of Livestock and Livestock Products (Millions of Pounds of Meat)
PCYCOM - Canadian Per Capita Income
PHG4 - U.S. Hog Price (U.S. $)
POLS - Processors Stocks of Poultry Meat (Opening Inventories)
POPC - Population of Canada
POVD1 - Poultry Inventories (Grain Consuming Animal Units)
PSS4 - U.S. Live Cattle Price (U.S.$)
RESQD - Residual Item for Net Exports of Grain Identity
SSFPX - Chicago Near Futures Price for Soybeans
SWFPX - Chicago Near Futures Price for Wheat
TGREX - Exports of All Grains
TIME - Time Variable
USLP - U.S. Livestock Price in U.S. $
USPASH - Unit Value of Non-Competing Agriculture Products in U.S. Dollars
WAGF - Wage Rate - Average Weekly Earnings in Food Processing Industries
WALV - Conversion Factor to Convert Various Classes of Cattle to Grain Consuming Unit Basis

POLICY:

DOMP - Domestic Milling Price of Wheat
EXCHI - Exchange Rate - Price of U.S. Currency in Canadian Dollars
FCPR - 90 Day Finance Company Paper Rate
MODEL: ORIGMOD

A MACRO POLICY SIMULATION MODEL OF THE CANADIAN AGRICULTURAL SECTOR

SYMBOL DECLARATIONS

COEFFICIENT:

BACP.0, BACP.1, BACP.2, BACP.3, BACP.4, DPRP.0, DPRP.1, DPRP.2, DPRP.3, ECFI.0, ECFI.1, ECFI.2, ECFI.3, ECFI.4,
EGFP.0, EGFP.1, FAOP.0, FAOP.1, FAOP.2, FAOP.3, FECD.0, FECD.1, FECD.2, FECD.3, FECD.4, FECD.5, FECD.6, FEGPX.0,
FEGPX.1, FEGPX.2, FEGPX.3, FEGPX.4, FGRPX.1, FGRPX.2, FGRPX.3, GRACQ.0, GRACQ.1, GRACQ.2, GRACQ.3, GRACQ.4,
GTRM.0, GTRM.1, GTRM.2, GTRM.3, GTRM.4, INVD.0, INVD.1, INVD.2, INVD.3, INVD.4, INVD.5, INVD.6, INVD.7, LIVM.0,
LIVM.1, LIVM.10, LIVM.2, LIVM.3, LIVM.4, LIVM.5, LIVM.6, LIVM.7, LIVM.8, LIVM.9, LIVPX.0, LIVPX.1, LIVPX.2,
LIVPX.3, MTIM.0, MTIM.1, MTIM.2, MTIM.3, MTIM.4, OILPX.0, OILPX.1, OILPX.2, OILV.0, OILV.1, OILV.2, PCLVPD.0,
PCLVPD.1, PCLVPD.2, PCLVPD.3, PLCPI.0, PLCPI.1, PLCPI.2, PLCPI.3, PLCPI.4, PLCPI.5, POFP.0, POFP.1, POFP.2, POFP.3,
POFP.4, POFP.5, POFP.6, REGG.0, REGG.1, REGG.2, REGG.3, REGG.4, REGG.5.

EQUATIONS

GRAIN SECTOR:

1: Grain Acreage:
   GRAQ = (GRACQ.0 + GRACQ.1 + FCGDQ + GRACQ.2 + FMIPQ + GRACQ.3 + FCLDQ + GRACQ.4 + LIFTQ) * DUM3

2: Identity for Grain Production:
   GPRDQ = GRACQ * GRAYQ

3: Identity for Grain Supply:
   GPRS = INVDT(-1) * DUM1 + INVDT(-1) + DUM2 + (INVDT(-1) + GPRDQ) * DUM3 + INVDT(-1) * DUM4

4: Feed Grain Demand:
   FECD = FECD.0 + FECD.1 * LIVPX + FECD.2 * FEGPX + FECD.3 * TLIVD(-1) + FECD.4 * DUM2 + FECD.5 * DUM4 + FECD.6 * DUM3

5: Grain Inventory Demand:
   INVDT = INVDT.0 + INVDT.1 * GRAPX(-1) + INVDT.2 * (TGREX-AGEX) + INVDT.3 * DUM1 + INVDT.4 * DUM2 + INVDT.5 * DUM3 + INVDT.6 * LIVPX + INVDT.7 * INVDT(-1)

6: Identity for Net Exports of Grains:
   NTGR = GPRS - INVDT - FOGD - BAGD - FECD + RESD
MODEL: ORIGMOD
A MACRO POLICY SIMULATION MODEL OF THE CANADIAN AGRICULTURAL SECTOR

SYMBOL DECLARATIONS

EQUATIONS

GRAIN SECTOR (cont'd)

7: Retail Price of Bakery and Cereals:
   \[ BACP = BACP.0 + BACP.1 \times DOMP + BACP.2 \times FCPR + BACP.3 \times BACS + BACP.4 \times BACP(-1) \]

8: Farm Price of Food Grains:
   \[ FGRPX = FGRPX.0 + FGRPX.1 \times SWFPX(-1) + FGRPX.2 \times EXCHI(-1) + FGRPX.3 \times TIME \]

9: Farm Price of Oils seeds:
   \[ OILPX = OILPX.0 + OILPX.1 \times (SSFPX(-1) \times EXCHI(-1)) \]

10: Identity for Index of Domestic Grain Prices:
    \[ GRAPX = (FEGPX/56.6185 \times FEGPX \times GRIM13 + OILPX/106.48 \times OILPX + GRIM28 + FGRPX/74.065 \times FGRPX \times GREX1)/(FEGPX \times GRIM13 + OILPX \times GRIM28 + FGRPX \times GREX1) \]

11: Retail Price of Fats and Oils:
    \[ FAOP = FAOP.0 + FAOP.1 \times FCPR + FAOP.2 \times OILPX + FAOP.3 \times FAOP(-1) \]

12: Farm Price of Feed Grains:
    \[ FEGPX = FEGPX.0 + FEGPX.1 \times FCOP(-1) + FEGPX.2 \times EXCHI(-1) + FEGPX.3 \times TIME \]

LIVESTOCK SECTOR:

13: Definition for U.S. Price of Steers in Canadian Dollars:
    \[ CANPSS4 \equiv PSS4 \times EXCHI \]

14: Definition for U.S. Price of Hogs in Canadian Dollars:
    \[ CANPHC4 \equiv PHG4 \times EXCHI \]

15: Definition for Index of U.S. Livestock Price in Canadian Dollars:
    \[ CANUSLP \equiv (CANPSS4/29.4058 \times CANPSS4 \times CIED \times WALV \times ARCW + CANPHC4/22.5351 \times CANPHC4 \times 0.31485 \times HINVDQ \times ARCW)/((CANPSS4 \times CIED \times WALV) + CANPHC4 \times 0.31485 \times HINVDQ \times ARCW) \]
MODEL: ORIGMOD

A MACRO POLICY SIMULATION MODEL OF THE CANADIAN AGRICULTURAL SECTOR

SYMBOL DECLARATIONS

LIVESTOCK SECTOR (Cont'd)

16: Definition for Total Livestock Inventories: (Cattle, Hogs, Dairy and Poultry)
   TLIVD = LIVD + POVD1 + DCVD1

17: Imports of Livestock and Meat:
   MTIM = MTIM.0 + MTIM.1 * CANUSLP + MTIM.2 * LDUM + MTIM.3 * DMTSY(-1) + MTIM.4 * (PCYCOM * POPC/1000)^4
   MTIM.5 * MTIM(-1)

18: Identity for Net Exports of Livestock and Meat:
   NTMT = MTEX - MTIM

19: Inventory Demand for Livestock:
   LIVM = LIVM.0 + LIVM.1 * LIVPX(-2) + LIVM.2 * FEGPX(-2) + LIVM.3 * FCPR(-2) + LIVM.4 * LIVM(-1)
   + LIVM.5 * DUM2 + LIVM.6 * DUM3 + LIVM.7 * DUM4 + LIVM.8 * (LIVPX(-1) - LIVPX(2)) + LIVM.9 * (FEGPX(-1) - FEGPX(-2)) + LIVM.10 * (FCPR(-1) - FCPR(-2)) + LIVM.11 * LVPP

20: Identity for Meat Supply:
   DMTSY = BDRE + LIVM(-1) - LIVM + MTIM - MTEX

21: Per Capita Retail Demand for Meat:
   PCLVPD = PCLVPD.0 + PCLVPD.1 * LVPP + PCLVPD.2 * PCYCOM + PCLVPD.3 * PCLVPD(-1)

22: Market Clearing Function for Retail Meat:
   PCLVPD * POPC/1000 = DMTSY

23: Farm Price of Livestock:
   LIVPX = LIVPX.0 + LIVPX.1 * CANUSLP + LIVPX.2 * LIVPX(-1) + LIVPX.3 * (LIVM(-2) - LIVM(-3))

24: Definition for Livestock (Cattle and Hogs) Inventories:
   LIVD = LIVM/ACWL
MODEL: ORIGMOD

A MACRO POLICY SIMULATION MODEL OF THE CANADIAN AGRICULTURAL SECTOR

SYMBOL DECLARATIONS

REGULATED SECTOR:

25: Retail Price of Dairy Products:
    DPRP = DFRP.0 + DFRP.1 * GTRM + DFRP.2 * WAGF + DFRP.3 * DPRP(-1)

26: Regulated Farm Price for Milk: Gross Target Returns for Milk:
    GTRM = GTRM.0 + GTRM.1 * FEGPX(-1) + GTRM.2 * CPIAQ(-1) + GTRM.3 * GDST(-1) + GTRM.4 * GTRM(-1)

27: Retail Price of Poultry:
    PLCPI = PLCPI.0 + PLCPI.1 * POFP + PLCPI.2 * WAGF + PLCPI.3 * LVPP + PLCPI.4 * PLCPI(-1)
        + PLCPI.5 * POLS

28: Retail Price of Eggs:
    ECPI = ECPI.0 + ECPI.1 * REGGP + ECPI.2 * WAGF + ECPI.3 * FCPR + ECPI.4 * ECPI(-1)

29: Regulated Farm Price of Poultry:
    POFP = POFP.0 + POFP.1 * EGGFP(-1) + POFP.2 * WAGF(-1) + POFP.3 * DUM1 + POFP.4 * DUM2
        + POFP.5 * DUM3 + POFP.6 * (CHPSUS(-1) * EXCHI(-1))

30: Poultry Feed Prices:
    EGGFP = EGGFP.0 + EGGFP.1 * (FEGPX + OILPX)/2

31: Regulated Farm Price of Eggs:
    REGGP = REGGP.0 + REGGP.1 * EGGFP + REGGP.2 * EGST(-1) + REGGP.3 * WAGF + REGGP.4 * FCPR + REGGP.5 * CHDM1

32: The Index of Retail Prices of Regulated Sector Products:
    RSCP = (3.3328 * DPRP + 0.617 * ECPI + 0.9053 * PLCPI)/4.8551

ACCOUNTING SECTOR:

33: Definition for Unit Value of Non-Competing Agriculture Imports in Canadian Dollars:
    CANPASH := USPASH * EXCHI

34: Retail Price Index for Food At Home
    CPIUFO = (FAOP * 0.3795 + LVPP * 5.9249 + FCPI * 0.394 + DPRP * 3.3328 + ECPI * 0.617 + PLCPI...
CHAPTER 6: VALIDATION

The previous chapter presented the results of estimating the structural model. In this chapter, the estimated structure of the model will be validated using various criteria, statistical as well as judgemental.

After the model is estimated and the estimates evaluated through classical statistical criteria like the \( R^2 \), the D.W., elasticities, standard errors, etc., the next logical step in the modelling process is corroborating the model with the system. In other words, the estimated structure of the model has to be validated as an initial step towards using the model as an operational and analytical tool.

The validation of a multi equation econometric model is as much a statistical as a judgemental exercise. The crucial element of any validation exercise is not to lose sight of the purpose for which the model is built because the criteria that will be most relevant will depend on it. Pindyck and Rubinfeld (1976 - Pg 315) has expressed this point very clearly in the following way:

"The fact that there are several equations means that high statistical significance for some equations may have to be balanced against low statistical significance for other equations. Even more important, however, is the fact that the model as a whole will have a dynamic structure which is much richer than that of any one of the individual equations of which it is composed. Thus even if all the individual equations fit the data well and are statistically significant, we have no guarantee that the model as a whole when simulated will reproduce those same data series closely. Finally, it is possible that in an ex post (or historical) simulation some of the endogenous variables will "track" the original data series closely while others will not. Some models are built
primarily for forecasting, while others are built primarily for descriptive purposes and hypothesis testing. As in the single equation case, different criteria will apply depending on the model's purpose.

The stated objective of this thesis is to empirically evaluate the impact of external influences such as world grain and livestock prices and exchange rate changes and internal influences such as changes in fiscal and monetary policies on the Canadian agricultural sector and ultimately on the food - CPI.

In the course of obtaining the statistical estimates for the structural equations of the three sector model of the Canadian agricultural sector, changes, inevitably have to be made to the structural equations as originally specified. Certain variables have to be dropped altogether, some substituted or supplemented with new ones. Since the model was built not to test some specific hypothesis but to gauge the empirical relationship between certain variables that will be consistent with the theoretical and institutional structure of the Canadian agriculture sector these compromises, to a certain extent, were considered unavoidable and necessary if the original purposes for which the model was built are to be met.

Admittedly, in some cases, variables which did not meet the standard statistical criteria have been included and in some other cases variables whose inclusion the theory has suggested was not included. The justification for these deviations from the purist's approach to applied econometric work, is defended on the following grounds:

1) Those variables, which are statistically insignificant are included if and only if the signs do not go against a priori
expectations suggested by economic theory.

2) In some cases, when the choice of the variable to be included boils down to between one with higher statistical significance or one with better simulation performance and relevance to the purpose of the model, the explicit bias has been towards the latter, the variable with relevance.

The approach taken towards validating the estimated structure of the model was guided to a large extent by the paper by Drymès et al (1972) and the following two passages from the authors’ philosophy towards evaluating econometric models is worth quoting:

"In the current state of our knowledge and analytical needs, to concentrate our attention solely on proving or disproving the "truth" of an econometric model is to choose an activity virtually guaranteed to suppress the major benefits which can flow from the proper use of econometric models. Having constructed the best models of which we are capable, we ought to concern ourselves directly with whether or not particular models can be considered to be reliable tools for particular uses, regardless of the strict faithfulness of their specification."

"Tests on evaluation procedures should initially at least centre on the ability of the model to generate "historical" simulations which conform to the actual data. These simulations might be either deterministic or stochastic, and either static (one period) or dynamic (multi-period) in nature. A minimal requirement would involve a broad consistency of the data generated by a deterministic single period simulation with the data from the actual historical record (both within and outside the sample period)"

There exists various statistical criteria in the literature which can be used to carry out such an investigation and these criteria can be usefully classified under two major headings namely:

1) Parametric evaluation criteria;
2) Non Parametric evaluation criteria.
Drymes et al. have conveniently made a comprehensive if not exhaustive list of the non-parametric evaluation criteria which is reproduced below:

An Outline of Non-Parametric Measures

A. Single-Variable Measures
   1. Mean forecast error (changes and levels)
   2. Mean absolute forecast error (changes and levels)
   3. Mean squared error (changes and levels)
   4. Any of the above relative to:
      a) the level or variability of the variable being predicted
      b) a measure of "acceptable" forecast error for alternative forecasting needs and horizons

B. Tracking Measures
   1. Number of turning points missed
   2. Number of turning points falsely predicted
   3. Number of under- or over-predictions
   4. Rank correlation of predicted and actual changes (within a subset of "important" actual movements)
   5. Various tests of randomness:
      a) of directional predictions
      b) of predicted turning points

C. Error Decompositions
   1. Bias and variance of forecast error
   2. Errors in start-up position vs errors in the predicted changes
3. Identification of model subsectors transmitting errors to other sectors

D. Comparative Errors

1. Comparison with various "naive" forecasts
2. Comparison with "judgemental", "consensus", or other non-econometric forecasts
3. Comparison with other econometric forecasts

E. Cyclical and Dynamic Properties

1. Impact and dynamic multipliers
2. Frequency response characteristics

Limitations of time and resource do not permit the use of all these non parametric performance measures in validating the agricultural sector model. However, a wide selection of these measures have been used and they are listed below:

1) Root Mean Square Error (historical and ex-poste)
2) Root Mean Square Percentage Error (historical and ex-poste)
3) Mean Error (historical and ex-poste)
4) Mean Percent Error (historical and ex-poste)
5) Standard deviation of the above eight measures
6) Number of turning point errors
7) Number of under-overpredictions
8) Impact and dynamic multipliers and elasticities

The model of the Canadian agricultural sector was estimated and simulated using TROLL, (TIME-SHARED REACTIVE ON-LINE LABORATORY),
an interactive computer system developed at MIT and now used by the
Commodity Market Analysis and Trade Policy Directorate of the Canadian
Department of Agriculture.

The first four single value non parametric measures are
defined as follows:

1) RMS Error = \[ \frac{1}{n} \sqrt{\sum_{t=1}^{n} (Y^s_t - Y^a_t)^2} \]

2) RMS Percent Error = \[ \frac{1}{n} \sqrt{\sum_{t=1}^{n} \left( \frac{Y^s_t - Y^a_t}{Y^a_t} \right)^2} \]

3) Mean Error = \[ \frac{1}{n} \sum_{t=1}^{n} (Y^s_t - Y^a_t) \]

4) Mean Percent Error = \[ \frac{1}{n} \sum_{t=1}^{n} \left( \frac{Y^s_t - Y^a_t}{Y^a_t} \right) \]

where \( Y^s_t \) = the simulated value of \( Y_t \)
\( Y^a_t \) = the actual value

\( n \) = the number of periods in the simulation

The model was estimated with varying data ranges with a
maximum range of 1966-1 to 1976-4. The maximum simulation range of
the complete model however, starts from 1968-1 and ends at 1977-4. Consequent-
ly, the model was first simulated from 1968-1 to 1976-4. This is
historical simulation. Secondly, the model was simulated from 1977-1 to
1977-4. This is ex-poste simulation using actual values for exogenous
variables in the system. The four performance measures defined above
together with their standard deviations were calculated for both sets
of simulations. In effect then that part of the simulation from 1977-1 to 1978-4 is ex-poste forecast using actual observed values for exogenous variables and model generated values for lagged endogenous variables. The simulation errors for the period 1977-1 to 1977-4 can therefore be interpreted as ex-poste forecast errors and comparing them with the errors obtained for the historical simulation (1968-1 to 1976-4) provides one test for the model's performance outside the period over which its coefficients were estimated.

The above statistical criteria measures the "fit" of the model in a simulation context. In other words, it measures the closeness between the behavior of the model and the behavior of the real world. The question then, is how close is "close". Like other statistical measures such as the $R^2$, the mean and root mean square errors are not absolutes although all other things being equal the lower the size of the simulation error the better. In the course of the simulation, inevitably, some endogenous variables will have small errors and some endogenous variables (even if it is estimated perfectly) will have large errors. One would be taking a very narrow view if judgement is passed on a variable solely on the absolute size of the simulation errors. Other factors such as the number of turning points, whether the variable in question responds to external stimuli in a manner that is consistent with what the economic theory will predict, the importance of the variable in meeting the objectives of the model should all be part and parcel of the validation exercise. That is why the number of turning points and the number of underpredictions and overpredictions are also calculated and analyzed. The analysis of the model's dynamic response to external
stimuli is postponed to the next chapter where the results of the simulation to the experiments conducted on the model are examined in detail.

The presentation of the simulation results will now proceed as follows: First, although the model is simulated as a complete system the discussion of the simulation results will be limited to only selected endogenous variables to conserve space. The simulation results for all the endogenous are of course available in the form of a computer printout. Secondly, the actual and simulated values are graphed for the selected crucial endogenous variables and presented. (FIGS: VI-V6)

Thirdly, to limit space, the discussion of the simulation results will be carried out in terms of root mean square percentage errors, turning point errors and where relevant the number of overpredictions and underpredictions. This would be done for both historical and ex-poste simulation results and a comparison between the two different simulations would be made using the above performance measures. It should be pointed out that the simulation of the model was carried out using the TSLS estimates.

A table of summary statistics precede the discussion of the simulation results for each of the selected endogenous variables. In the table, the mean, root mean square and the standard deviation of the error and the percentage error of the historical simulation and the ex-poste simulation is given. CONSOL-ER and CONSOL-PCER, refers to the error and the percentage error respectively of the historical simulation (i.e. simulated value minus historical value and the simulated value minus historical value as a percentage of the historical value) while CONSOL 1-ER and CONSOL 1-PCER refers to the error and the percentage
error respectively of the ex-poste simulation. Below the table, the number of turning point errors, the number of times the model underpredicted and overpredicted the changes in the historical value during historical simulation is provided. These statistics were obtained by using the following procedure: If the ratio of the first difference of the historical (actual) values for the endogenous variable to the first difference of the simulated value is positive (both change in the same direction) then there is no turning point error. However, if this ratio is greater than 1 then this is counted as an underprediction and if this is less than 1 this is counted as an overprediction. If the ratio is negative this of course constitutes a turning point error since the model's predicted change is opposite in direction to the actual change. Two points of clarification should be made here: 1) As this analysis requires first differences of simulated values the first observation is 1968-2 rather than 1968-1; 2) The number of under- and overpredictions refer only to those cases where no turning point errors are made.
STATISTICS FOR SIMULATION OUTPUT BY VARIABLE

**TABLE VI: INVDT - ENDOGENOUS**

<table>
<thead>
<tr>
<th></th>
<th>CONSOL-ER</th>
<th>CONSOL-PCER</th>
<th>EX-POSTE</th>
<th>CONSOL-ER</th>
<th>CONSOL-PCER</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MEAN</strong></td>
<td>0.392</td>
<td>3.781</td>
<td>-3.395</td>
<td>-7.602</td>
<td></td>
</tr>
<tr>
<td><strong>RMS</strong></td>
<td>4.610</td>
<td>14.993</td>
<td>4.504</td>
<td>9.788</td>
<td></td>
</tr>
<tr>
<td><strong>STD.DEV</strong></td>
<td>4.658</td>
<td>14.714</td>
<td>3.417</td>
<td>7.119</td>
<td></td>
</tr>
</tbody>
</table>

Number of Turning Point Errors | 0
Number of Underpredictions | 18
Number of Overpredictions | 17

**EQ.5: INVENTORY DEMAND FOR GRAIN**

The model simulates INVDT with a 14.993 RMS percentage error during historical simulation and 9.788 RMS percentage error during ex-poste simulation. There were no turning point errors and the number of under- and overpredictions are virtually equal.

The relatively high RMS percentage error was largely influenced by large errors over the period 1974-3 to 1975-2 when the model overpredicted the levels as well as the change in INVDT. This was mainly due to the domestic farm livestock price variable which enters the inventory equation as an opportunity cost variable being underestimated in the last two quarters of 1974. This is probably due to the lingering effects of the Nixon price freeze which distorted U.S.-Canada trade in livestock and meat and hence Canadian livestock prices.
STATISTICS FOR SIMULATION OUTPUT BY VARIABLE

TABLE V2: NTGR - ENDOGENOUS

<table>
<thead>
<tr>
<th></th>
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<th>EX-POSTE</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>CONSOL-ER</td>
<td>CONSOL-PCER</td>
<td>CONSOL1-ER</td>
</tr>
<tr>
<td>MEAN</td>
<td>0.128</td>
<td>8.794</td>
<td>1.135</td>
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<tr>
<td>RMS</td>
<td>2.349</td>
<td>63.440</td>
<td>2.303</td>
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<tr>
<td>STD.DEV</td>
<td>2.379</td>
<td>63.719</td>
<td>2.314</td>
</tr>
</tbody>
</table>

Number of Turning Point Errors 15
Number of Underpredictions 4
Number of Overpredictions 16

EQ.6: NTGR: Net Trade in Grains

The model simulates NTGR with a RMS percentage error of 63.44 during historical simulation and 41.234 during ex-poste simulation. The size of the errors are large but it should be noted that NTGR was determined residually from grain supply, inventory demand and feed demand equations with grain demand for bakery and cereals and fats and oils treated as exogenous. Furthermore, relative to the size of the grain supply and inventory demand variables net trade in grains is small so that even small errors in either of the former variables will (unless they cancel out) lead to large errors in NTGR. Viewed from these perspectives the size of the errors are not as alarming as they may first appear.

Not surprisingly, the number of turning point errors are also large (15) with the number of overpredictions (16) dominating the number of underpredictions (4).
FIGURE V2: NGTR - NET GRAIN EXPORTS

WILLION TONES

14 12 10 8 6 4 2 0

ACTUAL SIMULATED

STATISTICS FOR SIMULATION OUTPUT BY VARIABLE

TABLE V3: LIVM - ENDOGENOUS

<table>
<thead>
<tr>
<th></th>
<th>HISTORICAL</th>
<th>EX-POSTE</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>CONSOL-ER</td>
<td>CONSOL-PCER</td>
</tr>
<tr>
<td>MEAN</td>
<td>-50.910</td>
<td>-1.098</td>
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<tr>
<td>RMS</td>
<td>74.531</td>
<td>1.661</td>
</tr>
<tr>
<td>STD.DEV</td>
<td>55.207</td>
<td>1.263</td>
</tr>
</tbody>
</table>

Number of Turning Point Errors 2
Number of Underpredictions 21
Number of Overpredictions 12

EQ.19: LIVM: INVENTORY DEMAND FOR LIVESTOCK

This is an important variable in the model and it is simulated extremely well as indicated by a very low RMS percentage error of 1.661 and a maximum error during the period of historical simulation of 3.3 percent. The RMS percentage error for the ex-poste simulation is 2.359, which is only slightly higher than the corresponding statistic for the historical simulation. Particularly, because the historical series is irregularly cyclical the simulation performance of this equation is more impressive.

The model missed only two turning points in the historical series and the number of underpredictions are greater than the number of overpredictions by 9 observations.
FIGURE 43: LIVM - LIVESTOCK INVENTORY DEMAND

WILLIAM POUNDS

- ACTUAL
- SIMULATED
STATISTICS FOR SIMULATION OUTPUT BY VARIABLE

TABLE V4: LVPP - ENDOGENOUS

<table>
<thead>
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<th>EX-POSTE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CONSL-ER</td>
<td>CONSL-PCER</td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>1.448</td>
<td>1.592</td>
<td>-11.620</td>
</tr>
<tr>
<td>RMS</td>
<td>8.774</td>
<td>7.286</td>
<td>14.608</td>
</tr>
<tr>
<td>Std. Dev</td>
<td>8.777</td>
<td>7.211</td>
<td>10.223</td>
</tr>
</tbody>
</table>

Number of Turning Point Errors: 12
Number of Underpredictions: 2
Number of Overpredictions: 21

EQ.21: LVPP: THE RETAIL PRICE OF MEAT

The model simulates this crucial retail price LVPP, with a
RMS percentage error of 7.286 and a maximum error of 17 percent. The
RMS percentage error for the ex-poste simulation is slightly higher at
9.868 percent. This variable was determined by a market clearing condition
for retail meat and therefore bears the brunt of errors from the supply as
well as the demand equation for retail meat. The size of the errors,
given this perspective, can therefore be considered small.

The graph shows that the historical series undulates whereas
the simulated series is sharp and jagged. The model therefore perhaps
exaggerates the flexibility of retail meat prices in adjusting to changing
market conditions. It was not, therefore, surprising to see that there were
12 turning point errors. The model overestimated the actual LVPP judging
by the 21 times the change in LVPP was overestimated. Two large errors
(a percentage error of 17 percent) - one an overestimate in 1968-2 and the other an underestimate in 1975-1 were both caused by errors from the supply side the source of which can be found in errors in the livestock and meat import equation.
FIGURE V4: LVP$ — RETAIL PRICE OF MEAT
TABLE V5: RSCP - ENDOGENOUS

<table>
<thead>
<tr>
<th></th>
<th>HISTORICAL</th>
<th>EX-POSTE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CONSOL-ER</td>
<td>CONSOL-PCER</td>
</tr>
<tr>
<td>MEAN</td>
<td>-0.947</td>
<td>-0.555</td>
</tr>
<tr>
<td>RMS</td>
<td>3.384</td>
<td>2.775</td>
</tr>
<tr>
<td>STD.DEV</td>
<td>3.295</td>
<td>2.758</td>
</tr>
</tbody>
</table>

Number of Turning Point Errors: 11
Number of Underpredictions: 13
Number of Overpredictions: 11

EQ:32: RSCP: THE INDEX OF RETAIL PRICES OF REGULATED SECTOR PRODUCTS

The model simulates RSCP, which absorbs all the errors of the retail prices of dairy, egg and poultry prices with a RMS percentage error of 2.775 and a maximum percentage error of 7 percent. The RMS percentage error for the ex-poste simulation period is lower (1.646 vs. 2.775) than that of the historical simulation period.

There were 11 turning point errors but 8 of them took place before 1971 when the regulatory agencies' involvement in determining the regulated sector retail prices was in its infancy. The number of times the model underpredicted the change in RSCP (13) is approximately equal to the number of times it overpredicted (11).
FIGURE V5: RSCP - RETAIL PRICE OF REGULATED SECTOR PRODUCTS

INDEX

ACTUAL
SIMULATED

TABLE V6: CPIFQ - ENDOGENOUS

<table>
<thead>
<tr>
<th></th>
<th>HISTORICAL</th>
<th>EX-POSTE</th>
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<tbody>
<tr>
<td></td>
<td>CONSOL-ER</td>
<td>CONSOL-PCER</td>
</tr>
<tr>
<td>MEANS</td>
<td>0.460</td>
<td>0.747</td>
</tr>
<tr>
<td>RMS</td>
<td>3.534</td>
<td>3.401</td>
</tr>
<tr>
<td>STD.DEV</td>
<td>3.554</td>
<td>3.365</td>
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</table>

Number of Turning Point Errors: 15
Number of Underpredictions: 5
Number of Overpredictions: 15

EQ.35: CPIFQ: RETAIL PRICE INDEX FOR FOOD AT HOME

CPIFQ, which is a weighted index of all the retail price indices in the model is simulated with a RMS percentage error of 3.4 and a maximum percentage error of 8.0. The RMS percentage error for the ex-poste simulation period is 4.446.

Fifteen turning point errors were made and the number of overpredictions (15) exceed the number of underpredictions (5) by 10.

The simulation performance of the variable that is the focal point of the whole model is considered to be very satisfactory.
FIGURE 6: CPIFO - CPI - FOOD
The econometric model of the Canadian agricultural sector in the process of validation through historical and ex-poste simulation also underwent extensive sensitivity tests through being subjected to different simulation ranges and changes in coefficients on structural equations. Throughout this process, the model's tracking performance remained basically good although the size of the simulation errors of course varied with each simulation. On the basis of this admittedly limited but what is considered adequate validation the model is judged reliable enough to conduct policy experiments on it.
CHAPTER 7: POLICY EXPERIMENTS

In this chapter, the model will be used to simulate the impact of changes in fiscal, monetary and exchange rate policies and changes in world grain and livestock prices on the Canadian agricultural sector. First, the background to the policy experiments is provided; secondly, the nature of the experiments is explained; finally, the results of the policy experiments are analyzed.

BACKGROUND:

The years 1972-74 as is now well known was a period of turbulence in the world economy. The breakdown of the Bretton Woods international monetary system and the widespread use of floating exchange rates, the Arab oil crisis, the food shortage and commodity price boom were the major events of this period. A worldwide inflationary-recessionary situation unprecedented in scale and scope took grip of the world economy.

In the domestic economy a restrictive monetary policy followed by the Bank of Canada in 1969-70, and a strong current account created a persistent upward pressure on the Canadian dollar which was then floated in May 1970. The rising unemployment rate and the downturn in economic activity which Canada found itself in 1970-71 however led the monetary authorities to follow a path of monetary expansion over the 1971-73 period rather than allowing the floating Canadian dollar to go up further. Consequently, the money supply $M_1$, $M_2$, $M_3$ expanded at rates which averaged 12-13 percent annually. When the Arab oil crisis came at the end of 1973 Canada was temporarily shielded from feeling its full impact immediately because of her healthy oil trade account at the time. The recession of 1974,
which was worldwide in scope, was therefore much milder in Canada.

However, the lagged effects of the excessive monetary expansion over the 1971-73 period together with the expansion in government sector demand in 1974-75 (average annual increase 20.5 percent) led to a wage explosion in 1974-75 when average hourly manufacturing wages rose by 14.5 percent. This came at a time when the U.S., Canada's main trading partner, was beginning to reap the benefits of the recessionary shake out and the U.S. wage settlements were becoming more stable. The first consequence of this out of joint development of the Canadian economy vis-à-vis its trading partners was that the trade account deteriorated as the Canadian import demand increased at a faster rate than foreign demand for Canadian exports. The Canadian trade account in 1975 was in deficit for the 1st time in many years as a result of imports increasing at a rate of 9.4 percent and exports increasing only at a 2 percent rate. Secondly, the large borrowings both domestic and abroad - necessitated by an expansion of the government sector at all levels raised interest rates, attracted foreign capital and resulted in record capital inflows ($4.5 billion in 1975) and appreciated the Canadian dollar. In 1976 Canada therefore found itself in a position which was unenviable to say the least. A rising and high unemployment rate of 7.1 percent, a large current account deficit, a record high interest rate and a high exchange rate. The only bright spot in the picture was the 7.5 percent rise in the CPI which compared with the 10.8 percent rise in 1975. The rapid decline of the Canadian dollar which began in 1977 and extended into 1978 was not therefore surprising and indeed must be regarded as necessary.

In the Canadian agricultural sector the years 1972-1975 were.
boom years after a long period of calm and stability which could in part be attributable to the Canadian Wheat Board's willingness to stabilize production and domestic prices by accumulating stocks during the late sixties in the face of fluctuating world demand for grain. By 1970 grain stocks (especially wheat) held by the Canadian Wheat Board were equal to two years production. A one year emergency programme LIFT (Lower Inventory For Tomorrow) was therefore introduced. Under this program farmers were paid $6 per acre to increase fallow (and not to grow wheat) and an additional $4 per acre payment was available if this land was seeded to perennial forage.

Crop failures around the world in 1972-73 resulted in a quantum jump in the demand for food and feed grains around the world and major grain exporters like Canada saw export revenues and farm incomes soar. The export price of Canadian wheat climbed to $2.63 in 1972-73 and reached the unheard of heights of $5.49 in 1973-74. Farm cash receipts increased by 60 percent and the value of grain exports doubled between 1972 and 1974. But between 1973 and 1975 the CPI (food) rose at an annual rate of over 14 percent, contributing substantially to inflationary pressures that were emerging in the rest of the economy.

Clearly over the 1970-75 period, large exogenous shocks originating both from the international and national economy were imposed on the agricultural sector. The agricultural economy's reaction could be found in the observed marked rise in the relative prices of food. However, what does remain unclear is the influence played by each of the exogenous factors and the channels through which these exogenous shocks were transmitted to the agricultural sector ultimately resulting in sharply rising food prices.
These are the questions that will provide the terms of reference for the five policy simulation exercises that will be carried out on the model which has been estimated and validated.

Specifically, simulation exercises will be carried out using the following exogenous and policy variables: world prices of grains, livestock, the exchange rate, interest rates (mpney stock) and personal disposable income.

The macro experiments (experiment 1-3) will be carried out using the Bank of Canada's flexible exchange rates version of RDX2 to generate changes resulting from exchange rate, budgetary and monetary policy shocks on the following variables: per capita disposable income (PCYCOM), 90 day finance company interest rate (FCPR), the consumer price index of all items (CPIAQ), the wage rate (WAGF) and the exchange rate (EXCHI).

These variables are exogenous to the Canadian agricultural sector model but are endogenous in the RDX2 model. Hence by dynamically simulating RDX2 with the desired policy experiments a time path for a new set of values for the macro variables are generated. These new values for the exogenous variables are then used to dynamically simulate the Canadian agricultural sector model. The difference between the resulting values for the endogenous values and the values obtained in the base historical solution can then be attributed to the policy experiment.

EXPLANATION OF EXPERIMENTS

EXPERIMENT 1 - A permanent 10% depreciation of the Canadian dollar relative to the U.S. dollar with the exchange rate maintained at 10% below its historical value from 1971-1 to 1976-4.
EXPERIMENT 2 - This is a monetary policy experiment restricting the rate of M1 growth to 6.3% (the growth rate of real GDP) during the period 1971-1 to 1973-3 when actual rate of M1 growth was 15.2%. This experiment looks at the impact of monetary policy - acting through interest rates, on the agricultural sector.

EXPERIMENT 3 - This is a fiscal policy experiment with taxes being permanently cut by $1 billion for the period extending from 1971-1 to 1976-4 while keeping money stock at its historical level - a bond financed fiscal expansion experiment.

EXPERIMENT 4 - The U.S. price of livestock (hogs and cattle) relative to the U.S. price of grain is increased by 13.5% permanently starting in 1968-1. The 13.5% increase in the relative price of livestock was inspired by Eckstein and Heien (1978) who estimates the elasticity of corn price with respect to livestock price to be .286. A 20% increase in the livestock price will increase the grain price by 5.7% (.286 x 2) so that there will be a 13.5% increase in the price of livestock relative to grain.

EXPERIMENT 5 - In this experiment the U.S. price of livestock (cattle and hogs) as well as the U.S. grain prices (wheat, corn and soybeans) is raised by 13.5% permanently starting 1968-1. This experiment is designed to capture the effect of general inflation in agriculture sector prices relative to the rest of the economy prices.

POLICY EXPERIMENT RESULTS:
Although the results of the five experiments described above are available for all the endogenous variables in the model only the
results of the following six variables, which were selected for the important roles they play in the model and are judged to best describe the internal workings of the model, will be presented and discussed. The selected variables are: grain inventory demand (INVDT), net trade in grains (NTGR), livestock inventory demand (LIVM), the retail price of livestock (LVPP), the regulated sector product price (RSCP), and the retail price index of food (CPIFQ).

It is worth pointing out that in experiments 1 and 3 the experimental value for the variable that is shocked is maintained for 24 quarters; the nature of the shock is permanent. In experiments 4 and 5 the experimental value is maintained for only 1 quarter. The nature of the shock is temporary. Falling in between this permanent and the temporary shock is experiment 2 where the experimental value is maintained for 11 quarters. Consequently, the values taken by the endogenous variables in the experimental solution for experiments 1, 2 and 3, must be interpreted differently from those of experiments 4 and 5 as the former incorporate the impact effect as well as the cumulative totals of the delayed effects. To elaborate, in an experiment where the new experiment value is maintained for n quarters, the changes that take place in the endogenous variables in quarter 1 reflect the impact effect, changes in quarter n reflect the impact effect and the delayed effects from quarter 1 to quarter n-1. For example, the percentage difference between the experiment and control value taken by endogenous variable in the twenty-fourth quarter in experiments 1 and 3, where the shocks are of a permanent nature, represents the cumulative delayed effects of the experiment for the previous 23 quarters plus the impact effect.
of the 24th quarter, whereas in experiments 4 and 5, where the shocks were of a temporary nature, it would represent the delayed effect of the experiment.

To analyze the effect of the experiments, impact and cumulative elasticities are used for experiments 1, 4 and 5; impact and cumulative percentage changes are used for experiment 2 and impact and cumulative multipliers are used for experiments 3. In addition, mean and maximum percentage changes are also calculated for all the experiments.

A short description of these summary statistics that are used to report the results of the experiments follow:

1) Impact elasticity is the percentage change (experiment solution value minus control solution value as a percentage of the control solution value) in the endogenous variable that takes place in the first quarter of the experiment per one percent change in the exogenous (policy) variable.

2) Cumulative elasticity is the cumulative (impact plus delayed) percentage change in the endogenous variable per one percent change in the exogenous (policy) variable.

3) Impact multiplier is the absolute change (experiment solution value minus control solution value) in the endogenous variable that takes place in the quarter in which the exogenous (policy) variable is changed by one unit.
4) Cumulative multiplier is the cumulative absolute change in the endogenous variable per one unit change in the exogenous (policy) variable.

5) Impact percentage change is the percentage change (experiment solution value minus control solution value as a percentage of the control solution value) that takes place in the first quarter of the experiment.

6) Mean percentage change is the mean, taken over the experiment period, of the experiment solution values minus control solution values as a percentage of the control solution value.

7) Maximum percentage change is the maximum within the simulation period of the experiment solution values minus control solution values as a percentage of the control solution values.

EXPERIMENT 1 - EXCHANGE RATE DEPRECIATION

The summary statistics for the results of a permanent (24 quarters) ten percent devaluation of the Canadian dollar is tabulated in Table S1. Figure XI graphically illustrates the dynamic adjustment path taken by grain inventories (INVDT), net trade in grains (NTGR), livestock inventories (LIVM), retail price of meat (LVPP), index of retail price of regulated sector product (RSCP), retail price index of food (CPIFQ) during the course of the experiments.

INVDT:

The impact elasticity of experiment 1 on INVDT is -.08 and
the cumulative elasticity is -1.37. Since grain production is maintained at its historical level during experiment 1 the impact on inventories is a direct result of two factors: the negative impact on inventories of a rise in domestic livestock prices and the positive impact exerted by rising domestic grain prices when the Canadian dollar falls. Evidently, the effect of the rising opportunity costs of holding inventories (by farmers) as the livestock prices rise is stronger then the speculative demand induced by a rise in expected grain prices by grain inventory holders (primarily the wheat board but also includes private grain companies and farmers) as grain inventories are consistently below control with the depreciation of the dollar.

The fall in grain inventories may have been exaggerated because the feedback effect from the increased transaction demand generated by exchange rate induced exports could not be explicitly taken into account in the model. A permanent devaluation of the dollar clearly has a permanent negative impact on grain inventories.

NTGR:

The impact elasticity of experiment 1 on NTGR is .98 and the cumulative elasticity is -.76. Since NTGR is determined as a residual and it is assumed that depreciation does not have any effect on grain production the dynamic adjustment path of NTGR is determined by that of grain inventory demand (INVDT) and feed grain demand (FEGD). With the exception of the first quarter, FEGD decreased to 1973-3 before rising above control while INVDT consistently declined as a result of the depreciation.
This led to a positive but fluctuating percentage changes in NTGR up to the second quarter of 1974. From thereon the percentage changes fluctuated between positive and negative but there was no distinct pattern.

However, the cumulative impact of a permanent 10 percent depreciation of the dollar is negative with net grain exports decreasing below control by 7.6 percent at the end of 24 quarters. This is so because feed demand initially declined as the negative impact of higher feed prices was stronger than the positive effect of livestock prices. This situation reversed itself later as the continuously strong livestock prices accelerated feed demand which exceeded the increases in grain supplied as a result of lower grain inventories. The net effect was a reduction in grain exports.

The short run effect of a permanent devaluation as expected was positive but the long run effect is negative because of an increased demand for grains as an intermediate good into livestock production.

LIVM:

A permanent ten percent depreciation in the exchange rate resulted in an impact elasticity of -.01 and a cumulative elasticity of .79.

During the first three quarters livestock inventories fall because retail meat prices rose as a result of an increase in demand and a decrease in imports induced by the exchange rate depreciation.

From the fourth quarter onwards the exchange rate induced rise in expected livestock prices began to dominate the demand for livestock inventories more so than the concomitant rise in expected feed grain prices and
interest rates. Consequently, livestock inventories began to rise as the capital value of livestock rose relative to the consumption price. With expectations of rising prices sustained by the exchange rate depreciation the strength of the livestock inventory build up was maintained.

A permanent depreciation therefore led to a permanently higher stock of livestock. It is also a reflection of long lags in the livestock industry that at the end of 24 quarters inventories of livestock were still rising.

LVPP:

A permanent ten percent depreciation of the Canadian dollar, resulted in an impact elasticity of .04 and a cumulative elasticity of .8. There was an acceleration of retail meat prices which by the end of the fifth quarter was 9.2 percent above control. Although high retail meat prices restrained demand, the tight meat supplies created by strong investment demand led to a chronic deficient supply situation which did not begin to ease until the third quarter of 1976.

This sequence of events is in accordance with the underlying economic structure of the model. The exchange rate depreciation leads to an immediate sharp rise in Canadian livestock prices and when this was extrapolated led to expectation of higher prices prevailing in the future. As a consequence the demand for investment holdings in livestock started to increase in the third quarter which led to a reduction in slaughter and hence meat supply. The reduction of livestock and meat imports as their domestic currency price rose also made a substantial
contribution to tightening of meat supplies starting from the second quarter. On the other hand, depreciation raised per capita income (in money and real terms) and this led to higher interest rates as the demand for money increased. Higher per capita income raised the demand for meat and higher interest rates reduced the profitability of investment in livestock. The net effect of depreciation however was to increase investment as the price effect prevailed over the interest rate effect and this reduced the current supply of meat with the consequence that meat prices rose sharply and remained above control throughout the experiment period.

RSCP:

The impact elasticity of a permanent exchange rate shock on RSCP is .02 and the cumulative elasticity is .87.

The main channels through which a permanent exchange rate shock is transmitted to RSCP is through interest rates, the wage rate, the CPI-all items and the U.S. poultry price. Unambiguously, all these effects are positive on RSCP. It is worthwhile to note that the expansionary effect of devaluation on disposable incomes does not have any impact on RSCP except through the cross substitution effect of LVPP on PLCPI.

Since price formation within the regulated sector is closely tied to the CPI-all items, wages and interest rates by cost of production formulas, the exchange rate depreciation unambiguously lead to higher retail prices for the regulated sector products.

CPIFQ:

A permanent 10 percent exchange rate shock on CPIFQ will
result in an impact elasticity of 0.08 and a cumulative elasticity of 0.72.

It is worth noting that 70 percent and 94 percent of the total impact has taken place by the end of the 4th quarter and 6th quarter respectively. In other words food prices will rise by 5.7 percent at the end of 4 quarters and by 6.8 percent at the end of 6 quarters if there was a 10 percent permanent depreciation of the dollar.

The main channels of transmission of the exchange rate shock on CPIFQ is through higher levels of income, wage rates, interest rates, and domestic prices of grain and livestock, all of which have a positive impact on RSCP and a net positive impact on LVPP. In addition, the direct transmission of non competing import prices as the exchange rate depreciated also contributes significantly to the rise in CPIFQ.
<table>
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<tr>
<th>VARIABLE</th>
<th>IMPACT ELASTICITY</th>
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<th>MAXIMUM PERCENTAGE CHANGE</th>
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<td>.87</td>
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<td>5) RSCP</td>
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<td>.72</td>
<td>6.99</td>
<td>8.74</td>
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</tbody>
</table>
FIG. XI

BEHAVIOR OF SELECTED ENDOGENOUS VARIABLES FOLLOWING A 10% PERMANENT DEVALUATION (SHOCK MINUS CONTROL AS A PERCENTAGE OF CONTROL)

% 

EXPERIMENT 2 - MONETARY CONTRACTION

In experiment 2, the money supply (MI) growth between 1971-1 and 1973-3 was reduced to 6.3 percent (which was the growth rate of real GDP for the period) from its actual growth rate of 15.2 percent. How does a contractionary monetary policy affect the agriculture sector is the question this experiment attempts to answer.

Table S2 provides summary statistics of the effect of the experiment 2 on the variables - INVDT, NTGR, LIVM, LVPP, RSCP and CPIFQ. FIG X2 graphs the dynamic path taken by these variables following a restrictive monetary policy.

INVDT:

The impact percentage change on INVDT when monetary growth is restricted is .01 and the cumulative percentage change (cumulated to 1973-3) is 3.35. The mean percentage increase in grain inventories is 1.02 percent. However, the maximum percentage change did not occur till 1974-2 when grain inventories were above 9.6 percent above control. This is not surprising because the restrictive monetary policy began to bite on interest rates only in the fourth quarter of 1971 and the exchange rate did not appreciate significantly till the first quarter of 1973. The rise in interest rates and the exchange rate appreciation led to a fall in livestock prices increasing the incentive for holding grain inventories in spite of the fact that expected grain prices have fallen.

NTGR:

Tight monetary policy resulted in an impact percentage
change of - . 1 and a cumulative percentage change of -10.65. The mean percentage change relative to control is - 4.62 percent. Initially, NTGR declined as the exchange rate appreciation lowers livestock prices increasing the incentive for holding grain inventories and increasing feed grain demand as feed grain prices decline. However, towards the end of 1974, after M1 had returned to its historical level, the progressive decline in domestic livestock prices caused by an appreciating exchange rate and rising interest rates led to a fall in feed demand which more than offset the continuing build up of grain inventories. The net decline in domestic demand for grain therefore resulted in increased grain exports. As in experiment 1, the short run response of grain exports is different from the long run response.

LIVM:

A tight monetary policy over the period 1971-1 to 1973-3 would result in a zero impact percentage change and a - . 76 cumulative percentage change. LIVM would, on average, be lower by .26 percentage during the experiment period than would otherwise be the case.

A tight monetary policy produces higher interest rates, and an appreciating exchange rate that lowers the world grain and livestock prices in domestic currency terms. High interest rates and lower domestic livestock prices have a negative effect whereas lower domestic grain prices has a positive effect on livestock inventory demand. At the same time, a tight monetary policy has a deflationary effect on disposable incomes and hence on retail prices of meat which in turn has a positive effect on LIVM. Clearly, the negative effects of a tight monetary
policy dominate the positive effects as LIVM consistently declined. In fact, because of the long lags before the tight monetary policy begins to take effect the maximum reduction in LIVM occurs only in 1975-4 when LIVM is 4.8 percent less than the control solution value. What is evident is the fact that a tight monetary policy continue to exert strong effects on livestock inventories four years after money stock has returned to the control level.

LVPP:

A contractionary monetary policy results in an impact percentage change of -.004 and a cumulative percentage change of -.9 percent. If MI's growth had been arrested for 11 quarters so that it did not exceed real GDP growth meat prices would have decreased at a mean percentage rate of 2.5 percent over the period 1971-1 to 1973-3. The impact of the reduction in money stock growth on LVPP however reached its peak only in 1974-2 when meat prices were lower by 12.8 percent than would otherwise have been the case.

The effects of a tighter monetary policy on meat prices are transmitted through the following channels. A reduction in MI growth, with a lag, raises interest rates which leads to a reduction in a demand for investment holdings in livestock which increases meat supplies and lower meat prices. An additional factor is the appreciation of the exchange rate that followed higher interest rates, which reduced the domestic currency price of U.S. livestock which also provides an incentive for disinvestment in livestock inventories.

Consequently, retail meat prices dropped sharply in the short run but by the end of 1976-4 the adjustment process was largely completed and meat prices climbed back to control levels.
RSCP:

The tight monetary policy led initially to a .09 percent impact increase in RSCP but the cumulative percentage change in RSCP is -2.69. The maximum decline in RSCP, however, did not take place until 1974-2 when RSCP was 4.7 percent below control. The tight monetary policy led to an increase in interest rates, a fall in the wage rate and appreciated the exchange rate. The positive influence of higher interest rates dominated RSCP up till the first quarter of 1972 but when the restrictive monetary policy began to have a significant effect on lowering wages and the exchange rate, RSCP started to fall at a significant rate from the second quarter of 1973 onwards. It should be noted that the deflationary impact of a tight monetary policy on income does not directly affect RSCP.

The result of the experiment showed that a tighter monetary policy than the one that the Bank of Canada actually followed during the period covering 1971-1 to 1973-3 would have resulted in lower regulated sector food prices. More precisely, the index of retail prices of regulated product prices for the 3-year period covering 1973 to 1975 would, on average, be lower by 2.75 percent compared to the control solution.

CPIFQ:

A tight monetary policy will have a deflationary effect on food prices in the short run. The impact percentage change (.04) however is positive and this was caused by a rise in RSCP as interest costs increased. Although it takes several quarters before the influence of a tight monetary policy is felt on food prices, the results of
experiment 2 showed that monetary restraint during the period covering 1971-1 to 1973-3 would have led to food prices that would be lower, on average, by 1.08 percent compared to the control solution.

A tight monetary policy raises interest rates, appreciates the exchange rate lowers wages and reduces disposable income. The negative effect of high interest rates and lower domestic livestock price (result of exchange rate appreciation) dominate the positive effect of exchange rate induced lower feed prices on livestock inventory investment thus increasing the supply of meat. This combined with weak demand as a result of depressed incomes exerts a downward pressure on meat prices. An Appreciating exchange rate also lowers the domestic price of non-competing imports. With lower wages and lower feed prices induced by a strong currency a downward pressure is exerted on the retail prices of regulated sector products even though interest costs have risen. In short, a tight monetary policy contributes towards increasing supplies and reducing the costs of major agricultural products. The net result is a fall in food prices in the short run. However, by the end of 1976-4 food prices had climbed back to control levels.
<table>
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<tr>
<th>VARIABLE</th>
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<td>6) CPIFQ</td>
<td>.04</td>
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BEHAVIOR OF SELECTED ENDOGENOUS VARIABLES WHEN GROWTH RATE OF M1 IS
RESTRICTED TO GROWTH RATE OF REAL GDP (SHOCK MINUS CONTROL AS A
PERCENTAGE OF CONTROL)
EXPANSIONARY FISCAL POLICY

In experiment 3, the effect of a permanent $1 billion tax cut on the agriculture sector is studied. It should be mentioned that throughout this experiment the money stock is held at control so what is being studied is the effect of a demand expansion through a bond financed tax cut. The summary statistics for the experiment is provided in Table S8 and the dynamic adjustment path of the six selected endogenous variables is graphed in Table X3.

INVDT:

A permanent billion dollar tax cut resulted in an impact multiplier of -.01 and the cumulative multiplier is -1.47. It is seen that the tax cut policy does not have a strong effect on INVDT. Since grain and livestock prices are the main determinants of INVDT, interest rates and exchange rates are the two channels through which the tax cut policy could influence INVDT. However, the tax cut policy had only a weak effect on interest rates and exchange rates and therefore on grain inventories.

NTGR:

A permanent tax cut of $1 billion would have almost no effect on NTGR. The impact multiplier is .01 and the cumulative multiplier is -.02. Since food demand for grains is exogenous in the model the tax cut could not affect it. (In any case the effect most probably would be negligible). This leaves open only two other channels mainly the exchange rate and interest rates, which could affect NTGR through the equations for INVDT and FEGD. But as was stated earlier,
the tax cut policy exerted a minimal effect on the exchange rate and interest rates and hence on NTGR, although the cumulative effect, as expected, was negative.

LIVM:

A permanent billion dollar tax cut per quarter results in an impact multiplier of -1.19, and the cumulative multiplier is 26. In other words, LIVM would be 26 million pounds above control at the end of 24 quarters if there was a permanent tax cut of $1 billion.

The tax cut policy raises disposable incomes, interest rates and depreciates the exchange rate. The impact of the tax cut policy on LIVM is transmitted through several conflicting channels. Higher retail meat prices as a result of higher incomes results in lower LIVM as the relative price of meat rises. Higher interest rates for well known reasons has a negative impact on LIVM. The exchange rate effect on LIVM is negative in the short run because of the stronger grain price effect but positive in the long run because of the stronger livestock price effect. The resulting net effect of a tax cut policy on LIVM is negative up to 1974-3 but from there onwards becomes strongly positive.

LVPP:

A billion dollar tax cut per quarter holding money supply at its historical level resulted in an increase of the retail price index of meat by .1 index point in the first period and by 4.78 index points by the end of 24 periods. At first glance, it seems surprising that given the size of the tax cut the cumulative rise in meat prices was only 3 percent of control. However, it must be remembered that
this is a bond financed tax cut which means that interest rates rise. Also the exchange rate depreciates as the trade balance, as a result of the tax cut, deteriorates. The impetus given to the demand for meat by the tax cut did not therefore lead to acceleration of meat prices because a rise in interest rates and a rise in feed costs (induced by exchange rate depreciation) led to a fall in investment holdings of livestock and consequently, the supply of meat was substantially increased.

RSCP:

A tax cut of $1 billion per quarter maintained over 24 quarters has a positive but insignificant impact on RSCP. The impact multiplier is .05 and the cumulative multiplier is 6.21 (which is 3.5 per cent above control).

In a sector where price determination is largely divorced from demand changes an increase in personal disposable income has little impact on RSCP. Also because the tax cut had only a minimal impact on wages, interest rates and the exchange rates - variables which can influence RSCP, the overall impact of the tax cut policy on RSCP was negligible with most of the impacts coming from the cost side.

CPIFQ:

The impact of a billion dollar tax cut on the CPI - food (CPIFQ) is insignificant. The impact multiplier is .06 and at the end of 24 quarters CPIFQ has increased by only 4 index points.

On the surface this result may be surprising but actually it should not be so. It is true that the tax cut did raise personal disposable income but it is also true that financing the tax cut raised
interest rates but in contrast to the tight monetary policy case (which also raised interest rates) the exchange rate depreciated because the balance of payments deteriorated. Although the exchange rate depreciation and the upward movement in interest rates was weak, it did increase meat supplies and this helped to arrest the rise in retail price of meat caused by demand pressures.
TABLE S3: SUMMARY STATISTICS FOR EXPERIMENT 3

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<th>VARIABLE</th>
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<td>5) RSCP</td>
<td>.05</td>
<td>6.21</td>
<td>.84</td>
<td>1.55</td>
</tr>
<tr>
<td>6) CPIFQ</td>
<td>.06</td>
<td>4.0</td>
<td>2.55</td>
<td>4.51</td>
</tr>
</tbody>
</table>
FIG. X3

BEHAVIOR OF SELECTED ENDOGENOUS VARIABLES FOLLOWING A ONE BILLION $ TAX CUT (SHOCK MINUS CONTROL AS A PERCENTAGE OF CONTROL)
EXPERIMENT 4 -- A TEMPORARY RISE IN THE RELATIVE WORLD PRICE OF LIVESTOCK

In experiment 4, the impact of a sharp but short-lived rise in the world price of livestock relative to the world price of grains is studied.

The summary statistics for this experiment is provided in Table S4 and the dynamic adjustment path of the six selected endogenous variables is graphed in Table X4.

INVDT:

The impact of a 13.5 percent temporary rise in the relative world livestock price results in an impact elasticity of -0.09 and a cumulative elasticity of 0. In this experiment, in contrast to experiment 1, domestic grain production is allowed to be affected by the rise in the world livestock price.

Consequently, a rise in world livestock price not only reduces grain production but also reduces grain inventories as livestock production becomes more profitable. Grain inventories were therefore consistently below control. After the second quarter of 1971 the effect of a rise in the livestock price on grain inventories has virtually dissipated.

NTGR:

A sharp rise in the relative world price of livestock would have a large positive impact immediately on NTGR with elasticity equal to 1.64 but the long run effect would be virtually zero.

This is so because with the rise in livestock prices with grain prices remaining unchanged, inventory demand declines by more than feed
demand has increased so that net exports of grain increases. However, the rise in livestock price generated a fall in grain production in the third quarter of 1968 while inventories continued to decline. This led to a reduction in grain supplies and since feed demand continued to increase in response to enhanced profitable opportunities in livestock production more and more grain was diverted from the export market to the domestic market. With the exception of two quarters NTGR was, therefore, below control from 1968-3 onwards.

LIVM:

A 13.5 percent rise in the world price of livestock relative to the world grain price results in an impact elasticity of -01 and a cumulative elasticity of .01. The negative impact effect is a direct result of a reduction in imports which reduced meat supplies and raised the retail price of meat thus increasing the opportunity cost of holding livestock inventories.

When the temporarily higher livestock prices were translated into expected prices, livestock inventories increased, albeit, unsteadily, so that livestock inventories were consistently above control. However, since expectations of higher prices were not sustained additions to the livestock herd declined steadily from 1969-4 onwards.

VPP:

A 13.5 percent temporary rise in the relative price of livestock resulted in an impact elasticity of .03 and induced an accelerated rise in the retail price of meat for the first three quarters, by the end of which, the meat retail price was 6.6 percent above control.
however, this was not to last long as from the seventh quarter onwards, retail meat prices continuously fell below control so that by the end of the 40th quarter meat prices were virtually back at control.

The initial rise in the relative world price of livestock when extrapolated generated expectations of higher future prices which led to increased investment in livestock inventories from the second quarter onwards. But this was a temporary effect as expectations were not sustained. On the other hand, the larger stock of livestock led to increased flow supplies of meat which was more than sufficient to meet the demand. The excess supply of meat consequently resulted in declining meat prices.

RSCP:

The impact of a one period rise in the relative world price of livestock on RSCP can be traced to a single source—the retail price of meat (LVPP) which enters as an explanatory variable in the equation for retail price of poultry (PLCPI) since red meat is a close substitute for poultry. The dynamic adjustment path of RSCP with respect to experiment 4 is therefore determined by the path taken by LVPP. The impact elasticity is .003 and the cumulative elasticity is 0. Evidently, the impact of experiment 3 on RSCP is minimal.

CPIFQ:

A 13.5 percent rise in the relative price of livestock for 1 quarter would result in an impact elasticity of .01 and a cumulative elasticity of 0. The CPI for food will increase by 2.9 percent by the
end of 3 quarters relative to control but by the end of 1969-2 CPIFQ dips down below control. In other words, CPIFQ increased sharply initially as a result of the rise in world livestock prices and then declines slowly over time.

The rise in the world livestock price reduces imports of livestock and meat which lowers meat supplies. The retail meat price, as a consequence, rose leading to a reduction in livestock inventories. Over time, the higher livestock prices and the tight supplies in the domestic market led to increased livestock inventories and hence the flow supply of meat increased which put downward pressure on meat prices. Since the regulated sector retail prices were hardly affected by this experiment the dynamic adjustment path of CPIFQ largely reflects the movements in LVPP.
TABLE S4: SUMMARY STATISTICS FOR EXPERIMENT 4

<table>
<thead>
<tr>
<th>VARIABLE</th>
<th>IMPACT ELASTICITY</th>
<th>CUMULATIVE ELASTICITY</th>
<th>MEAN PERCENTAGE CHANGE</th>
<th>MAXIMUM PERCENTAGE CHANGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) INVDT</td>
<td>-.09</td>
<td>0</td>
<td>-.42</td>
<td>-2.2</td>
</tr>
<tr>
<td>2) NTGR</td>
<td>1.64</td>
<td>.01</td>
<td>-1.44</td>
<td>-53.4</td>
</tr>
<tr>
<td>3) LIVM</td>
<td>-.01</td>
<td>.01</td>
<td>.41</td>
<td>.81</td>
</tr>
<tr>
<td>4) LVPP</td>
<td>.03</td>
<td>0</td>
<td>.23</td>
<td>6.61</td>
</tr>
<tr>
<td>5) RSCP</td>
<td>.003</td>
<td>0</td>
<td>.04</td>
<td>.76</td>
</tr>
<tr>
<td>6) CPIFQ</td>
<td>.01</td>
<td>0</td>
<td>.10</td>
<td>2.86</td>
</tr>
</tbody>
</table>
BEHAVIOR OF SELECTED ENDOGENOUS VARIABLES FOLLOWING A TEMPORARY 13.5%
INCREASE IN THE WORLD PRICE OF LIVESTOCK RELATIVE TO THE WORLD PRICE
OF GRAINS (SHOCK MINUS CONTROL AS A PERCENTAGE OF CONTROL)
EXPERIMENT 5 - A TEMPORARY RISE IN THE ABSOLUTE LEVEL OF WORLD LIVESTOCK AND GRAIN PRICES

In experiment 5, in contrast to experiment 4, the level of world grain prices as well as livestock prices is raised by 13.5 percent for 1 quarter. A temporary shock imposed by a sharp rise in the world agricultural prices is the effect that is being studied in this experiment. The summary statistics for this experiment is provided in Table S5 and the dynamic adjustment path taken by six selected endogenous variables is graphed in FIG. X5.

INVDT:

The impact elasticity of INVDT as a result of a sharp rise in world grain and livestock prices is -0.09. After the second quarter of 1970, the shock has considerably weakened so that by the end of 1977-4 the effect has virtually disappeared. The maximum impact of the experiment was felt in the second quarter when grain inventories were 2.2 percent below control. The dynamic adjustment path of grain inventories in experiment 5 is identical to experiment 4 except for the fact that grain inventories did not decline by as much because of the positive effect exerted by the speculative demand for grain inventories following an increase in grain prices.

NTGR:

A simultaneous rise in the world price of grain and livestock (experiment 5) has the same impact effect (positive) on NTGR as in the previous experiment where only world livestock prices rose but
the maximum fall in net exports which takes place in the third quarter is relatively much smaller. Except for this difference in magnitude, the dynamic adjustment path of $\Delta$ did not differ in any significant manner between the two experiments.

The conclusion that one can draw from those two experiments is that even with grain prices unchanged a change in livestock prices can have a substantial effect on grain exports.

Furthermore, a one percent change in livestock prices while keeping grain prices unchanged will have a larger impact in the short run on grain exports than a one percent change in grain prices, while holding livestock prices unchanged.

LIVM:

A simultaneous increase in world grain and livestock prices leads to an impact elasticity of .01 and while the dynamic adjustment path is identical with the previous experiment, livestock inventories as expected are lower when compared to the previous experiment.

LVPP:

A simultaneous 13.5 percent increase in the world grain and livestock prices has an impact effect of .03 which is identical to the previous experiment. The dynamic adjustment path taken by retail meat prices in experiment 5 is also very similar to experiment 4 except for the fact that meat prices as expected, tend to be lower initially before rising to higher levels. It is worth noting that the impact of livestock prices on meat prices is apparently stronger than that exerted by grain prices.
This asymmetrical response of retail meat prices to temporary shocks in world grain and livestock prices is explained by the different manner in which these external shocks are transmitted to domestic prices. In the case of a rise in grain prices the transmission of world prices to domestic prices is almost instantaneous. This led to a temporary unsustained fall in retail meat prices. In the case of a rise in livestock prices however, the transmission of world prices to domestic prices was not instantaneous and took several years to complete and this led to a slow and long adjustment process in inventories, meat supplies and, in retail meat prices.

RSCP:

A simultaneous increase in world grain and livestock prices leads to an impact elasticity of .003. In contrast to the other variables the rise in grain prices in addition to the rise in livestock prices makes a substantial difference to RSCP as grain prices are an important element in the price setting mechanism. Consequently, when compared to the previous experiment the regulated sector product price remained above control for 5 quarters longer and the maximum impact of the experiment is approximately 65 percent greater when compared to the previous experiment.

CPIFQ:

A sharp increase in grain prices together with the increase in world livestock prices (experiment 5) resulted in an impact elasticity of .01 which is identical with that of experiment 4 and
the dynamic adjustment path taken by CPIFQ is similar except that it took two more quarters before CPIFQ went down below control.
<table>
<thead>
<tr>
<th>VARIABLE</th>
<th>IMPACT ELASTICITY</th>
<th>CUMULATIVE ELASTICITY</th>
<th>MEAN PERCENTAGE CHANGE</th>
<th>MAXIMUM PERCENTAGE CHANGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) INVDT</td>
<td>-.09</td>
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<td>-.38</td>
<td>-2.2</td>
</tr>
<tr>
<td>2) NTGR</td>
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<td>-.01</td>
<td>-.66</td>
<td>-28.46</td>
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<tr>
<td>3) LIVM</td>
<td>-.01</td>
<td>.01</td>
<td>.37</td>
<td>.74</td>
</tr>
<tr>
<td>4) LVPP</td>
<td>.03</td>
<td>0</td>
<td>.22</td>
<td>5.60</td>
</tr>
<tr>
<td>5) RSCP</td>
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<td>0</td>
<td>.12</td>
<td>1.24</td>
</tr>
<tr>
<td>6) CPIFQ</td>
<td>.01</td>
<td>0</td>
<td>.13</td>
<td>2.65</td>
</tr>
</tbody>
</table>

TABLE S5: SUMMARY STATISTICS FOR EXPERIMENT 5

Simulation Range: 1968-1 to 1977-4
Policy Simulation Change: 1968-1 to 1977-4
Experiment Value Sustained: 1 Quarter
BEHAVIOR OF SELECTED ENDOGENOUS VARIABLES FOLLOWING A TEMPORARY 13.5% ABSOLUTE INCREASE IN THE WORLD PRICES OF LIVESTOCK AND GRAINS (SHOCK MINUS CONTROL AS A PERCENTAGE OF CONTROL)
CHAPTER 8: SUMMARY AND CONCLUSIONS

This study used a three-sector econometric simulation model of the Canadian agricultural sector to empirically investigate the impact of changes in exchange rates, fiscal and monetary policies and exogenous changes in the world grains and livestock prices on the Canadian agricultural sector in general and Canadian food prices in particular. The Bank of Canada RDX2 model was relied upon to generate the experimental values for the five macro variables which are exogenous to the Canadian agricultural sector model namely: personal disposable income, interest rates, the CPI, the wage rate, and the exchange rate.

The econometric model was estimated using ordinary least squares and two stage least squares and the results on the whole were satisfactory when judged by standard statistical criteria and bearing in mind that the objective was to obtain theoretically sensible and whenever possible statistically significant coefficients for the construction of a simulation model to conduct policy experiments. The estimated model when dynamically simulated as a complete system performed well and on the whole tracked the historical path of the endogenous variables closely. Both formal and informal validation tests conducted on the model revealed that its performance was consistent with what the underlying economic theory would have predicted.

Consequently, five simulation experiments were conducted on the model and a selection of the experiment results were reported and discussed in detail in the previous chapter. On the basis of the experiment results the following conclusions can be drawn:

1) Exchange rate changes have a major impact on the Canadian
agricultural sector and on food prices. Indeed, a one percent depreciation of the Canadian dollar will have a larger impact effect on retail meat prices than a one percent rise in absolute as well as relative world grain and livestock prices. This result it should be noted, incorporates not only the direct impacts of the exchange rate change on the interrelated grain and livestock sectors but also the indirect effects of the exchange rate change transmitted to the livestock sector through the macro variables particularly, disposable income, and interest rates.

The effects of a permanent depreciation of the exchange rate is reflected in a rise in food prices within a relatively short period of time. If the Canadian dollar depreciates by 10 percent permanently food prices would rise by 7.2 percent within 7 quarters and given that CPI - food has a 24.8 percent weight in the total CPI, the rate of inflation as measured by the latter index would rise by 1.8 percent. Food prices, can therefore be an important conduit through which exchange rates changes raise the measured CPI.

A permanent depreciation of the dollar results in a fall in net grain exports in the long run. In the short run, however, exports will increase as expected. This result is explained by rising feed grain demand which exceeds available supplies as, in the longer run, livestock inventories expand in response to increased profit opportunities.
Monetary policy has a significant impact on the grain sector, the livestock sector, the regulated sector and on food prices. The influence of monetary policy on the agricultural sector acting through interest rates, disposable income, the exchange rate, the wage rate, and the CPI, is, therefore, pervasive. The results of the monetary policy experiment showed that if the Bank of Canada restricted money supply growth (M1) to equal real GDP growth over the period 1971-3 to 1973-3 food prices would have been lower by 4.79 percent in 1973-3 and 6.6 percent in 1973-4.

Fiscal expansion, as measured by a permanent billion dollar tax cut while holding money stock at its historical level, will raise livestock inventories by 26 million pounds in the long run and raise food prices by 4 index points. The impact of fiscal policy on the agricultural sector is generally weak.

Temporary shocks in the form of sharp rises in world livestock prices relative to world grain prices and in the absolute rise in the world livestock and grain prices which are frequently experienced in the Canadian agricultural sector does not have a significant impact on the sector in the long run. Furthermore, temporary sharp increases in livestock prices while keeping grain prices constant has a deeper impact on both the livestock as well as the grain sectors than equivalent shocks in the form of a sharp rise in grain prices with livestock prices held constant. On the other hand, a grain price shock has a larger impact on regulated sector prices than on equivalent livestock price shock.
It has been a tradition in the economic policy making process that, in general, macro-policy formulation and execution is independent from the formulation and execution of agriculture policy. As much as beef prices must seem remote to Bank of Canada officials when they set monetary targets or intervention points for the Canadian dollar and to Finance officials when they determine the size of the budgetary deficit, the determination of exchange rates and interest rates have not, until recently, been the major concern of Canadian Wheat Board or Canadian Dairy Commission officials. However, contemporary events in the Canadian economy suggest and the empirical results of this thesis support the case that the forward linkages from the macro economy to the agricultural sector particularly through the exchange rate, interest rate and income channels are strong and so also is the backward linkage from the agriculture sector to the macro economy through food prices. Consequently, it can be stated that a closer coordination of policies at the two levels of economic decision making i.e. at the macro and at the sectoral level, will prove to be mutually advantageous.

Limitations and Directions for Future Research

It is not difficult to admit that in constructing, estimating, simulating and experimenting with a thirty four equation model of the Canadian agricultural sector with limited resources there are bound to be shortcomings. Among these shortcomings the following two particularly should be mentioned:

1) Statistical techniques used have been rudimentary
and there is much room for further experimentation with a wider range of statistical estimation and validation techniques which can only increase the reliability of the estimated coefficients.

2) More experimentation is needed with alternative forms of structural specification and expectations formation.

3) Relative prices are absent from the estimated model.

The demand and supply equations in the model as estimated do not contain relative prices as required by a theoretically correct specification. At least, in all the equations other than the livestock and import demand equation (eq: 17) and in the retail meat demand equation (eq: 21:) it can be said in their favour that the undeflated substitute good price is included as an explanatory variable. But in the latter two equations the attempt to estimate the equations using undeflated substitute good prices as well as deflating all the nominal variables on the right hand side of the equation (including the substitute good price) with the CPI - all items was not successful as the coefficient of the own price variable was insignificant and the coefficient of the substitute good price variable turned negative.

Particularly, in the case of these two demand equations in the livestock sector, therefore, the absence of relative prices, which is required if the specification is to be theoretically correct, may have introduced a distortion to the experiment results.

In both these cases, the direction of the bias that may have been introduced because absolute prices have been used where relative prices are called for, cannot be determined a priori. However, because meat supply will be affected by the livestock and meat imports equation and meat demand will
be affected by the per capita retail meat demand equation, the absence of relative prices when the model was estimated may have affected the accuracy of the retail meat price index (and hence the food CPI) and the livestock inventory demand variables during the simulation experiments. The interpretation of simulation experiment results on the variables LVPP, LIVM and CPIFQ should therefore take into consideration the above caveats.

A major finding of this thesis is that there are strong forward and backward linkages (through food prices) between the macro economy and the Canadian agriculture sector. This finding therefore suggests that by neglecting feed back effects from the agriculture sector particularly food prices the macro models are missing valuable information while the agriculture sector models even those that take into account forward linkages from the macro economy like the present one are not receiving fully accurate information from the macro models.

Clearly, then a refined version of the model outlined in this thesis therefore offers a viable opportunity to imbed the sectoral model into the national macro econometric model so that the sectoral impacts on the agricultural sector of the Canadian macro economic policy and the macro economic impacts of the Canadian agricultural policy can be studied and analyzed with far more greater detail and accuracy than has been so far been possible. If this thesis has made a positive contribution towards this direction then the effort put into it, in my view, has been worthwhile.
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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APPENDIX A

BLOCK STRUCTURE ANALYSIS OF
THE SIMULATION MODEL

NUMBER OF BLOCKS = 31

BLOCK 1
EQ NUM  VARIABLE
1       GRACQ

BLOCK 2 DEPENDENT ON BLOCK 1
EQ NUM  VARIABLE
2       GPRDQ

BLOCK 3 DEPENDENT ON BLOCK 2
EQ NUM  VARIABLE
3       GPRS

BLOCK 4
EQ NUM  VARIABLE
7       BACP

BLOCK 5
EQ NUM  VARIABLE
8       FGRPX

BLOCK 6
EQ NUM  VARIABLE
9       OILPX

BLOCK 7 DEPENDENT ON BLOCK 6
EQ NUM  VARIABLE
11      FAOP
BLOCK 8
EQ NUM 12
VARIABLE FEGPX

BLOCK 9 DEPENDENT ON BLOCKS 8 6 5
EQ NUM 10
VARIABLE GRAPX

BLOCK 10
EQ NUM 13
VARIABLE CANPSS4

BLOCK 11
EQ NUM 14
VARIABLE CANPHG4

BLOCK 12 DEPENDENT ON BLOCKS 10 11
EQ NUM 15
VARIABLE CANUSLP

BLOCK 13 DEPENDENT ON BLOCK
EQ NUM 17
VARIABLE MTIM

BLOCK 14 DEPENDENT ON BLOCK 12
EQ NUM 23
VARIABLE LIVPX

BLOCK 15 DEPENDENT ON BLOCKS 14 8
BLOCK 16  DEPENDENT ON BLOCK 14
EQ NUM  5
  VARIABLE
  INVDT

BLOCK 17
EQ NUM  26
  VARIABLE
  GTRM

BLOCK 18  DEPENDENT ON BLOCK 17
EQ NUM  25
  VARIABLE
  DPRP

BLOCK 19
EQ NUM  29
  VARIABLE
  POFP

BLOCK 20  DEPENDENT ON BLOCKS 8 6
EQ NUM  30
  VARIABLE
  EGGFP

BLOCK 21  DEPENDENT ON BLOCK 20
EQ NUM  31
  VARIABLE
  REGGP

BLOCK 22  DEPENDENT ON BLOCK 21
EQ NUM  28
  VARIABLE
  ECPI

BLOCK 23
EQ NUM  33
  VARIABLE
  CANPASH
BLOCK 24  DEPENDENT ON BLOCKS  3  16  15
  EQ NUM  VARIABLE  
   6  NTGR

BLOCK 25  DEPENDENT ON BLOCKS  13
  EQ NUM  VARIABLE  
   18  NTMT

BLOCK 26
  EQ NUM  VARIABLE  
   19  LVPP
   20  LIVM
   21  PCLVPD
   22  DMTSY

BLOCK 27  DEPENDENT ON BLOCK  26
  EQ NUM  VARIABLE  
   24  LIVO

BLOCK 28  DEPENDENT ON BLOCKS  19  26
  EQ NUM  VARIABLE  
   27  PLCPI

BLOCK 29  DEPENDENT ON BLOCKS  7  26  18  22  28  23  4
  EQ NUM  VARIABLE  
   34  CPIFQ

BLOCK 30  DEPENDENT ON BLOCK  27
  EQ NUM  VARIABLE  
   16  TLIVO
BLOCK 31  DEPENDENT ON BLOCKS  18  22  28
EQ NUM   VARIABLE
32        RSCP