THE UNIVERSITY OF MANITOBA

THE EFFECT OF MONETARY POLICY ON THE NET REVENUE OF WESTERN CANADIAN WHEAT PRODUCERS

by

© NEIL ALLEN HAMILTON

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE

OF DOCTOR OF PHILOSOPHY

DEPARTMENT OF AGRICULTURAL ECONOMICS AND FARM MANAGEMENT

May, 1986

ISBN 0-315-33887-3

THE EFFECT OF MONETARY POLICY ON THE NET REVENUE OF WESTERN CANADIAN WHEAT PRODUCERS

BY

NEIL ALLEN HAMILTON

A thesis submitted to the Faculty of Graduate Studies of the University of Manitoba in partial fulfillment of the requirements of the degree of

DOCTOR OF PHILOSOPHY

ABSTRACT

The Effect of Monetary Policy on the Net Revenue of Western Canadian Wheat Producers

by

Neil Allen Hamilton

Major Advisor: Dr. Colin Carter

Changes in the structure of agriculture have made producers more vulnerable to fluctuations in exchange rates, interest rates and inflation rates. The aforementioned variables are interrelated, as well as being jointly influenced by the Bank of Canada's monetary policy. The simultaneous adjustments which occur as a result of a shift in monetary policy affect each subsector of the economy in a different way. This study gives special consideration to the wheat producing sector due to its relative importance within the Canadian economy.

Throughout this thesis, net revenue is used as welfare measure. From a policy standpoint, it is important to determine how a change in Canada's monetary policy will impact on the net revenue (welfare) of individual wheat producers. In pursuing this goal, four specific objectives were outlined. These include: (1) to examine the theoretical relationship between monetary variables and the Canadian wheat industry; (2) to build a model which can be used to estimate the impact of monetary shocks; (3) to use the model to simulate how net revenue is affected by changes in monetary policy; and (4) to analyze the simulated results in order to provide policy prescriptions.

The estimated models are used to simulate how net revenue reacts to four different monetary policies. These include: a change in the size

of the money supply; and change in the growth rate of the money supply; as well as a change in the Bank of Canada's target interest rate and target exchange rate. In each scenario, the chain of events begins with a manipulation of the money supply, which in turn affects the interest rate, the Cdn./U.S. exchange rate and the domestic inflation rate.

The results of the study suggest that in the short run there is a positive relationship between the net revenue of individual wheat producers and changes in the money supply. Monetary policies which lead to an increase in the money supply exert a negative pressure on interest rates while at the same time causing the Cdn./U.S. exchange rate and the domestic inflation rate to rise. When the underlying relationships are examined, net revenue is found to be negatively related to interest rates and positively related to movements in the Cdn./U.S. exchange rate. The manner in which domestic wheat prices react to a change in the Cdn./U.S. exchange rate overshadows the impacts which interest and inflation rates exert on the cost of producing wheat.

Out of the four scenarios which were tested, a 1 percent change in the Bank of Canada's target interest rate produced the greatest change in a wheat producer's net revenue. Adjusting the growth rate of the money supply by 1 percent accounts for the second largest response. The third and fourth largest reactions are produced by a 1 percent change in the target exchange rate and a 1 percent change in the level of the money supply, respectively.

It is important to consider all of the implications which arise from a change in monetary policy. Examining the problem from a partial equilibrium setting may shed some light on how exchange rates affect export prices, or how interest rates impact on production costs, but tells us relatively little about how a producer's overall net revenue position is affected. This study attempts to bridge the macro-micro gap by outlining a model which is capable of assessing the microeconomic impacts which result from a particular change in monetary policy.

ACKNOWLEDGEMENTS

There are a number of people who were crucial in the development of this thesis. Dr. Colin Carter, who acted as my major advisor, provided constant encouragement and numerous constructive comments. Dr. Norman Cameron was instrumental in conceptualization of this thesis, and the macroeconomics contained herein are greatly improved by his input. A great deal of thanks is due to Dr. Harold Bjarnason and Dr. Bill Wilson for their probing questions and enlightening comments.

Special thanks is also extended to the Canadian Wheat Board, which provided financial support through its graduate fellowship program. Professor Peter Dungan and Mary MacGregor of the Institute for Policy Analysis expedited this work by supplying the required macroeconomic simulations. Edna Hiebert's diligent typing contributed to a simplified editing process.

The final acknowledgement is reserved for my family and friends. Throughout my entire time at university, my parents and family provided unwavering encouragement. Last but certainly not least, I would like to thank my wife, Diane, a co-sufferer and constant supporter throughout this entire process.

TABLE OF CONTENTS

Page

LIST OF TABLES

Page

LIST OF FIGURES

CHAPTER I

INTRODUCTION

1.1 Problem Statement

During the late 1960's and early 1970's, the Bretton Woods system of fixed exchange rates became a contributing force behind the worldwide balance of payments problem. By 1971, foreign holdings of U.S. dollars had grown to the point where U.S. gold reserves stood at only one sixth the size of the official U.S. foreign liability.[1] The U.S. administration reacted to this situation by refusing to convert U.S. U.S. dollars into gold and abandoned the defense of the U.S. dollar in foreign exchange markets. A subsequent meeting of world financial leaders in December 1971, resulted in the Smithsonian Agreement, whereby world currencies were revalued relative to gold.

Although the value of the U.S. dollar declined following revaluation, the move was not sufficient to restore international stability. In March 1973, the Bretton Woods system was officially abandoned, leaving in its place a complicated array of convertible and pegged currencies which function under the general guise of managed flexibility.

During the period of fixed exchange rates, the behavior of the Canadian dollar was rather unique. When the Bretton Woods system was originally established in 1944, Canada was one of 40 countries which agreed to peg the value of its currency. However, unlike other countries, Canada had initially abandoned fixed rates in October 1950 only to rejoin

---

[1]N.E. Cameron, Money, Financial Markets and Economic Activity. (Don Mills, Ont.: Addison-Wesley Publishers, 1984). pp. 603-604.

the system in May 1962. On the date that Canada rejoined the fixed exchange rate system, the Cdn./U.S. rate was pegged at \$1.081.[2] However, an unusually strong current account and a normal capital inflow led the Canadian Government to once again abandon fixed rates effective June 1, 1970.

Following Canada's adoption of flexible rates, the Cdn./U.S. exchange rate experienced a rapid revaluation falling from \$1.081 to below par. As depicted in Figure 1, the five years following the revaluation (1971-1976) failed to produce a pronounced trend in the Cdn./U.S. exchange rate.[3] However, beginning the fourth quarter of 1976, the value of the Canadian dollar began a protracted decline.

In late 1975 the Bank of Canada adopted a policy of Gradualism. Under this regime the growth rate of the money supply (M1) was gradually reduced in the aim of reining in inflation. Not surprisingly, this tight money policy contributed to a positive differential between Canadian and U.S. short term interest rates. As Canadian interest rates increased, private corporations and provincial crown corporations began to float an increased volume of bonds in the U.S. market.[4] The result was an immediate increase in the amount of long-term capital flowing into Canada,

---

[2]Given that the U.S. dollar is the predominant world currency, normal contention is to express exchange rates with U.S. dollars in the denominator. If the Cdn./U.S. exchange rate is \$1.081, then the value of the Canadian dollar is 92.5 cents U.S.. Therefore, the Cdn./U.S. exchange rate and the value of Canadian dollars in terms of U.S. dollars are reciprocals. As the Cdn./U.S. exchange rate increases, the value of the Canadian dollar decreases.

[3]C. Freedman and D. Longworth, "Some Aspects of the Canadian Experience with Flexible Exchange Rates in the 70's", Technical Report 20, Bank of Canada, July, 1980, p. 7.

[4]C.L. Barber and J.C.P. McCallum, Unemployment and Inflation, the Canadian Experience. (Toronto: James Lorimer & Company in association with The Canadian Institute for Economic Policy, 1980), p. 70.

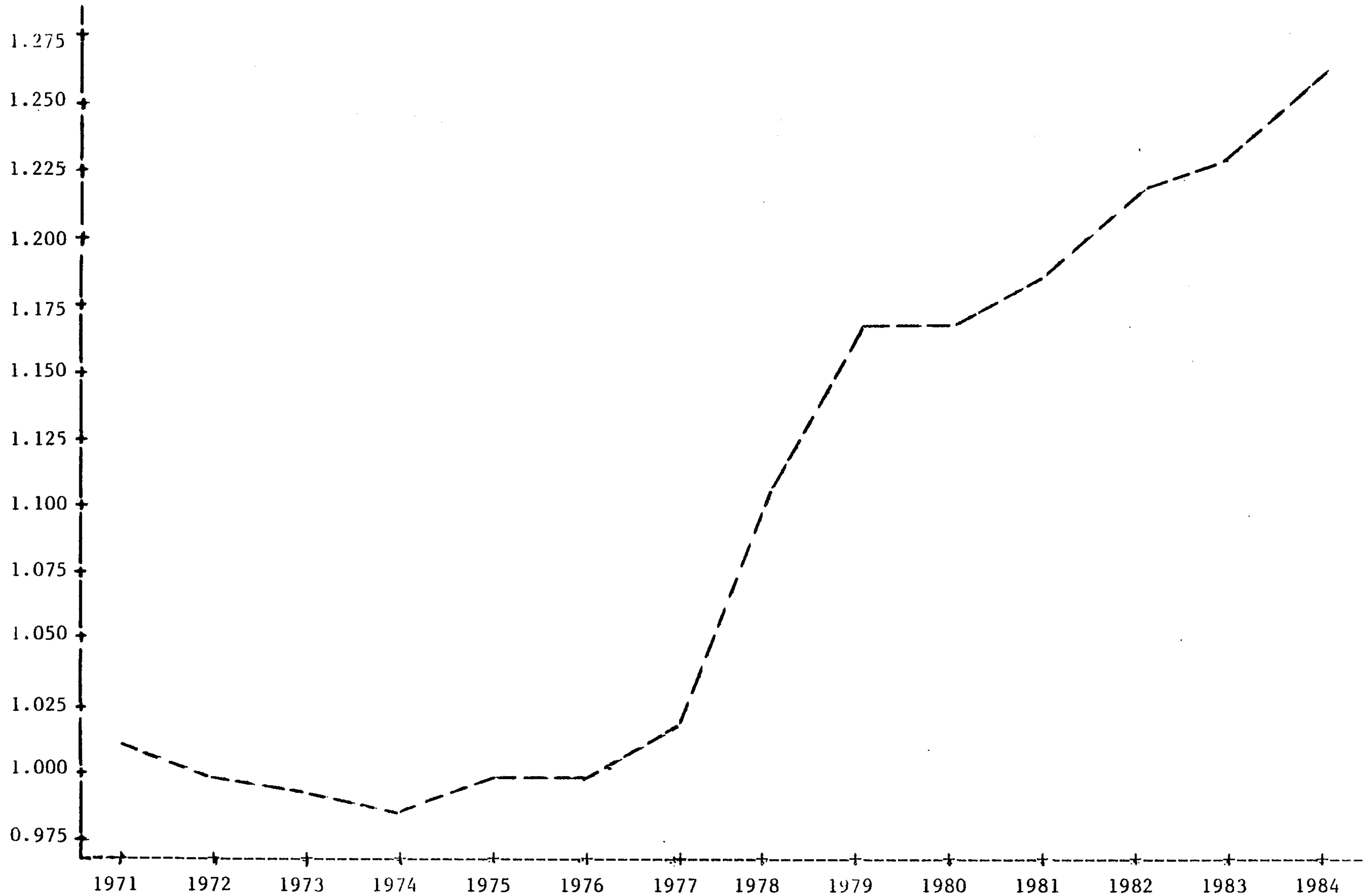

Figure 1

Cdn./U.S. Exchange Rates

Source: Bank of Canada, <u>Bank of Canada Review</u>, various issues.

and an increased requirement for future debt servicing. Escalating debt payments, poor performance in merchandise trade, and reduced international confidence in Canada's fiscal affairs due to high inflation, unemployment and internal struggles with Quebec, all combined to exert negative pressure on the value of the Canadian dollar.

The long slide in the value of the Canadian dollar was successful in reestablishing Canada's competitive position in merchandise trade. In 1975 Canada recorded a trade deficit of $638 million, but as the Cdn./U.S. exchange rate appreciated (i.e., the value of the Canadian dollar declined), the deficit quickly turned into a surplus. By 1982 Canada's net trade balance stood at a record level of $17.8 billion.[5]

It is debatable whether a depreciation in the value of the Canadian dollar benefits or harms the Canadian economy. As noted in the previous paragraph, depreciation increased Canada's international competitive position and hence, reduced unemployment. However, declines in the value of the Canadian dollar produce an increased rate of domestic inflation (through the increased price of imported goods) and may also result in an increase in nominal Canadian interest rates.

Examining monetary shocks from a traditional macroeconomic context does not always provide an adequate base for analysis. In order to analyze the full effect of monetary shocks, a disaggregated approach is required. Individual sectors of the economy will react in different ways. In some sectors monetary shocks will transmit directly into the price of both inputs and final products, while in other sectors the linkage may be indirect or possibly even nonexistent.

---

[5]Bank of Canada, Bank of Canada Review, Table 68, p. S130, July 1984.

Monetary linkages between the macroeconomy and agriculture represent an important area of study. This is particularly true in the case of Canadian wheat production, where monetary variables such as exchange rates, inflation rates and interest rates are expected to have an impact on both the profitability and behavior of individual firms. Although considerable effort has been extended at the macroeconomic level, little has been written in regard to the macro-micro linkages. As Schuh[6] notes, the literature which exists on the macroeconomics of agriculture is cast in a sectoral context. As a result, the linkages between individual agricultural units and the general economy have tended to be ignored.

In order to provide a clear illustration of the relationship between Canada's macroeconomy and an individual wheat producer, this study will examine four monetary linkages. The first two deal with the impact of exchange rates on both the Canadian wheat market and the factor input markets. A third linkage lies between the factor input markets and domestic inflation, while a fourth and final linkage relates to interest rates as an input in wheat production. These four linkages are discussed in the following paragraphs.

The first consideration is the structure and behavior of the world wheat market. There are at least three competing theories regarding the formation of wheat prices. In their 1978 article, Alaouze, Watson and Sturgess[7] argue that the world wheat market is best described as a

---

[6] G.E. Schuh, "The New Macroeconomics of Agriculture", AJAE, Vol. 58, December 1976, pp. 802-811.

[7] C.M. Alaouze, A.S. Watson and N.H. Sturgess, "Oligopoly Pricing in the World Wheat Market", AJAE, Vol. 60, No. 2, May 1978, pp. 174-185.

triopoly, with Canada acting as the price leader. Carter and Schmitz[8] take a different tack, hypothesizing that world prices are set by major importers such as Japan and the EEC through manipulation of import tariffs (or their quota quivalents). Recent studies by Oleson[9] and Groenewegen[10] conclude that Canada's role has shifted from price leader to price taker, with world wheat prices established in the U.S. market.

All of these theories will be dealt with later, but for the time being, if we are willing to accept that the U.S. behaves as a price leader, then it is possible to envision how a change in exchange rates will impact on Canadian wheat prices. The problem revolves around two exchange rates; the relative value of world currencies in terms of U.S. dollars, and the conversion between Canadian and U.S. dollars. Assuming that international wheat sales are prices in U.S. dollars, the relative value of the U.S. dollar becomes very important to wheat importers. When the value of the U.S. dollar increases, the price of wheat as expressed in an importer's currency will also increase. The price change which results from an adjustment in the value of the U.S. dollar will be tempered by the fact that most importing nations insulate their domestic price from the world price. The result is that a change in the value of the U.S. dollar will probably not have that large an impact on the export demand for wheat.

---

[8]Colin Carter and Andrew Schmitz, "Import Tariffs and Price Formation in the World Wheat Market", AJAE, Vol. 61, No. 3, Aug. 1979, pp. 517-522.

[9]B.T. Oleson, "Price Determination and Market Share Formation in the International Wheat Market", unpublished Ph.D. Thesis, University of Minnesota, Aug. 1979, pp. 158-164.

[10]J.R. Groenewegen, Market Commentary. (Ottawa: Agriculture Canada, June, 1984), pp. 14-19.

Given that Canada is not an importer of wheat, and assuming once again that world wheat prices are denominated in U.S. dollars, a change in the Cdn./U.S. exchange rate is not expected to exert a pronounced influence on Canadian wheat exports. Although Canadian export prices as expressed in U.S. dollars remain constant as the Cdn./U.S. exchange rate changes, the Canadian domestic price (as expressed in Canadian dollars) will be directly affected. In other words, as the Cdn./U.S. exchange rate increases, both the price received by Canadian producers and the price paid by Canadian consumers will increase.

Figure 2 provides an illustration of price spreads between Canada and the U.S. Between 1970/71 and 1976/77, Canadian and U.S. wheat prices followed each other very closely. However, beginning in 1976/77, the Cdn./U.S. exchange rate escalated rapidly (Figure 1) and the gap between Canadian and U.S. prices as expressed in their own currencies began to widen. As the Cdn./U.S. exchange rate continued to appreciate, the price difference widened to its 1983/84 level of approximately $56 per tonne. Meanwhile, Canadian and U.S. wheat prices as expressed in U.S. dollars maintained a fairly parallel course.

Throughout the period of appreciating Cdn./U.S. exchange rates, it appears that the C.W.B. chose to price wheat in U.S. dollars. It has been widely argued that a deterioration of the Canadian grain transportation system contributed to a reduction in Canadian wheat exports from 1976/77 to 1978/79.[11] If transportation was a serious constraint, as suggested by the CWB's purchase of hopper cars, the policy of pricing export sales in U.S. dollars probably was successful in maximizing producer returns. If

---

[11]Hon. Jean-Luc Pepin, Minister of Transportation, in an address to the Saskatchewan Wheat Pool Annual Meeting of Delegates, 1980. Regina, Saskatchewan, Nov. 20. 1980.

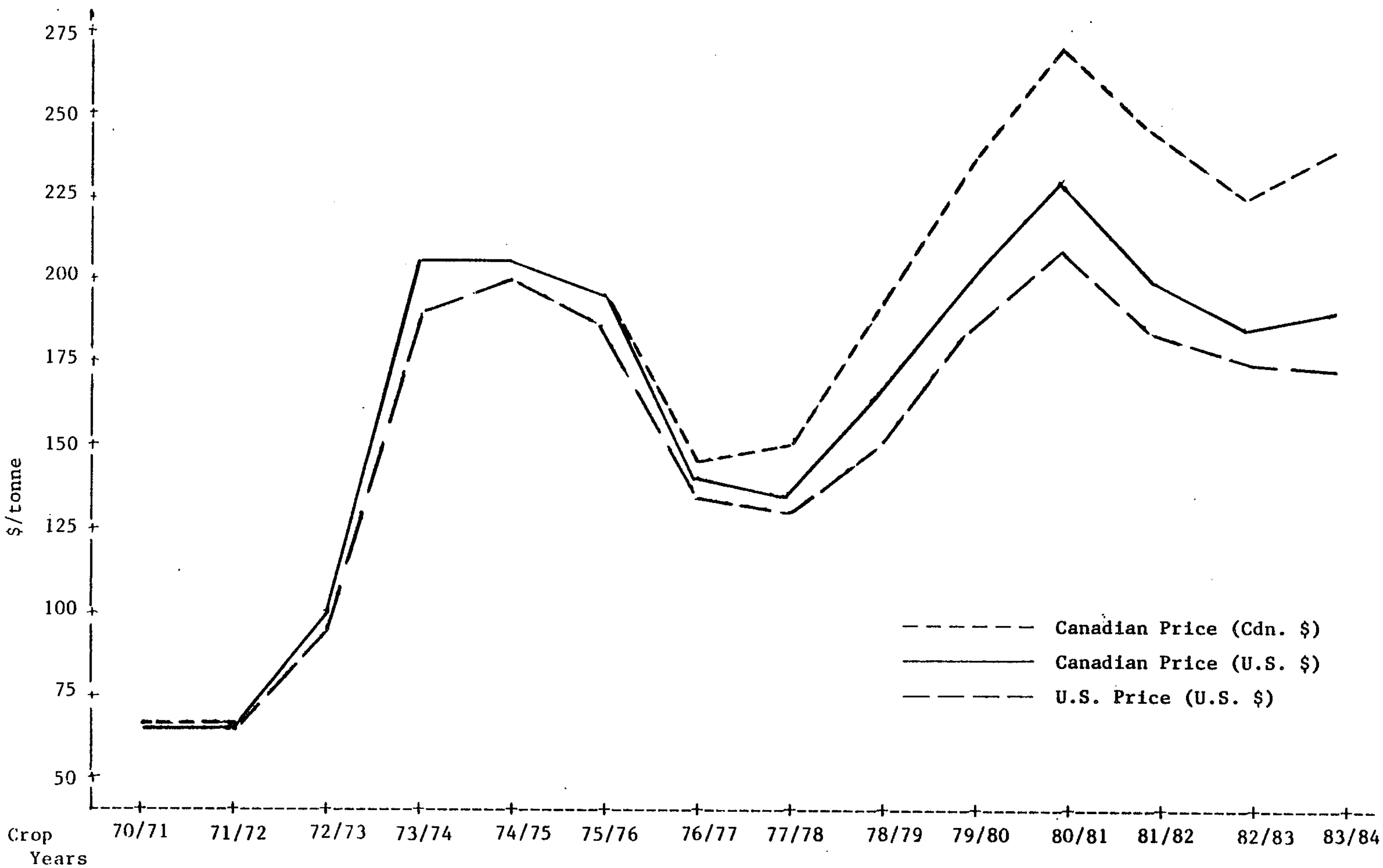

Figure 2

Wheat Prices

Source: International Wheat Council, <u>World Wheat Statistics</u>, 1984 the Wheat Board had chosen to use the devaluation in the Canadian dollar to undercut U.S. prices, Canada would have assumed the role of price leader with the U.S. following suit. Consequently, Canadian producers would have suffered a decline in domestic price without receiving any benefit through increased exports.

The result of the CWB's pricing policy was that Canadian market share did not increase as the Cdn./U.S. exchange rate increased. Figure 3 plots Cdn./U.S. wheat exports and the Cdn./U.S. exchange rate over the 1970/71 to 1983/84 period. Relative export volumes are used in place of absolute levels in order to separate changes in the Cdn./U.S. relationship from general deviations in world wheat trade.

In examining Figure 3, it is obvious that Canadian wheat exports did not increase relative to U.S. exports as the Cdn./U.S. exchange rate increased. If anything, the overall relationship appears to be negative; however, there are certain instances where changes in Cdn./U.S. exports do appear to coincide with changes in the Cdn./U.S. exchange rate. Although a weak relationship could be postulated, these parallel movements may be better explained by variations in supply and demand.

For example, between 1972/73 and 1973/74, Cdn./U.S. wheat exports and the Cdn./U.S. exchange rate declined simultaneously. The reduction in the Cdn./U.S. market share was more likely due to a difference in storage stocks and productive capacity than to a change in the exchange rate. At the beginning of the 1972/73 crop year, U.S. wheat stocks exceeded Canadian levels by 8.6 million tonnes.[12] This large difference was partly due to Canada's LIFT program, which was instituted in 1971 to take land

[12]Wheat market statistics are included in Appendix A.

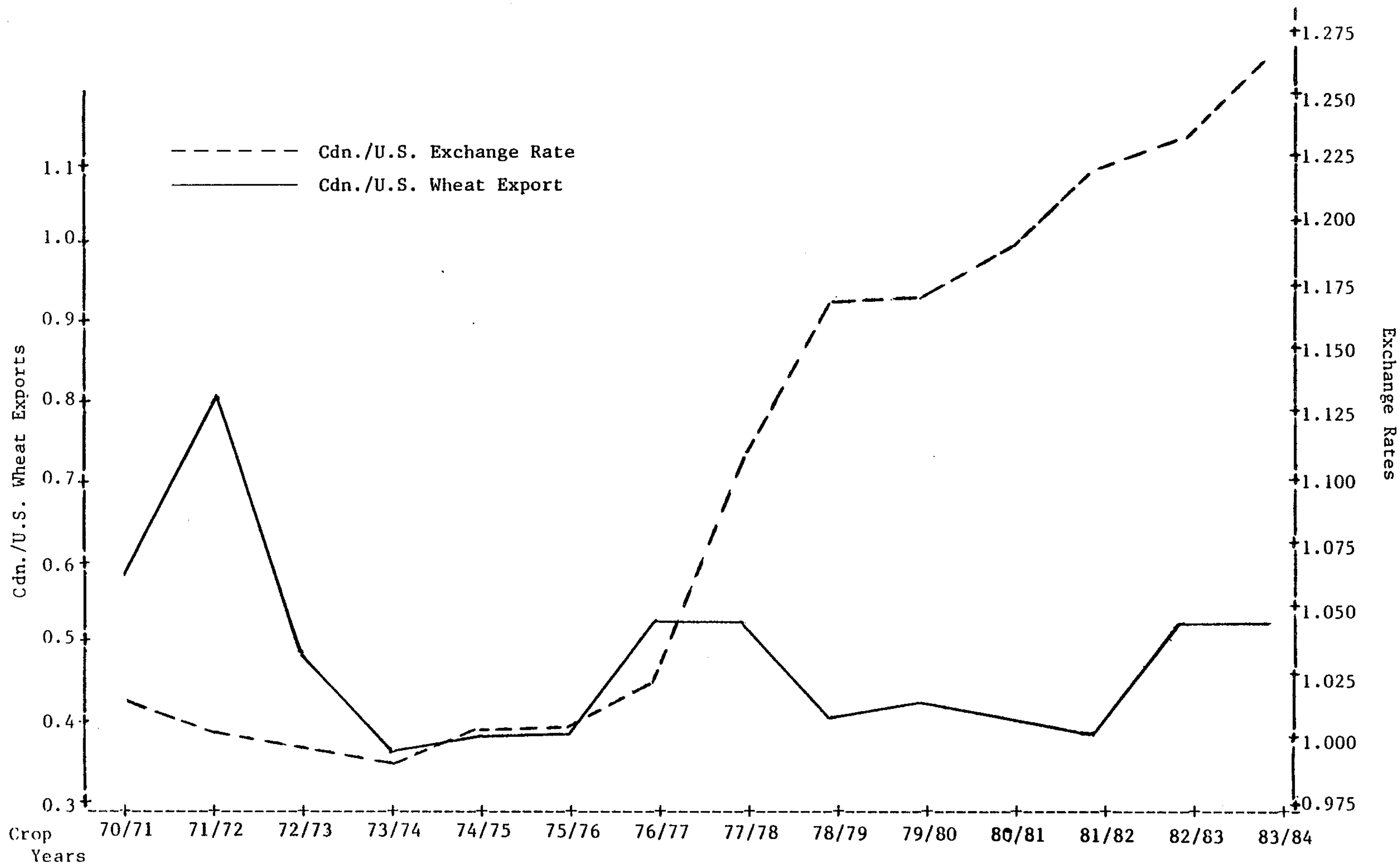

Figure 3

Cdn./U.S. Exchange Rates vs. Cdn./U.S. Wheat Exports out of production and reduce storage stocks. As wheat prices began to escalate in 1973, the U.S. capitalized on its existing storage stocks and huge productive capacity in order to outpace Canadian wheat exports.

A second example of a parallel movement between export ratios and the exchange rate took place between 1975/76 and 1976/77. Declining prices led the U.S. to reduce wheat exports throughout this period resulted in an increase in Cdn./U.S. export ratio. This was compounded by a dramatic increase in the exportable surplus of both Argentina and Australia which cut into markets previously served by the U.S.. Argentina's exports increased from 3.1 million tonnes in 1975/76 to 5.8 million tonnes in 1976/77. Australian exports increased at a lower rate, rising from 8.2 to 9.7 million tonnes.

The final period to be considered covers 1981/82 to 1982/83. The behavior of the Cdn./U.S. export ratio during this period can largely be explained by Soviet purchases. Following the U.S. embargo in 1980, the U.S.S.R. began to rely more heavily on Canada for its wheat supply. U.S. exports to the U.S.S.R. fell from 6.9 million tonnes in 1981/82 to 3.0 million tonnes in 1982/83. Meanwhile, Canadian exports to the U.S.S.R. grew from 4.8 to 7.0 million tonnes. In total, the U.S.S.R.'s purchases resulted in a net shift of 6.1 million tonnes of wheat from the U.S. to Canada.

This cursory examination of the world wheat market can be summed up by the following hypothesis. Canada's domestic price of wheat is directly related to the Cdn./U.S. exchange rate, but Canadian wheat exports are largely unrelated to the Cdn./U.S. exchange rate. It is important to recall, however, that the trade side of the question does not encompass the full impact of an exchange rate change. A second linkage lies between the exchange rate and the cost of producing wheat. More specifically, the question can be reduced down to estimating how a change in the Cdn./U.S. exchange rate will impact on the price Canadian wheat producers pay for individual factor inputs.

Appealing to the law of one price,[13] it seems plausible that any factor input enjoying free trade between Canada and the U.S. should be directly affected by a change in the Cdn./U.S. exchange rate. Fertilizer, farm machinery, refined petroleum products and formulated agricultural chemicals represent four agricultural inputs which are traded in some form between Canada and the U.S..[14] Table 1 records the total value of Canadian-U.S. trade in these four inputs over the past three years. In 1983, Canada enjoyed a positive balance in fertilizer trade of $604 million. Total net trade in refined petroleum products for the same period stood at $1.857 billion, which is more than three times the fertilizer balance. For the other two inputs, Canada recorded trade deficits. Net Canadian imports of U.S. farm machinery during 1983 totalled $867 million, which is equivalent to 42 percent of the total amount of machinery depreciation charged by Canadian farmers during that year.[15] Meanwhile, the net imported value of agricultural chemicals reached $168 million, or 35 percent of the total Canadian farm expenditure on chemical products.

---

[13] R.G. Bressler and R.A. King, Markets, Prices, and Interregional Trade. (New York: John Wiley & Sons Inc., 1970), pp. 87-89.

[14] Fertilizer, machinery and petroleum products move between Canada and the U.S. without tariffs or quotas. However, formulated agricultural chemicals can only be imported by manufacturers, and are usually very specialized in nature (i.e., not generally applicable to wheat production).

[15] Statistics Canada, Farm Net Income 1983, Catalogue Number 21-202, 1983, p. 43.

Table 1

Value of Canadian/U.S. Trade

Classification	1981	1982	1983
	..............$'000 (Cdn.)................		
Canadian Exports:[a]			
Fertilizer	940,607	750,451	775,122
Farm Machinery	798,676	566,891	492,061
Petroleum Products	1,887,455	1,793,317	1,997,381
Agricultural Chemicals	620	4,032	6,697
Canadian Imports:[b]			
Fertilizer	150,553	137,693	171,065
Farm Machinery	2,136,440	1,547,045	1,349,475
Petroleum Products	74,283	61,596	140,832
Agricultural Chemicals	129,856	171,946	174,844
Net Canadian Trade:			
Fertilizer	790,054	612,758	604,057
Farm Machinery	-1,337,764	-980,154	-857,414
Petroleum Products	1,813,172	1,731,721	1,762,318
Agricultural Chemicals	-129,236	-167,964	-168.154

[a]Statistics Canada, Exports by Commodity, Catalogue Number 65-004, December 1983.

[b]Statistics Canada, Imports by Commodity, Catalogue Number 65-007, December 1983.

As is the case for most products, the U.S. is Canada's most important trading partner in terms of agricultural inputs. During 1983, 62 percent of Canada's world trade in fertilizer was carried on with the U.S.. Other inputs exceed this level, with the U.S. accounting for 80 percent of Canada's world trade in agricultural chemicals, 89 percent of agricultural machinery and 95 percent of Canada's total trade in petroleum products. The strength of the relationships between the Canadian price of agricultural inputs and the Cdn./U.S. exchange rate depends not only on the level of trade but also on the structure and pricing behavior of the individual factor input markets. Each market behaves in a different way and as such, transmission of exchange rate shocks will vary between products.

Thus far only directly traded commodities have been considered. By extending the discussion, a third linkage, namely, the indirect effect on non-traded goods, can be included. In an open economy such as Canada's, a currency depreciation is bound to have domestic price effects. Prices increases have an ongoing impact on the rate of inflation (through formal wage agreements) and as such, may either create or sustain an environment of inflationary expectations.[16] A change in the exchange rate will indirectly affect the price of all inputs, not just those which are traded.

The causation between domestic inflation, interest rates and exchange rates presents a very difficult empirical question. It is hard enough to determine the direction of causation, let alone the speed and

---

[16]G.G. Thiessen, "The Canadian Experience with Monetary Targetting", a paper presented to the International Conference on Monetary Targetting, sponsored by the Federal Reserve Bank of New York, New York, May 2-5, 1982, p. 13.

size of response, given that both exchange rates and prices are constantly in motion.[17] The problem is further exacerbated by the fact that monetary authorities tend to combat exchange and inflationary movements by manipulating of the same monetary aggregates.

The traditional view of monetary targetting stresses that policy makers should be indifferent to movements in the exchange rate. However, continued downward pressure on the Canadian dollar and a growing concern over imported inflation resulted in the Cdn./U.S. exchange rate receiving an increased weight in the conduct of Canadian monetary policy.[18] Since 1978 there has been a series of exchange rate changes which the Bank of Canada has attempted to moderate. When interest rates go up abroad, Canadian interest rates tend to follow. Current policy at the Bank of Canada is to react to international pressure by allowing some of the impact to fall on domestic interest rates and some on the exchange rate.[19]

Interest rates represent a fourth linkage to the macroeconomy and are of particular concern to agriculture. Estimates for western Canada show that in 1983, interest accounted for approximately 16 percent of total operating costs.[20] There can be little doubt that the connection between interest and exchange rates is important when discussing the net income of western Canadian wheat producers. At this point, our discussion has come full circle: once the impacts of monetary shocks on the wheat

---

[17] P.N. Kenen and C. Pack, Exchange Rates, Domestic Prices and the Adjustment Process. Occasional Paper No. 1. (New York: The Group of Thirty, 1980), p. 3.

[18] G.G. Thiessen, op.cit., p. 11.

[19] Dept. of Finance, "Foreign Exchange Market Intervention in Canada", a report submitted to the Working Group on Exchange Market Intervention of the Economic Summit, Ottawa, Canada, Sept. 1982, p. 9.

[20] Statistics Canada, Farm Net Income 1983, op.cit., p. 47.

market, the input markets and interest rates have been considered, it should be possible to make a comprehensive statement about producer income.

The structure of the wheat market forces an individual producer to act as price taker. If the Cdn./U.S. exchange rate changes, the Canadian domestic price of wheat will change in the same direction. Wheat exports, on the other hand, are hypothesized to remain largely unaffected. The result is that a change in the Cdn./U.S. exchange rate will have a direct impact on gross revenue. However, since it is net revenue rather than gross revenue which affects an individual producer's welfare, changes in both the price of factor inputs and interest rates must also be accounted for.

Any cost or benefit derived from a monetary shock will be absorbed by producer income. If producers perceive monetary changes to be transitory, the impact may be limited to a short run variation in income. The probable result is that producers will make a short run adjustment in personal consumption and operating expenditure. However, if producers come to view monetary adjustments as a permanent phenomenon, the value of fixed assets and industry structure may also be affected.

Although the preceding discussion has revolved around an individual producer's welfare, the importance of this issue is far broader. Wheat production is not only the mainstay of western Canadian agriculture but is also a significant contributor to Canada's balance of payments. In 1983, wheat exports produced $4.6 billion in foreign earnings, which is equivalent to 48 percent of the total value of Canada's agricultural exports.[21] From these figures, it is clear that wheat and wheat producers comprise an important component of the Canadian economy.

1.2 Objectives and Scope of the Study

The monetary regime adopted by the Canadian government has a direct effect on exchange rates, interest rates and inflation. Although the relationship between monetary variables and Canada's macroeconomy is fairly well defined, the connections between these variables and individual sectors of the economy are not well understood. The assumption that a macroeconomic effect is equal to a sum of its parts, may be very misleading. What is deemed to be beneficial for the economy in general may not be beneficial for every subsector. This is not to say that every subsector should receive individual attention in the policy process, but the differences which exist should at least be recognized.

The unique position of Canadian wheat producers make them an interesting sector for examination. Not only is the net revenue of wheat producers affected by monetary policy, but these impacts are often impossible to guard against. Under certain conditions, monetary shocks will work to the benefit of Canadian wheat producers. However, alternative cases can be perceived whereby Canadian wheat producers will suffer declines in net revenue.

From a policy standpoint, it is important to determine exactly what impact a change in Canada's monetary policy exerts on the net revenue of Canadian wheat producers. In order to achieve this general goal, four specific objectives are:

---

[21] Personal correspondence with Mike Shumsky, Statistics Canada, May 23, 1985.

1. to examine the theoretical relationship between monetary variables and the Canadian wheat industry;

2. to build an econometric model which can be used to estimate the impact of monetary shocks;

3. to use the estimated model to simulate how the net revenue of wheat producers is affected by changes in monetary policy; and

4. to analyze the results of the simulations in order to provide policy prescriptions.

The scope of this research has been limited so as to be concerned only with short run income variations. Although long run equilibriums exist in economic theory, it can be argued that we never actually attain them. In order for a long run equilibrium to occur, all economic variables must equal their expected values. The unlikelihood of such a situation means that the economy is constantly operating in the short run. Limiting the discussion to short run income variations also has a practical attraction in that it precludes the necessity of discussing capital asset values or structural change.

The problem is further limited by including only wheat production. Since very few western Canadian farms are restricted solely to wheat, it may seem more reasonable to accommodate all crops rather than limiting the discussion. However, in order to accomplish such a task, the idiosyncrasies of numerous commodity markets and the possibility of substitution between crops would have to be examined. Therefore, it was decided that the problem would be simplified to include only wheat, with net revenue stated on a per hectare basis.

Excluding all crops other than wheat will obviously reduce the generality of the results. However, we should not loose sight of the fact that wheat is the most important crop in western Canada. In 1983, wheat comprised 57 percent of total western Canadian crop receipts. When examined on a Canada-wide basis, wheat accounted for approximately 42 percent of total crop receipts.

From the outset, it is recognized that it will be difficult to separate monetary effects from what are termed to be real (supply and demand) pressures. For example, it is very hard to identify exactly what proportion of exports are due to an exchange rate change when world consumption and production patterns for wheat are changing simultaenously. Finally, since this study presupposes monetary flexibility, the period of analysis will range from Canada's adoption of flexible rates in 1970 up to the second quarter of 1984.

1.3 Organization of the Study

The remainder of this study is divided into six sections. Chapter II reviews the related literature. Chapter III presents a theoretical discussion ranging from the determination of exchange rates to the indirect impact of exchange rates on the factor input markets. Chapter IV provides a conceptual framework for the model, while Chapter V includes the model specification and estimation. Chapter VI outlines the modelling scenarios and provides an analysis of the results. The seventh and final chapter presents a summary of the thesis, with special reference to policy implications.

CHAPTER II

REVIEW OF RELATED LITERATURE

Prior to the 1970's, agriculture was basically modelled as a closed system. Agricultural economists generally categorized their discipline within the sphere of microeconomics, and as such, tended to divorce themselves from macroeconomic considerations.[22] In the early 1970's, the world economy experienced a number of structural changes which brought into question the independent treatment of agriculture within economic models. Two of the more significant structural changes included a 52 percent increase[23] in the real value of agricultural trade between 1971 and 1974, as well as a move away from fixed exchange rates toward a system of managed flexibility.

As the structure of the world economy changed, so did its performance. Supply shocks during the early 1970's led to speculation that the flexible exchange rate system may in fact be contributing to instability. In an insightful paper, Schuh[24] examined the relationship between exchange rates and U.S. agriculture. The basic contention of his paper was that

---

[22] A.F. McCalla, "Impact of Macroeconomic Policies Upon Agricultural Trade and International Agricultural Development", AJAE, Vol. 64, Dec. 1982, p. 861.

[23] The real value of agricultural trade was derived by devaluing the current dollar value of world agricultural trade by the U.S. consumer price index. The source of this information was: Food and Agriculture Organization of the United Nations, FAO Trade Yearbook--1977, Vol. 37 (Rome: Food and Agriculture Organization, 1978), p. 38; and U.S. Bureau of Commerce, Statistical Abstracts of the United States--1985 (Washington D.C.: U.S. Government Printing Office, 1984), p. 467.

[24] E.G. Schuh, "The Exchange Rate and U.S. Agriculture", AJAE, Vol. 56, Feb. 1974, pp. 1-12.

exchange rates play a significant role in explaining both agricultural trade and the value of agricultural resources.

Schuh argued that the U.S. dollar was over-valued throughout most of the 1950's and 1960's. The result was an increase in the price of U.S. commodities as expressed in foreign currency. As the importer's price for U.S. commodities increased, the foreign demand for U.S. products began to disappear. This occurred despite the fact that new technology was increasing the efficiency and output of U.S. agricultural. The end result was that the U.S. producers failed to capitalize on technological progress. Instead, the benefits of technology were transferred to foreign and domestic consumers through a reduction in food prices.

The autonomous decrease in commodity prices which occured as a result of an overvalued U.S. dollar was a powerful incentive for technological change. Faced with declining prices, producers were forced to increase output in order to maintain their revenue position. Research institutes responded to the call for higher yields and a steady flow of new technology was developed. Research and extension focused primarily on land augmenting inputs such as seed, fertilizer and chemicals. Labour augmenting capital was not researched as extensively since it was viewed as being a less effective way of increasing ouput.

When the U.S. dollar was finally adjusted[25] agricultural prices (as expressed in the importers' currency) began to fall. If Schuh's interpretation is correct, the devaluation of the U.S. dollar led to an increased demand for U.S. agricultural commodities which helped to spur the mid-1973 rise in agricultural prices. Although Schuh recognizes the importance of other factors such as weather and the failure of the Peruvian fishmeal industry, he stresses that the role of exchange rates should not be ignored.

The argument posed in this study is opposite to the one put forward by Schuh. When viewed from the context of the underlying economic conditions, the Canadian dollar is currently trading at a very weak position relative to the U.S. dollar. If this is the case, the Canadian wheat industry may be subject to structural pressures opposite to those described in Schuh's discussion of induced technological change. If a depreciation in the value of the Canadian dollar affords Canadian wheat producers an increased return, it may also allow them to adopt a less efficient mode of production. In other words, producers may not be forced to make the adjustments which should occur as a result of economic pressure.

Schuh's article stimulated a good deal of research. In 1976, Kost[26] reviewed the theory associated with the trade impacts of a currency

---

[25]The first devaluation had its origin on August 15, 1971 when the U.S. announced that it was suspending convertibility of dollars into gold. In December 1971, members of the IMF realigned their currencies, with the U.S. dollar being devalued 8.57 percent vis-a-vis gold. In February 1973, the U.S. devalued their currency again, this time the U.S. dollar dropped by approximately 10 percent relative to other hard currencies.

[26]W.E. Kost, "Effects of Exchange Rate Change on Agricultural Trade", Agricultural Economics Research, Vol. 28, No. 3, July 1976, pp. 99-106.

devaluation. In that article, Kost argued that agricultural economists had been guilty of misapplying theory, and that the importance of exchange rates had been overemphasized. In attempting to prove his hypothesis, Kost made use of a simple two country one commodity trade model.

Agricultural products are generally characterized to have low elasticities of supply and demand, and as a result, Kost was able to demonstrate that a devaluation in an exporter's currency should generate a larger change in price than in quantity. Kost theorized that the exchange rate effect on volume is relatively small and that any change in the commodity price will be limited to the percentage change in the exchange rate. Since the main reaction to an exchange rate change is captured by price, it seems reasonable that any trade barrier which isolates a domestic market from the world price should serve to restrict the exchange rate effect. This is equivalent to saying that trade barriers reduce the amount by which exchange rates shift the export supply and import demand curves.

Response to Schuh's article was not limited to the theoretical issues presented by Kost. Vellianitis-Fidas[27] set out to estimate whether the devaluation of the U.S. dollar had altered the quantity of agricultural products exported out of the U.S. Using an econometric model, the author demonstrated that exchange rates were not significant in explaining the variation in U.S. agricultural exports. Although this may be somewhat surprising, Vellianitis-Fidas claimed that the results are not counter

---

[27] A. Vellianitis-Fidas, "The Impact of Devaluation on U.S. Agricultural Exports," Agricultural Economics Research, Vol. 28, No. 3, July 1976, pp. 107-116.

intuitive when considered in conjunction with Kost's theoretical work.

Vellianitis-Fidas presented two arguments in defense of her results. The first was that barriers to trade isolate import demand. The second was that the maximum amount by which demand can shift is limited by the size of the devaluation, and that the actual U.S. dollar devaluation was less than the official U.S. dollar devaluation vis-a-vis gold. Given that many currencies move in concert with the U.S. dollar, the demand curve for U.S. exports should be expected to shift less if we consider only the actual U.S. dollar devaluations.

Both Kost and Vellianitis-Fidas refute Schuh's hypothesis that the devaluation of the U.S. dollar had a significant impact on U.S. agricultural trade. However, both authors concede that the price of U.S. agricultural commodities may have been affected by currency changes. In a subsequent article, Johnson, Grennes and Thursby[28] focused attention specifically on the price effect of an exchange rate change. The intent of Johnson et al's article was to estimate what portion of the early 1970's increase in wheat prices was attributable to the devaluation of the U.S. dollar. Other variables, which provide alternate explanations include: the tariff policies of the EEC and Japan, trade controls on the part of Canada and Australia, as well as U.S. transport policies which tend to distort ocean freight rates.

A trade model was specified, which isolated the effect of the aforementioned variables. The model distinguished trade flows by place of origin, which added a sense of realism to the analysis. In the world

---

[28]P.R. Johnson, T. Grennes and M. Thursby, "Devaluation Foreign Trade Controls and Domestic Wheat Prices," AJAE, Vol. 59,. Nov. 1977, pp. 619-627.

wheat market, importers differentiate between exporting nations for technical as well as political reasons. Consequently, it is not uncommon for an importer to purchase from a number of different export sources.

The results of Johnson et al's model suggest that a 10 percent devaluation of the U.S. dollar (relative to the German mark and Japanese yen) caused the price of U.S. wheat to increase by a maximum of 7.1 percent. As a result, Johnson et al conclude that exchange rates contributed to the rise in U.S. wheat prices during the 1973-74 period, but that their effect should not be overstated. During the same period, Japan and the EEC reduced their import tariffs, which served to increase the world demand for wheat. A second change was that Canada and Australia implemented two-price systems for wheat. Subsidization of domestic prices increased local consumption, and reduced the amount of wheat moving into the export market. As a result, the international wheat market faced upward pressure on prices. Given the small size of the domestic markets in both Canada and Australia, and the inelasticity of demand, it is doubtful that the resulting change in domestic use had any noticeable impact on the international price of wheat.

Shipping costs are another variable which are thought to have had an impact on wheat prices during the 1973-74 period. Ships operating under U.S. registry are known to charge higher rates due to U.S. construction costs and operating restrictions.[29] These U.S. ships depend on cargo preference laws (i.e., P.L.480 and Russian shipments) for survival. A large proportion of the increase in exports which occurred during 1973-74 period was destined for the U.S.S.R.; consequently, these shipments served

---

[29] J.K. Binkley and B. Harrer, "Major Determinants of Ocean Freight Rates for Grains: An Econometric Analysis", AJAE, Vol. 63, February, 1981, p. 48.

to increase the average ocean shipping cost. Between 1972-73 and 1973-74, the average U.S. ocean freight rate increased by more than 200 percent.[30] As freight rates increased, the price received by exporters decreased. Johnson et al conclude that U.S. shipping policy may have exerted a negative impact on U.S. wheat prices which was at least as great as the positive impact caused by the devaluation of the U.S. dollar.

In the second section of their article, Johnson et al analyze the structural pressure created by increased wheat prices. The results of Floyd's land price model[31] were used to establish a relationship between the price of land and the price of wheat. In order to facilitate such a comparison, the authors rely on two questionable assumptions. The first assumption is that the domestic price of U.S. wheat can be used as a proxy for average U.S. agricultural prices. The second assumption is that land values are influenced only by the gross value of crop production.

Floyd's model predicts that the value of land will change by a factor of 1.5 to 3 times the change in product price. Using the parameters estimated in their model, Johnson et al predict that a 10 percent devaluation will cause wheat prices to increase by approximately 7 percent. The increased wheat prices brought about by a 10 percent devaluation will subsequently cause land rental rates to increase from 10.5 to 21 percent. When Johnson et al compared the predicted increase in land

---

[30]Food and Agriculture Organization of the United Nations, F.A.O. Trade Yearbook--1983 (Rome: Food and Agriculture Organization, 1984), p. 22.

[31]Floyd used a six equation model to estimate the relationship between U.S. agricultural prices and the price of land. J.E. Floyd, "The Effects of Farm Price Supports on the Returns to Land and Labor in Agriculture," JPE, Vol. 73, 1965, pp. 148-58.

values to the actual increase, they conclude that the model over-estimates the relationship.[32]

According to Johnson et al, the actual data are inconsistent with Schuh's contention that currency devaluations have a major impact on the value of the fixed factors of production (land). Although not acknowledged by the authors, the evidence provided by Johnson et al may in fact support Schuh's contention. The theory of land bid models,[33] tells us that land rental rates are responsive to net revenue rather than gross revenue (product price). The early 1970's was a period of escalating input prices. A very important part of the problem is omitted if we include only product prices. It is interesting to note that Floyd's coefficients, which later became an important part of Johnson et al's analysis were estimated during the early 1960's when input prices were reasonably constant. Had Johnson et al re-estimated these coefficients for the early 1970's, they may have found quite different results.

The foregoing debate on exchange rate effects was brought into focus by Chambers and Just.[34] The divergence of results which emerged from the various studies posed a puzzling problem. The original article

---

[32]Following the 1971 devaluation, wheat prices rose 7 percent, while land values increased 4.5 percent. The devaluation prior to 1973-74 was followed by a rise in wheat prices of 19 percent with land up 13.1 percent.

[33]One example of these models is W.F. Lee, "A Capital Budgeting Model for Evaluating Farm Real Estate Purchases", <u>Canadian Farm Economics</u>, Vol. 11, No. 3, 1976, pp. 1-10.

[34]R.G. Chambers and R.E. Just, "A Critique of Exchange Rate Treatment in Agricultural Trade Models", <u>AJAE</u>, Vol. 61, May 1979, pp. 250-257.

by Schuh and a subsequent one by Fletcher, Just and Schmitz[35] suggest that exchange rates are an important determinant of agricultural prices. Meanwhile, Kost, Vellianitis-Fidas and Johnson et al have shown counter examples whereby exchange rates have a reduced effect. Based on their review of the problem, Chambers and Just speculate that the divergence in results may be due to differences in the specification of demand and supply equations within the various models.

The studies conducted by Vellianitis-Fidas, Kost and Johnson et al assume that the excess demand for wheat is solely a function of its own price. This is contrary to neoclassical theory which designates that demand is a function of income and all other related prices rather than just one specific price. Chambers and Just's basic contention is that both price and income effects should be included when estimating an exchange rate induced shift in excess demand. If an exporter devalues its currency, the importer's income will increase.[36] In a case where the income effect is large enough, there is no reason to believe that the change in commodity price must be limited by the magnitude of change in the exchange rate.

Chambers and Just draw upon a hypothesis originally put forward by Orcutt[37] in order to provide a pragmatic approach to the problem. If we

---

[35] S.M. Fletcher, R.E. Just and A. Schmitz, "The Impact of Exchange Rates and Other Factors on North American Wheat Export Demand", World Food Crisis: Issues and Policy Alternatives. Ed. Gordon, C. Rausser. (Amsterdam: North Holland Publishing Co., forthcoming), as cited in R.G. Chambers and R.E. Just, op. cit.

[36] This is true only when large proportion of goods is traded. The Canadian-U.S. comparison represents a good example.

[37] G.H. Orcutt, "Measurement of Price Elasticities in International Trade," Review of Economics and Statistics, Vol. 32, 1950, pp. 1178-32.

assume that exchange rate effects differ from price effects, both the exchange rate and price should be specified as separate regressors. As noted by Chambers and Just, recent research by Fletcher, Just and Schmitz apply these techniques (exchange rate as a separate regressor) to the wheat market. The results are reported to indicate that exchange rates have had a dramatic effect on both the price and export volume of U.S. wheat.

The manner in which exchange rates impact on domestic prices was further discussed by Bredahl, Meyers and Collins.[38] This work questions the validity of the assumption that there is perfect price transmission between U.S. export prices and the domestic price in foreign countries. Price transmission parameters are usually bounded by zero and one. Under the classical assumption of perfect market clearing, the price transmission parameter is set equal to one. However, Bredahl et al found that when governments insulate their domestic price from prices established in the world market the estimate of price transmission may be at or very near to zero. There is strong evidence that many of the major trading countries insulate their internal prices. Given this information Bredahl et al argue that calculating a weighted price transmission elasticity based on assumed supply and demand elasticities while neglecting foreign price adjustment[39] will obviously result in an overestimate of elasticity.

At this point, the formal review of received literature is complete. What is now required is that we abstract from the findings of the

---

[38]M.E. Bredahl, W.H. Meyers and K.J. Collins, "The Elasticity of Foreign Demand for U.S. Agricultural Products: The Importance of Price Transmission Elasticity", AJAE, Vol. 61, 1979, pp. 58-63.

39This type of elasticity calculation is used in P.R. Johnson, "The Elasticity of Foreign Demand for U.S. Agricultural Products", AJAE, Vol. 59, 1977. pp. 619-627.

cited literature in order to explain the problem at hand. There appears to be three important omissions in the existing body of literature, especially when viewed from a Canadian context.

The first omission is that the simple trade models used in most of the aforementioned studies fail to account for the interaction between exporters. Under a regime of floating exchange rates, it is not only the U.S. dollar which is changing in value. All other hard currencies may also be experiencing a simultaneous revaluation. For example, a change in the value of the U.S. dollar relative to a bundle of foreign currencies may be quite different from a change which takes place in the Cdn./U.S. exchange rate.

If Canada and the U.S. actually behave as price competitors, then it is possible that a devaluation in the U.S. dollar may not result in an increase in U.S. market share. For this to occur, the Cdn./U.S. exchange rate would have to increase more than the U.S. dollar devalues. Although the export price of U.S. wheat as expressed in foreign currency would fall, the increase in the Cdn./U.S. exchange rate would cause the Canadian export price (as expressed in foreign currency) to fall below the already depressed U.S. price. The end result is that if relative market share changes at all, it should shift in Canada's favour.

However, if Canada actually sells wheat by matching the U.S. price (as hypothesized in Chapter One), the ratio between Canadian and U.S. wheat prices as expressed in U.S. dollars will remain relatively constant. Given this, there is no economic reason why relative market share will change. Instead of affecting relative market shares, a change in the Cdn./U.S. exchange rate will create a divergence in the domestic price of wheat between the two countries.

A second area of omission is in the way the impact of exchange rate changes are assessed. Discussion of exchange rate impacts are typically limited to export price and volume. Despite the fact that these effects are most obvious, they may not be the most important. Input costs must be included before a comprehensive statement is possible.

The foregoing criticism is justified if we view the problem from a Canadian context. In the case of U.S. wheat production (which forms the base for the previously cited studies), the prices of factor inputs such as fertilizer, machinery and agricultural chemicals are determined domestically and as such are largely isolated from exchange rate changes. In Canada's case, the same conclusion does not hold. Given that a large proportion of the inputs used by Canadian wheat producers are either produced or priced in the U.S., a change in the Cdn./U.S. exchange rate is theoretically expected to effect both input prices as well as output prices.

The idea that exchange rates affect all input prices equally may be a misnomer. As Isard[40] points out, when commodities are examined on an individual basis, the effect of an exchange rate change may vary. At the most disaggregated level, the law of one price cannot be counted on to maintain equivalent prices. This is particularly true for markets such as fertilizer and agricultural chemicals. Within these markets, perfect competition does not exist; therefore, it is not surprising that commodity arbitrage persists between Canada and the U.S.. In other words, a change

---

[40] P. Isard, "How Far Can We Push the Law of One Price". <u>American Economic Review</u>, Vol. 29, Dec. 1979, pp. 942-948. Although Isard can be considered to be a pioneer in this area, his work does draw upon a previous study by Irving B. Kravis and Robert E. Lipsey, "Price Competitiveness in World Trade", <u>The National Bureau of Economic Research Studies in International Economic Relations</u>, Vol. 16, 1971.

in the Cdn./U.S. exchange rate may not necessarily be matched by a change in the Cdn./U.S. price of factor inputs.[41]

The third and final omission to be discussed is in regard to the endogenous nature of exchange rates. The last few years have yielded convincing evidence of how important the exchange rate can be to the overall economy. Changes in exchange rates have a strong influence on inflation, trade and economic growth. Most countries have an exchange rate policy, in the sense that they cannot afford to be indifferent to where the exchange rate is going. Exchange rate movements are generally accounted for within an overall economic strategy.[42]

Until recently, studies within agriculture such as Schuh, Vellianitias-Fidas, and Johnson et al have tended to treat exchange rates as exogenous factors. In a 1982 study, Chambers and Just[43] specify a model whereby agricultural trade and the value of the U.S. dollar (exchange rate) are endogenously determined. The exchange rate equation included in the Chambers and Just model can be broadly described as monetarist in nature. The independent variables which appear in the equation are: the discount rate, the general price level, as well as a lagged variable which represents the balance of payments.

Chambers and Just use their model to examine how changes in the level of domestic credit (i.e., money supply) affects the value of the

---

[41]C.A. Carter and N. Hamilton, "The Law of One Price in Wheat Inputs", unpublished paper, University of Manitoba, 1984.

[42]O. Emminger, Exchange Rate Policy Reconsidered. Occasion Paper No. 10. (New York: The Group of Thirty, 1982), pp. 1-2.

[43]R.G. Chambers and R.E. Just, "An Investigation of the Effect of Monetary Factors on Agriculture:, Journal of Monetary Economics, Vol. 9, 1982, pp. 235-247.

U.S. dollar and its subsequent impact on agricultural trade. The results suggest that a 10 percent reduction in domestic credit eventually leads to a 17 percent increase in the export price of U.S. wheat. Although Chambers and Just make some progress toward addressing the issue of macroeconomic shocks, the authors recognize that they have linked the agricultural sector to only one of a number of important monetary variables.

> With little doubt, the effects reported here would be magnified if other linkages were specified. For example, the level of the discount rate and the corresponding level of interest rates determine to a large extent the amount farmers borrow to finance either the purchase of new land and equipment or the actual planting of crops. Such effects, coupled with those already noted through the exchange rate, may be too large to be ignored and may, in fact, magnify considerably the results obtained here.[44]

The omission of interest and inflation rates from the problem may prove far from trivial, since these variables have a direct impact on the cost of producing wheat.

Over the past 10 years, a good deal of work has been devoted to studying the impact of exchange rates on agriculture, but most of this research has concentrated on the U.S. market and is not designed to analyze the problem from a Canadian perspective. When the possible failure of the law of one price in the factor input markets is combined with the macroeconomic interactions between exchange rates, interest rates and inflation rates, some interesting questions emerge.

1. What is the nature of the relationship which exists between monetary variables and wheat production?

2. How will changes in monetary variables effect the net revenue of Canadian wheat producers?

With these questions in mind, it is possible to proceed with the theoretical framework and model specification.

---

[44]Ibid., p. 246.

CHAPTER III

THEORETICAL FRAMEWORK

This chapter presents a conceptual framework for assessing the effect of monetary shocks. The first section provides a brief overview of exchange rate determination. Following this a description of two financial-equilibrium models which are widely used in forecasting exchange rates will be presented. The third and fourth sections discuss the linkages between money supply, interest rates, exchange rates and domestic prices. The final sections address how monetary shocks impact on the factor input and output markets, which directly affect the net revenue of Canadian wheat producers.

3.1 Determination of Exchange Rates

As in most macroeconomic theories, there does not appear to be any one definitive proposition regarding exchange rate determination. Although economists generally agree that exchange rates are market clearing prices which fluctuate in order to equilibriate supply and demand in the foreign exchange market,[45] the exact manner by which this process takes place is open to debate. Four major viewpoints regarding the theory of exchange rate determination include: Purchasing Power Parity, the Balance of Payments Theory, Forward Exchange Theory and the Speculative Run View. Each of the aforementioned variants provides a partial explanation of exchange rate movement, but each view also has some limitations.

---

[45] P. Isard, Exchange Rate Determination: A Survey of Popular Views and Recent Models. Princeton Studies in International Finance No. 42. (Princeton, N.J.: Princeton University, 1978).

3.1.1 Purchasing Power Parity. The modern theory of Purchasing Power Parity dates back to the writings of Cassel.[46] In 1918, Cassel proposed the Absolute Purchasing Power Parity hypothesis, which states that the exchange rate between two countries should be equal to a ratio of their general price levels. Since most price data take the form of indexes rather than absolute values, a relative form of the hypothesis eventually emerged. According to the relative hypothesis, the exchange rate between countries should be a constant multiple of the ratio of their general price indexes.

As noted above, Purchasing Power Parity is a theory of equilibrium between exchange rates and some designated ratio of price indexes. Mathematically, this can be depicted as follows:

$$P = EP^* \text{ or } E = P/P^* \tag{3.1}$$

where:

P = an index of domestic prices

P* = an index of foreign prices

E = an exchange rate with domestic currency expressed in terms of foreign currency.

Any divergence between exchange rates and the ratio of designated price indexes will prompt a corrective force which acts to restore equilibrium. However, since it takes time for these corrective forces to exert their influence, the validity of Purchasing Power Parity depends on the time frame being examined.

---

[46] G. Cassel, "Abnormal Deviations in International Exchanges", Economic Journal, Vol. 28, December, 1918, pp. 413-415.

Recent evidence[47] suggests that Purchasing Power Parity may not be a very reliable way of predicting short term fluctuations in exchange rates. In order for Purchasing Power Parity to hold in the short run, commodity arbitrage between countries must be complete. Unless we are willing to rely on perfect market clearing,[48] it is likely that discrepancies between exchange rates and price indexes may persist for several years. This does not imply that Purchasing Power Parity has no predictive power. Over a period of time which is long enough for national price indexes to adjust, Purchasing Power Parity may have considerable validity.[49]

3.1.2 Balance of Payments View. The Balance of Payments View is closely related to the Bretton Woods system of fixed exchange rates. During that era, pressure to adjust official exchange rate levels was predicated on the occurrence of fundamental disequilibrium, which for all practical purposes came to be associated with persistent current account imbalances.[50] As a result, the Bretton Woods system served to induce a correlation between current account imbalances and subsequent adjustments in exchange rates.

---

[47] Lawrence H. Officer, "Effective Exchange Rates and Price Ratios Over the Long Run: A Test of Purchasing-Power-Parity Theory", Canadian Journal of Economics, Vol. 13, May 1980, pp. 206-230.

[48] For a critical assessment of continuous market clearing, refer to James Tobin, Asset Accumulation and Economic Activity. (Chicago: University of Chicago Press, 1980), pp. 32-35.

[49] Isard, Exchange Rate Determination: A Survey of Popular Views and Recent Models, op.cit., p. 8.

[50] Ibid., p. 8.

The popular Balance of Payments View is also known as the Elasticities Approach. Under such a model, the exchange rate is identified as the relative price of goods and is determined by the allocation of purchases between domestic and foreign markets. Given a fixed domestic price, a depreciation in the value of domestic currency relative to foreign currency raises the price of imports. Increased import price should result in a shift in demand toward domestically produced goods. If the supply of domestic goods is perfectly elastic, and the absolute value of the elasticity of the devaluing nation's demand for imports plus the elasticity of demand by the rest of the world for the devaluing nation's exports sum to less than one, then a depreciation of domestic currency will serve to increase the balance of payments.[51]

In the absence of capital flows, exchange rates can be adjusted in order to maintain an equilibrium trade balance. An exogenous shift in the current account toward a deficit will normally lead to a depreciation in the value of domestic currency. As the current account moves into a deficit, imports exceed exports, causing the supply of domestic currency to exceed the demand for domestic currency, and consequently, the value of the currency declines.

Although the principle behind the Balance of Payments Theory is well accepted, when examined alone, it does not appear to provide a adequate explanation of exchange rate movements. Capital flows must be incorporated into the model before a comprehensive view of short run exchange rate determination is possible.

---

[51]Formally, this is known as the Marshall-Lerner Condition. For a mathematical treatment, refer to H.G. Grubel, International Economics, (Homewood, Ill.: Richard D. Irwin Inc., 1977), pp. 322-324.

3.1.3 Forward Exchange Theory. Development of the Forward Exchange Theory is generally identified with Keynes.[52] Over the years, it has also come to be known as the Interest Rate Parity or Asset Market Theory. Basically, the Forward Exchange Theory recognizes that investors have a choice between domestic assets with an interest rate of r_d or foreign investments with an expected yield of r_f. If we assume that arbitrageurs have the ability to move freely between domestic and foreign markets, the following equilibrium condition should hold:

$$1 + r_d = s(1 + r_f)/f \qquad (3.2)$$

where:

s = the spot conversion between domestic and foreign currency (i.e., the current exchange rate)

f = the expected forward conversion between domestic and foreign currency (i.e., the expected future exchange rate).

The asset market equilibrium described in 3.2 can be manipulated so that s and f drop out of the equation. This leaves us with the following interest rate parity condition:

$$(r_f - r_d)/(1 + r_d) \approx r_f - r_d \qquad (3.3)$$

Those participants who are expected to arbitrage the international interest rate market include: foreign traders arranging for the purchase and sale of goods; interest rate arbitrageurs who recognize the potential for profit; as well as risk taking speculators. From Keynes' original literature, the notion emerged that speculation in pursuit of profit would prevent large discrepancies between forward exchange rates (f) and the spot rates (s^e) which the speculators expect to prevail on a future date. If s^e exceeds f, then there is an expected profit. The result is that the

---

[52] J.M. Keynes, A Tract on Monetary Reform. (London: MacMillan Publishers, 1923).

open interest in forward exchange increases to the point where the expected future spot rate and the forward exchange rate are equivalent.

$$s^e \approx f \qquad (3.4)$$

When considered together, conditions 3.3 and 3.4 provide a description of the Forward Exchange Theory.

$$(s^e - s)/s \approx r_f - r_d \qquad (3.5)$$

The above equilibrium condition (3.5) has an important practical application in that it can be used to forecast forward exchange rates. If we assume that interest rates are set exogenously (i.e., not determined in equation 3.5), then it is possible to derive a value for forward exchange. The inherent problem with this method is that variables such as interest rates are influenced by government policy and as such should not be treated as purely exogenous factors.

A second problem with the Forward Exchange Theory is that it treats speculation as a consistent phenomenon. In reality, each individual participating in the forward exchange market will react to a change in government policy or interest rates in a different way. The Forward Exchange Theory provides no information in regard to how the speculative process is formed.

3.1.4 Speculative Run View. According to the Forward Exchange Theory, almost all short term fluctuations in exchange rates can be linked to interest rate differentials. If we interpret these differentials as the expected rate of exchange rate depreciation, then there appears to be a good deal of support for the hypothesis that short term fluctuations in exchange rates are a function of market expectations.

Many market participants believe that exchange rates may move in speculative runs touched off by a change (or expectation of a change) in fundamental economic conditions. Although this fundamental change may spark a market reaction, the momentum generated by the market itself may produce exchange rate values which cannot be justified on the grounds of prevailing economic conditions. "When the train is racing through the station at 90 miles an hour, you don't think about where its going to stop; you just try to get on board," (anonymous broker).[53] This type of speculative mentality may be self-sustaining. If spectators perceive that a particular currency will decline in value, mass exodus out of that currency will in itself depress the price.

The Speculative Run View challenges the notion that investors are motivated by long run expectations.

> The ancedotal evidence suggests rather, that many of the largest participants in exchange markets--namely, international banks--operate within narrow limits in their open positions in different currencies, apparently resisting temptations to take long run positions on the basis of their long run expectations which no doubt are very imprecise. Indeed, several of the large banks who participate actively in exchange markets conventionally refrain from carrying open positions overnight.[54]

To date, there have been several attempts to model exchange market movements using simple commodity trading rules. Dooley and Shafer[55] examined the problem from the point of view of buying a currency when its value had risen a certain percentage from the nearest trough and selling when its value had fallen a certain percent from its nearest peak. Al-

---

[53] Isard, Exchange Rate Determination: A Survey of Popular Views and Recent Models, op.cit., p. 16.

[54] Ibid., p. 16.

[55] M.P. Dooley and J.R. Schafer, "Analysis of Short-Run Exchange Rate Behavior: March, 1973 to Sept. 1975", International Finance Discussion Paper No. 76, Washington, Federal Reserve Board, Feb. 1976.

though the Speculative Run View represents an interesting alternative, the existing models have not been very successful in predicting exchange rate movements.

3.2 Financial Equilibrium Models

The theories of exchange rate determination outlined in the previous section have spawned a number of predictive models. If we eliminate the Speculative Run variety from our discussion, we are left with two general types of model, namely, Keynesian and Monetarist. Although Keynesian and Monetarist exchange rate models are often thought to be mutually exclusive, they are, in fact, directly related.

Mundell[56] and Fleming[57] were the first to expand the basic Balance of Payments model to include capital flows. Instead of being confined to current account deviations, this new generation of Keynesian model established a link between domestic and foreign interest rates. Out of this model building process came a series of large econometric models, such as the Bank of Canada's RDX2 model and the Focus model which was designed by the University of Toronto's Institute of Policy Analysis.

This type of large macroeconomic model is built to describe the interactions of a particular country's economy. Included in most Keynesian models is a foreign exchange section, which estimates both trade and capital flows. Exchange rates are normally calculated by solving a Balance of Payments equation.

---

[56] R.A. Mundell, International Economics. (New York: MacMillan, 1968), chapters 11, 17 and 18.

[57] Marcus J. Fleming, "Domestic Financial Policies Under Fixed and Under Floating Exchange Rates", IMF Staff Papers, Vol. 9, November, 1962, pp. 369-79.

During the mid-1970's, many economists began to lose faith in the Keynesian approach to exchange rate determination. Keynesian models which were based on trade flows and interest rate differentials were unable to explain exchange rate movements when faced with inflation. Instead of concentrating on flows, recent literature dealing with exchange rate determination tend to emphasize stocks, particularly the money supply.

The evolution of the Monetarist Approach to exchange rates is very similar to the Monetarist cause in general. In both cases, it was felt that the predictive power of the models could be improved by concentrating on what was considered to be the key variable in the economy (i.e., the money supply). The Monetarist Approach is actually a réduced form method of estimating of a more complete (multiequation) Keynesian model.[58]

Bilson[59] provides an example of how flexible exchange rates can be derived using the Monetary Approach. Assuming that the demand for money is stable and can be specified by a Cagan function,[60] we have

$$\frac{M}{P} = ke^{-\varepsilon i}y^{n} \qquad (3.6)$$

where:

M	= stock of money demanded
P	= price level
i	= interest rate
y	= level of real income
k, n & ε	= parameters

---

[58] Isard, Exchange Rate Determination: A Survey of Popular Views and Recent Models, op.cit., p. 40.

[59] John F.O. Bilson, "The Monetary Approach to the Exchange Rate: Some Empirical Evidence", IMF Staff Papers, Vol. 25, 1978, pp. 50-54.

[60] Phillip Cagan, "The Monetary Dynamics of Hyperinflation", Studies in the Quantity Theory of Money, edited by Milton Friedman (Chicago: University of Chicago Press, 1956), pp. 25-117.

Now, if we include the purchasing power parity condition

$$E = \frac{P}{P^*} \tag{3.7}$$

where:

E	= exchange rate
P	= domestic price
P*	= foreign price

and assume an identical money demand function in the both countries, it is possible to substitute (3.6) into (3.7) in order to derive a relative money demand function. In the following equations, M represents the domestic money supply, while M* represents a foreign country's outstanding stock of money. For example, M and M* could represent the stock of Canadian and U.S. dollars, respectively.

$$\frac{M}{M} = \frac{Pke^{-\varepsilon i}y^{n}}{P^{*}k^{*}e^{-\varepsilon i^{*}}y^{*n}} \tag{3.8}$$

$$\frac{M}{EM^{*}} = \left(\frac{k}{k^{*}}\right)\left(\frac{y}{y^{*}}\right)^{n} . e^{-\varepsilon\ (i-i^{*})} \tag{3.9}$$

The relative money demand function (3.9) can be solved for the exchange rate (E) to yield

$$E = \left(\frac{M}{M^{*}}\right)\left(\frac{k^{*}}{k}\right)\left(\frac{y}{y^{*}}\right)^{-n} . e^{\varepsilon\ (i-i^{*})} \tag{3.10}$$

The Monetarist Approach to exchange rates is successful in simplifying the problem, but is not devoid of some negative aspects. Given that the Monetary Approach is based on a single equation technique, it may fail to account for some of the important interactions which occur in the economy.

3.3 Money Supply, Interest and the Rate of Inflation

Now that a brief overview of exchange rate determination has been presented, it is possible to discuss some of the other major monetary variables. By reverting back to basic macroeconomic theory, we are able to examine how government actions affect the economy. In his famous treatise on employment, interest and money, Keynes demonstrated that within a capitalist system, investment demand is highly unstable. The result is that aggregate demand tends to stray from a state of full employment. Keynes proposed that governments intervene, running either surpluses or deficits in order to stabilize the level of aggregate demand.

The Keynesian approach was widely adopted following World War II, but by the late 1960's, the inverse relationship which developed between employment and inflation (as exemplified by the Phillips Curve) led many Keynesians to question their beliefs.[61] With stagflation escalating, Keynesian prescriptions began to be viewed as ineffectual. Meanwhile, the Monetarist school maintained that the apparent correlation between money supply and inflation held the answer. The end result was that Monetarism won acceptance within many western nations, such as Canada, the U.S. and Britain.[62]

The basic policy tool prescribed under a Monetarist system is control of the money supply. Of all the monetary aggregates, the one most often selected for manipulation is M1. By definition, M1 includes

---

[61] M.J. Gordon, The Post-Keynesian Debate, a Practical Guide to Current Economic Policy Trends in Canada. The Canadian Institute for Economic Policy Series, Occasional Paper No. 2. (Ottawa: Canadian Institute for Economic Policy, 1980), p. 6.

[62] Canada's conversion to Monetarism or more specifically Gradualism was described in Chapter 1.

currency and demand deposits, and as such it is the most liquid of all financial assets.

Theoretically, there are four ways in which the central monetary authority can influence the size of the money supply. These include: open market operations, government transfer of deposits, manipulation of the chartered bank secondary reserve requirement and moral suasion. In Canada's case, only the first two options are exercised since the Bank of Canada views moral suasion as ineffective, and considers manipulation of reserve requirements to be contrary to the way monetary policy should be conducted.[63]

Since the adoption of Gradualism in 1975, almost all of the changes in Canada's monetary base have been the result of the open market operations (i.e., purchases and sales of treasury bills and bonds), and the transfer of Federal Government deposits. Transfers from the central bank to the chartered banks increase the cash reserves held by the chartered banks. This in turn allows the chartered banks to increase lending and consequently has an impact on the overall money supply.

At this stage, it may be beneficial to give a brief graphical description of how a change in the money supply exerts a short run impact on both interest rates and prices. The upper section of Figure 4 represents an equilibrium between the commodity market (IS) and the money market (LM), while the lower section provides an equilibrium between the aggregate supply and demand curves.

As money supply increases, the money market curve shifts right from LM_1 to LM_2. The appearance of excess money supply market pushes the

[63]N.E. Cameron, op.cit., pp. 534-538.

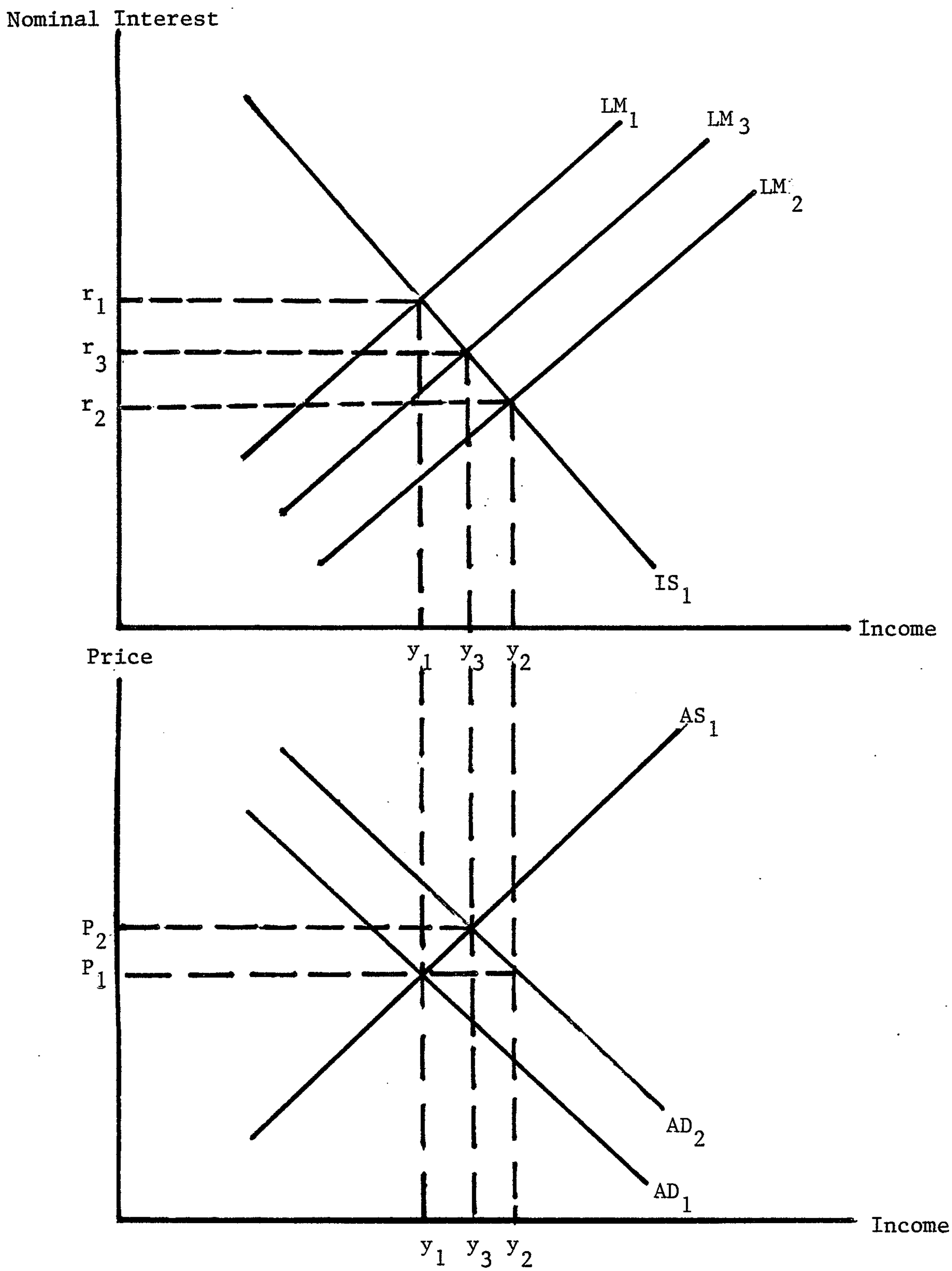

Figure 4

The Keynesian Approach to a Change in Money Supply the nominal interest rates down to r_2, and subsequently causes an increase in both investment and aggregate demand. The shift in the aggregate demand curve from AD_1 to AD_2 creates excess demand in the economy which in turn exerts an upward pressure on price. As prices begin to rise along AS_1 the real money supply (Ms/P) contracts from LM_2 to LM_3. When prices have risen to the point where AD_2 intersects AS_1, the economy is back in equilibrium. At the new equilibrium point, nominal interest rates have fallen from r_1 to r_3, prices have risen from P_1 to P_2, and income (employment) has increased from y_1 to y_3.

The model described in Figure 4 is obviously Keynesian in nature. The major difference between this model and one of a Monetarist design is in regard to the slope of the aggregate supply function (AS). Monetarist theory adheres to the classical notion that the aggregate supply curve is vertical in the long run. in the long run. Attempts to move away from this natural rate of unemployment through fiscal or monetary means will only affect prices, real income will remain unchanged.

It is important to note that Monetarists' view the aggregate supply curve as being vertical only in the long run. If we disassociate ourselves from the extreme position of rational expectations, and settle instead for an adaptive adjustment procedure, shifts in the money supply should have a short run impact on real income (employment).[64] As the money supply increases, both nominal prices and wages increase. Workers are assumed to judge this change in real wages incorrectly. In other words, workers will initially suffer from some degree of money illusion as they fail to properly account for the change in the price level.

---

[64] M. Friedman, "The Role of Monetary Policy", American Economic Review, Vol. 58, March, 1968, pp. 7-11.

The curve shown in Figure 5 depicts a trade-off between nominal wages and employment. An increase in nominal wages from W_1 to W_2 leads workers to increase their supply of labour, moving from point A to B. As the supply of labour increases, unemployment drops from the U_N (the natural rate) to U_1. Eventually, workers come to realize that their real wages have not increased, at which time, the supply of labour begins to contract back to U_N. After the adaptive process is complete, the short run Phillips curve (along which output increased) shifts to a vertical position at the natural rate of unemployment. The actual path of adjustment will most likely be similar to the arc joining points A and C. The resulting increase in wages has a direct impact on the rate of inflation experienced within the economy.

A similar argument to the one presented in the previous paragraph can also be applied to interest rates. If the monetary authority expands the money supply by purchasing bonds from the public, the price of bonds are bid up and interest rates fall. An increase in the amount of money held in household portfolios stimulates a rise in consumption. This, along with an increase in investment (which is prompted by lower interest rates) causes aggregate demand and prices to rise. Eventually, expectations adjust to the price increase, with lenders demanding inflation adjusted rates of interest before they will consent to lending out funds. Once inflationary expectations become entrenched, nominal interest rates should return to their original level or possibly even increase.

Over the long run, the aggregate supply curve is generally thought to be vertical. Such a result is possibly only if actual levels of demand always coincide with expected levels. If this is not the case, the

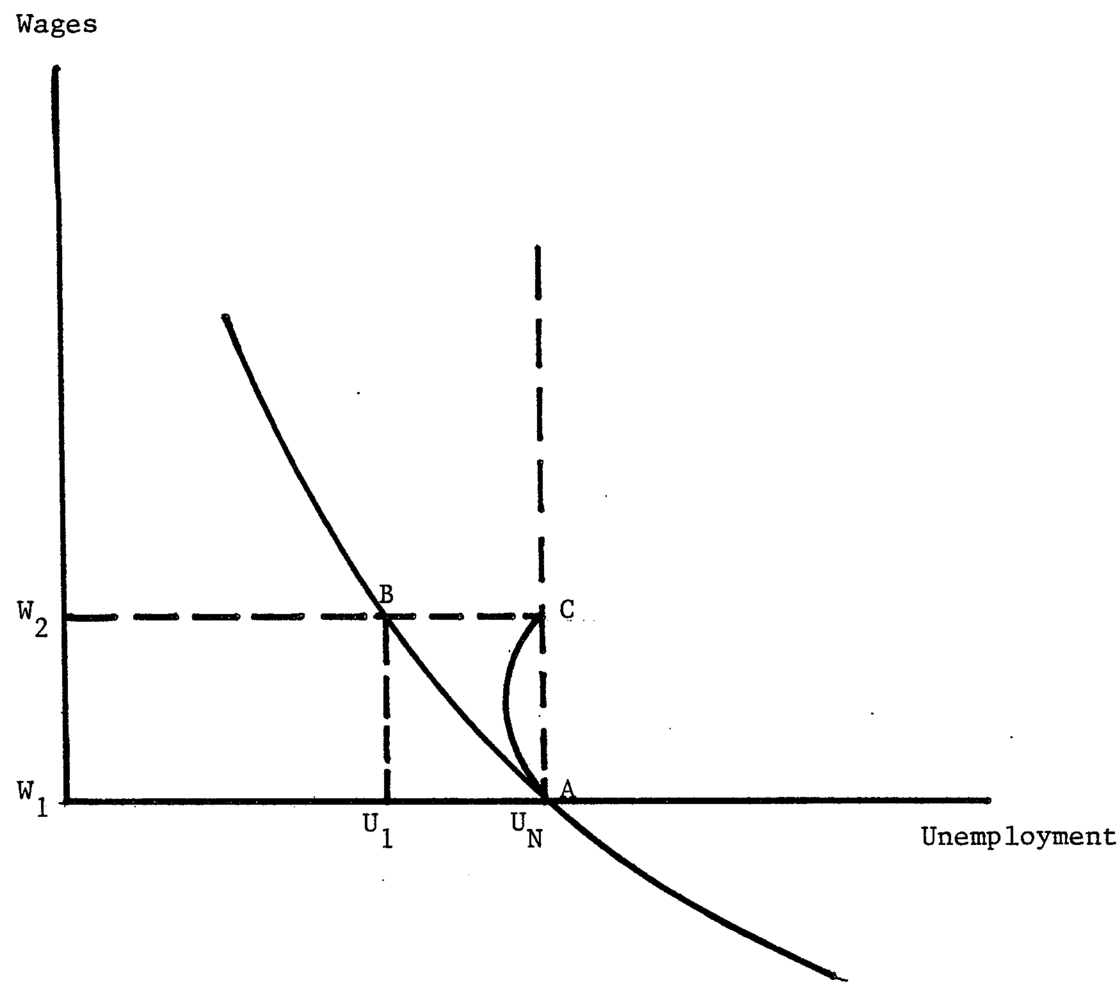

Figure 5

The Monetarist Approach to a
Change in Money Supply

economy will continually be knocked off its adaptive learning curve. In other words, we will always be in a short run situation where a growth (or decline) in output is possible.

3.4 The Effect of Exchange Rates on Domestic Prices

The previous section presented the basic linkages between money supply, interest rates and domestic prices. In order to provide a more complete analysis, exchange rates must also enter the picture. Often, we tend to view the exchange rate simply as a means of changing the demand for imports and exports. This initial pass-through effect represents only part of a much more complicated process. Exchange rate impacts are actually circular in nature. Dornbusch and Krugman's view is that exchange rates are determined in the asset market and in turn affect the current account; the current account through its impact on income, prices and wealth, affects the rate of change in the exchange rate.[65] Due to the complexity of the problem, exchange rate interactions will be explained in three separate sections.

The first and most obvious exchange rate linkage involves the direct (traded) goods market. Trade theory states that a devaluation in a particular country's currency will produce a lagged increase in net exports. This result is brought about by a relative decline in the price of exports and a relative increase in the price of imports. The strength of the relationship between import prices and domestic prices (inflation) depends on: the extent to which imports directly enter domestic consumption, the degree to which domestic goods are comprised of imported

---

[65] R. Dornbusch and Paul Krugman, "Flexible Exchange Rates in the Short Run", Brookings Papers on Economic Activity, No. 3, 1975, p. 555.

factor inputs, and the ability to replace imported goods by domestic goods in terms of both consumption and production.

The exchange rate relationship is not expected to be as symmetric for consumer goods as it is for homogeneous raw products. Product differentiation, whether real or perceived, may result in consumers being willing to pay a premium for imports. However, since not all consumers differentiate to the same degree, some consumers will be encouraged to shift consumption toward lower cost domestic goods.

Noticeable differences should also exist when comparing large versus small economies. Actually, it is not the absolute size of the economy but rather its diversity which becomes the central issue in this argument. Presumably, an undiversified economy does not possess the resources which are necessary to completely substitute domestic for imported goods. From this, it follows that an undiversified economy will often be unable to shield itself from imported inflation. This scenario is especially true in the case of grain, where many countries lack the physical capacity to become self sufficient.

A rise in import price relative to domestic price will serve to increase the demand for domestically produced goods. Demand for domestic goods is subsequently transferred into demand for the factors of production. So long as there is an excess supply of factor inputs, there should be very little upward pressure on price. Consequently, real domestic income will increase. If we assume that the propensity to import is directly related to domestic income, imports will also increase. Even though imports increase, the balance of payments should improve[66] since

[66]This can be shown by the Keynesian foreign trade multiplier as suggested by the P.B. Kenen and C. Pack, Exchange Rates, Domestic Prices and the Adjustment Process, (New York: The Group of Thirty), 1980, p. 12.

the incremental demand for imports is not expected to overtake the additional exports which result from the original currency depreciation.

If we drop the assumption of excess supply in the domestic economy, exchange rate changes begin to impact on a second area of concern; namely, the indirect goods and factor input markets. Goods which are not traded internationally are not directly affected by an exchange rate change. Instead, the price of these goods will be affected in an indirect manner through a change in domestic economy activity.

Increased demand for domestic goods normally affects the price of inputs. For example, in order to attract additional labour, money wages are bid up. This interaction places us right in the middle of the Phillips Curve debate. Recent work in this area[67] has been unable to refute the notion of a natural rate of unemployment. If the economy is pushed below (above) its natural rate, domestic prices will increase (decrease).

The absorptive approach to an exchange rate change incorporates the idea that domestic prices need not rise so long as aggregate demand is properly stabilized. This calls for a decline in government spending in order to make room for additional private sector activity. Unfortunately, cut-backs in government spending can only prevent demand pull inflation; pressure from the cost side will still exist, as higher import prices erode real wages.

Governments face a difficult situation in deciding whether to accommodate inflation. If inflation is not accommodated, unemployment

---

[67]A.M. Santamero and J.J. Seater, "The Inflation Unemployment Trade-Off: A Critique of the Literature", Journal of Economic Literature, Vol. 16, 1978, pp. 488-544.

will increase. On the other hand, if inflation is accommodated, the country will risk further depreciation of their currency. As the volatility of exchange rate movements increase, governments are not willing to sit idle.

> Both the fluctuations in (exchange) rates and their side effects soon caused governments to adopt exchange rate targets and intervene in markets. . . . Government realized that exchange rate movements had real effects: they altered relative prices and real income and they caused inflation or could serve to reduce inflationary pressure. . . . Confronted with a transitory decline in real income, policy makers much preferred using revenues or borrowing to a free adjustment of exchange rate.[68]

Market intervention on the part of government may not be able to alter the general trend of an exchange rate movement, but it can at least reduce the velocity of the change.

This brings us to the feedback effect, which is the third and last linkage between exchange rates and domestic prices. The way monetary and fiscal policy is used to fight the wage-price spiral largely determines the strength of the feedback effect. Foreign exchange market participants are very conscious of changes in government policy. Countries suffering from high inflation rates tend to experience currency depreciation, while those with low inflation see their currency strengthen. At the extreme, it can be contended that in the seven years prior to 1980, the speed of adjustment between exchange rates and domestic prices increased to the point where it became questionable whether real exchange rates could be altered.[69]

---

[68] R. Dornbusch and P. Krugman, op.cit., p. 538.

[69] P.B. Kenen, "Exchange Rate Variability: Measurement and Implications", International Finance Section, Princeton University, Research Memorandum, June 1979.

At this stage, the relationship between exchange rates and inflation has been emphasized. Although the basic linkage is fairly straight forward, the direction of causalty remains illusive. Causation poses an interesting question but is not the major concern of this study. For our purposes, the major concern regarding exchange rates will be their domestic price effect.

3.5 The Effect of Exchange Rates on Factor Input Prices

The next step is to examine how exchange rates impact on the factor inputs involved in wheat production. Table 1 shows that a large quantity of factor inputs are traded between Canada and the U.S. If we assume that these inputs are priced within a North American market, any change in the Cdn./U.S. exchange rate is expected to affect domestic commodity prices. Although direct price effects were discussed briefly in Section 3.4, the following section provides a more structured analysis.

A simple two region, single product model can be used to describe a trade equilibrium between Canada and the U.S. This model assumes that the supply and demand curves are given for both regions. In the absence of trade, the intersection of supply and demand will determine commodity prices within each of the individual regions.

If trade is introduced, product will move between regions provided that the difference in price is greater than the transfer cost (transportation plus any per unit tariff). Figure 6 presents a case where the before-trade price in country X exceeds the before-trade price in country Y by more than the transfer cost (T). The transfer cost adjustment is shown as a vertical shift in country Y's supply and demand schedules. The difference in transfer adjusted pre-trade prices is equal to a - b. This price differential presents a situation of arbitrage where potential

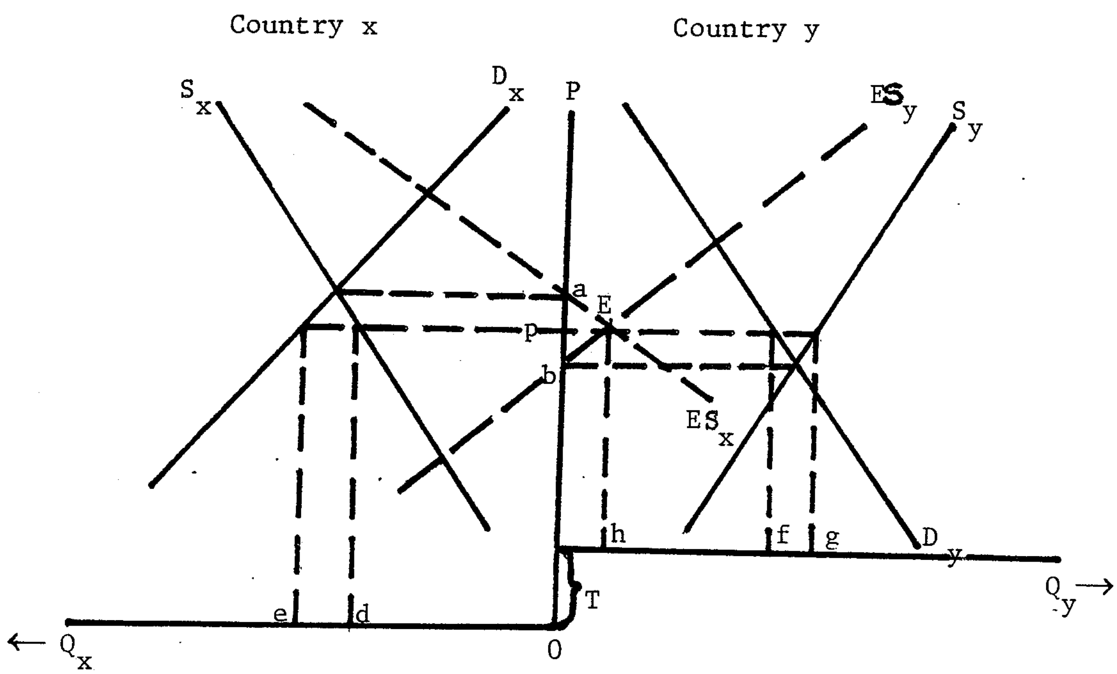

Figure 6

Equilibrium in the Two Market Model

profits can be made by moving goods from country Y into country X. As the movement of product continues, domestic prices within the two countries will equalize.

By horizontally subtracting Dy from Sy we can derive the excess supply curve (ESy). This curve gives us the amount of product country Y is willing to export at each price level. Similarly, the excess supply curve (ES_x) can be constructed by horizontally subtracting D_x from S_x. The excess supply curve (ES_x) provides a schedule of the amount of product region x is willing to export at each price level.

The point of intersection between ES_x and ES_y yields a trade equilibrium (E) between countries X and Y. An equilibrium price is established at p, with (Oh) exported from Y into X. Another way of stating the volume of trade is to say that at price p, country Y exports (g - f), while country X imports (e - d). It is important to note that all of these quantities are equivalent (e - d = g - f = Oh).

Given that the international equilibrium process has been established, it is possible to introduce exchange rates. Figure 7 provides a simplified exposition of a trade equilibria which is similar to the one derived above. The major difference is that Figure 7 examines the general case where a country (Canada) is either an exporter or importer of a particular commodity.

The right hand side of Figure 7 portrays the effect of an exchange rate change when Canada is a net importer. If we assume that the two countries involved are Canada and the United States, then it is possible to assess how a change in the Cdn./U.S. exchange rate will affect Canada's domestic price. An increase in the exchange rate is shown as a shift in the excess supply curve from ES to ES'. The result is that the price of

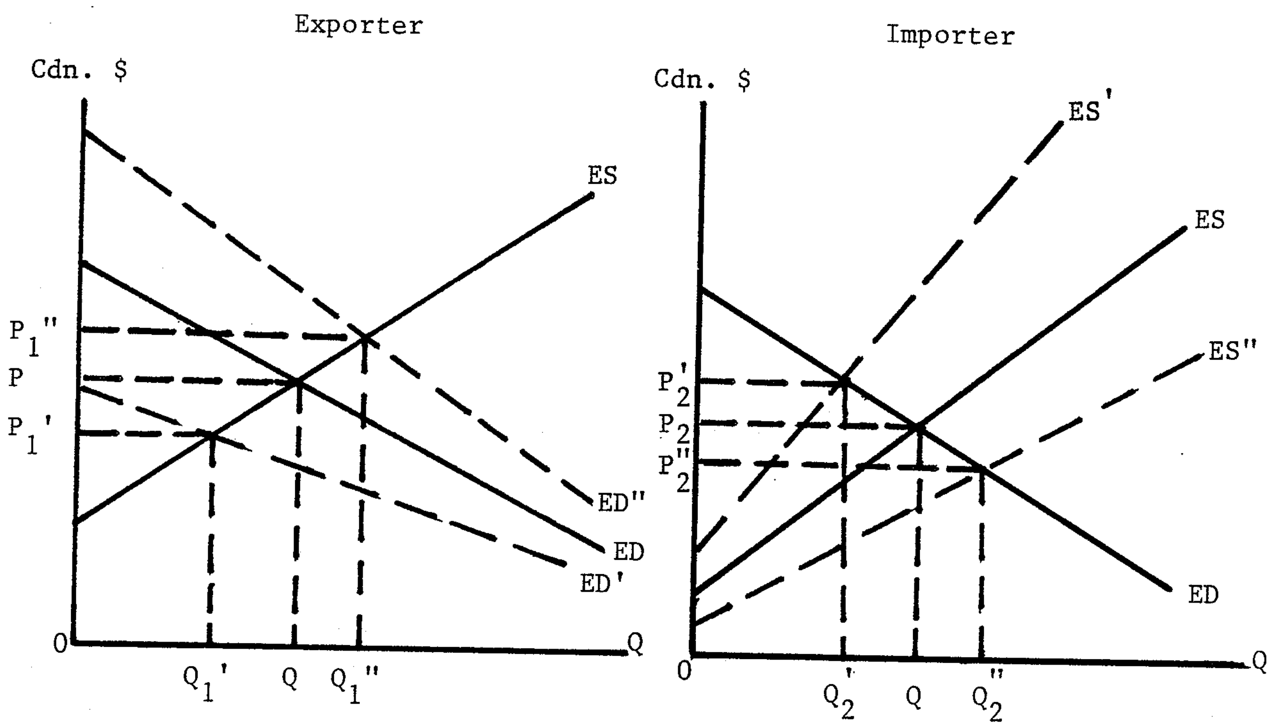

Figure 7

Exchange Rate Effects on Input Markets

goods imported into Canada increases from P_2 to P_2', while the quantity of goods imported into Canada decreases from 0Q to $0Q_2'$.

A decrease in the Cdn./U.S. exchange rate results in a decline in the domestic price of goods imported into Canada. This can be viewed as a shift in the export supply curve from ES to ES". Following an exchange rate decline, trade increases from 0Q to $0Q_2''$ with Canada's domestic price falling from OP to OP_2''.

The left hand side of Figure 7 portrays a situation where Canada is a net exporter of a particular commodity. As the Cdn./U.S. exchange rate decreases, it becomes more expensive for U.S. consumers to import Canadian products. This is shown as a decline in the demand for Canadian exports. Demand shifts from ED to ED', reducing trade and price by 0Q - Q_1 and OP - P_1, respectively.

Viewed from the opposite direction, an increase in the Cdn./U.S. exchange rate reduces the price U.S. consumers pay for Canadian imports. This is equivalent to an increase in the export demand faced by Canada. A shift in export demand from ED to ED" corresponds to a trade increase of $0Q_1''$ - 0Q, as well as an increase in Canadian domestic price from OP to OP_1''.

The trade model presented above assumes that traded products are homogeneous, and that commodity prices are determined through perfect competition. In other words, the international market is assumed to function under the law of one price.

> Students exposed to the pure theory of international trade have been seduced by visions of an imaginary world with few goods, each typically produced by several countries but nevertheless homogeneous. . . . In the absence of transport

costs each good is uniformly priced (in common currency units) throughout the world and the law of one price prevails.[70]

Discriminating monopolies and trade distortions create disparities between export and domestic prices. In order for the law of one price to hold (in the short run), we have to invoke the assumption of perfect market clearing. Isard[71] argues that real world examples of the law of one price are extremely difficult to identify. Due to the non-competitive nature of most markets, a change in exchange rates may tend to alter relative prices even when expressed in a common currency.

Over the long run, any relative price change associated with an exchange rate movement may be completely offset. If exchange rates were to change infrequently, the long run argument may be more pervasive; however, the reality of the situation is that exchange rates are rarely stable over long periods of time. Therefore, long run equilibrium may never be attained, and it is the short run impacts which, if not most important, are at least the most obvious.

3.6 Pricing Mechanisms Within the World Wheat Market

Now that the theoretical linkage between exchange rates and input prices has been presented, an issue which remains to be addressed is how a change in the Cdn./U.S. exchange rate will impact on Canadian wheat prices. However, before we can proceed, we must first discuss how world wheat prices are established. Since the early 1970's, three prominent theories have been put forward regarding the way world (and Canadian) wheat prices are determined. Each of these theories will be briefly reviewed.

---

[70] Isard, "How Far Can We Push the Law of One Price", op.cit., p. 942.

[71] Ibid.

3.6.1 <u>Triopoly Pricing</u>. Alaouze, Watson and Sturgess[72] suggest that the world wheat market functioned as a triopoly throughout the 1970's. The triopoly model is based on the following assumptions:

(a) that the duopolists (Canada and the U.S.) have a notion as to how the world wheat market should be divided between themselves and Australia, and that one of them (the U.S.) is prepared to initiate a price war should a minimum acceptable market share not be attained through negotiation;

(b) that the United States and Canada have an agreement as to how North America's market share should be divided;

(c) that Canada (through the CWB) attempts to maximize revenue and as such is assumed to act as price leader. Although Alaouze et al make this assumption, it is not essential that one participant always behave as the price leader;

(d) wheat is assumed to be homogeneous, and an individual country's supply curve inelastic;

(e) the final assumption is that the duopolists will hold surplus stocks.

The market share arrangement under a triopoly is illustrated in Figure 8. World demand for wheat is represented by D_wD_w. The residual demand curve facing the three major exporters is equivalent to D_rD_r. If Australia's exportable surplus is netted out of D_rD_r, we are left with DD, which is equal to the residual demand facing the duopolists. The broken line labelled D_2D_2 represents the market share curve which divides the residual demand facing the major exporters between the duopolists (to the left) and Australia (to the right). Meanwhile, the D_1D_1 curve further separates the market, by dividing the duopolists' share between Canada (on the left) and the U.S. (on the right).

Theoretically, the market is stable since Australia's share (bc) is less than that permitted by the duopolists (ac). If Australia's share

---

[72]C.M. Alaouze, A.S. Watson and N.H. Sturgess, op.cit., pp. 174-185.

was larger than the permitted level, then the duopolists would likely take aggressive action in order to attain their desired proportion of the market. In other words, so long as the Australian share is equal to or less than what the duopolists think that it should be, the triopoly system will be stable.

The second criterion for stability is that the duopolists function within their area of co-operation. In order to explain this concept, we

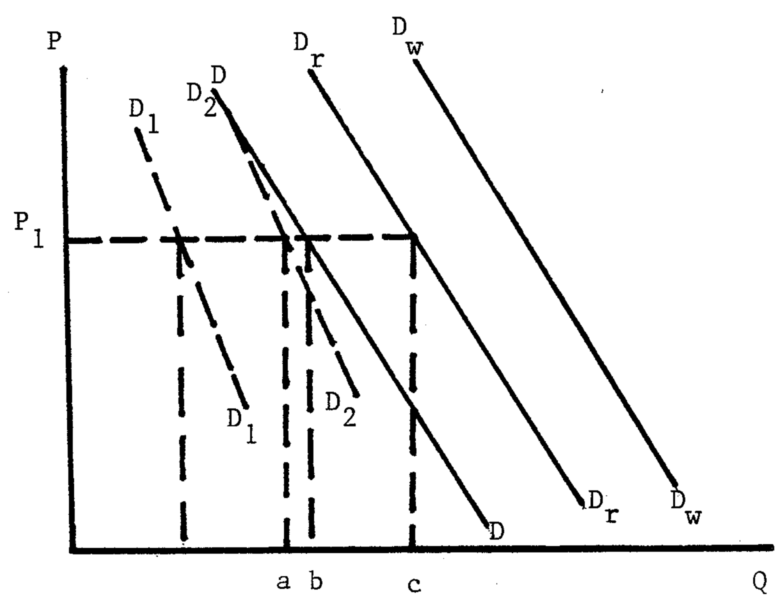

Figure 8

The Formation of Triopoly Pricing

Source: C.M. Alaouze, A.S. Watson and N.H. Sturgess, "Oligopoly Pricing in the World Wheat Market", AJAE, Vol. 60, May 1978, p. 179.

must revert to duopoly theory. McCalla[73] uses an extension of the Cournot's model to describe market interaction within a duopoly structure. Canada is once again assumed to be the price leader, while the U.S. is assumed to follow the Canadian price. There is a maximum price above which the U.S. will refuse to co-operate and will break away from the duopoly in order to maintain its desired market share. Furthermore, there is also a minimum price below which the U.S. would rather store its grain than sell it. It is also assumed that subject to constraints, the duopolists will attempt to maximize total revenue.

McCalla's hypothesis is depicted in Figure 9. The total demand for wheat is given by the DD curve. The SS curve represents the supply of wheat from competitive fringe countries. Subtracting SS from DD yields D_1D_1, which is equivalent to the demand curve facing the duopolists. The dd curve can now be constructed, and is based on the assumption that the price leader attempts to maximize its total revenue. Theoretically, the dd curve represents the price leader's market share. Total revenue is maximized by operating on the dd curve at the point where elasticity of demand is equal to one. In other words, total revenue is maximized when marginal revenue is equal to zero.

If Canada sets the price at P_1, the U.S. will accept a market share which is greater than or equal to CE. Similarly, at price P_0 the U.S. will desire a market share of no less than DF. Any point within the shaded area will be acceptable to the U.S. This is known as the area of co-operation and can expand or contract depending on the position of dd.

---

[73]A.F. McCalla, "Duopoly Model of World Wheat Pricing", op.cit.

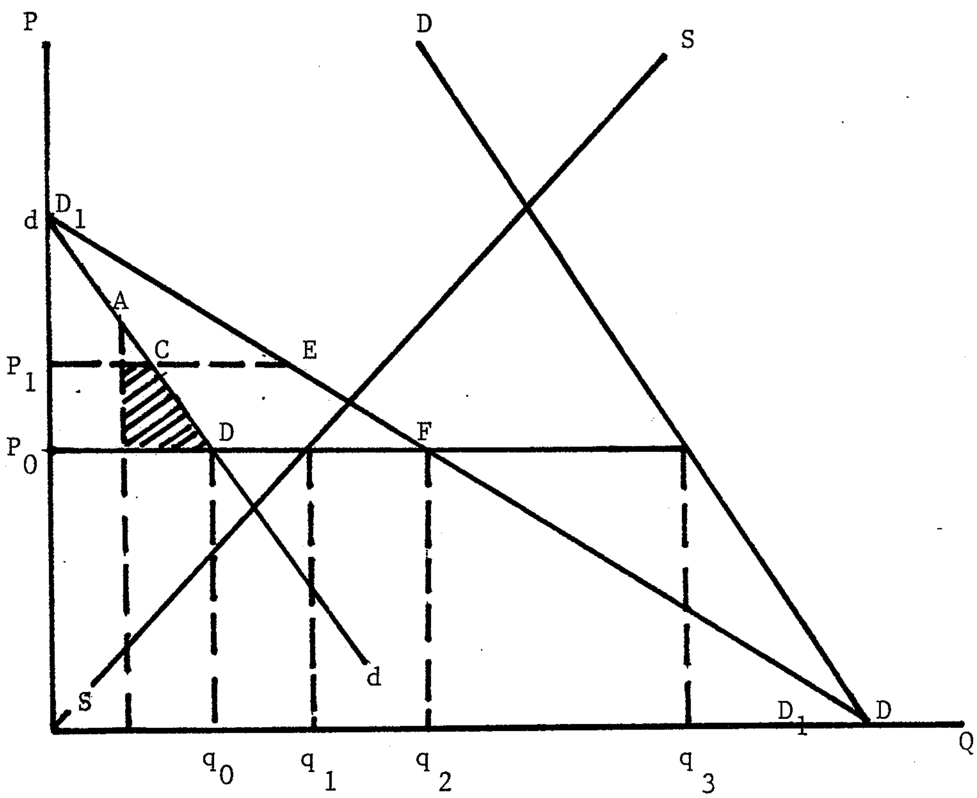

Figure 9

The Duopoly Pricing Model

Source: A.F. McCalla, "A Duopoly Model of World Wheat Pricing", <u>Journal of Farm Economics</u>, Vo. 48, 1966, p. 717.

Shifts in the dd curve are the result of either a change in market demand or a change in the factors which determine the price leader's desired market share. According to Figure 9, Canada's total revenue is maximized by selling Oq_0 at price P_0. Meanwhile, the U.S. sells $q_2 - q_0$, with the competitive fringe supplying $q_3 - q_2$ (which is equivalent to Oq_1). Fringe countries must either match P_0 or else charge a lower price in order to export Oq_1.

3.6.2 Monopsony Pricing. Carter and Schmitz[74] present a theory which differs from the one suggested by McCalla and Alaouze et al. The Carter-Schmitz hypothesis is that world wheat prices are determined by major importers. With the exception of the commodity price boom of 1973-74, world wheat trade can be viewed as a buyer's market with monopsony power concentrated in Japan and the EEC. This approach does not refute the existence of triopoly or duopoly structures but suggests that such arrangements play a relatively minor role when compared to the buying power of importing nations.

Carter and Schmitz use an optimal tariff model to develop their theory. According to Figure 10, S_f gives the supply schedule in the exporting country, with MC_f representing the marginal cost of importation when an importing country exerts monopsony power. In the case of the importing nation, S_d and D_d represent the respective supply and demand schedules.

Under a free trade situation, imports will equal BA (or OQ_6); however, the importing country can improve its position by imposing an optimum tariff ($Sd + MC_f$). The application of such a tariff causes the

[74]Colin Carter and Andrew Schmitz, op. cit.

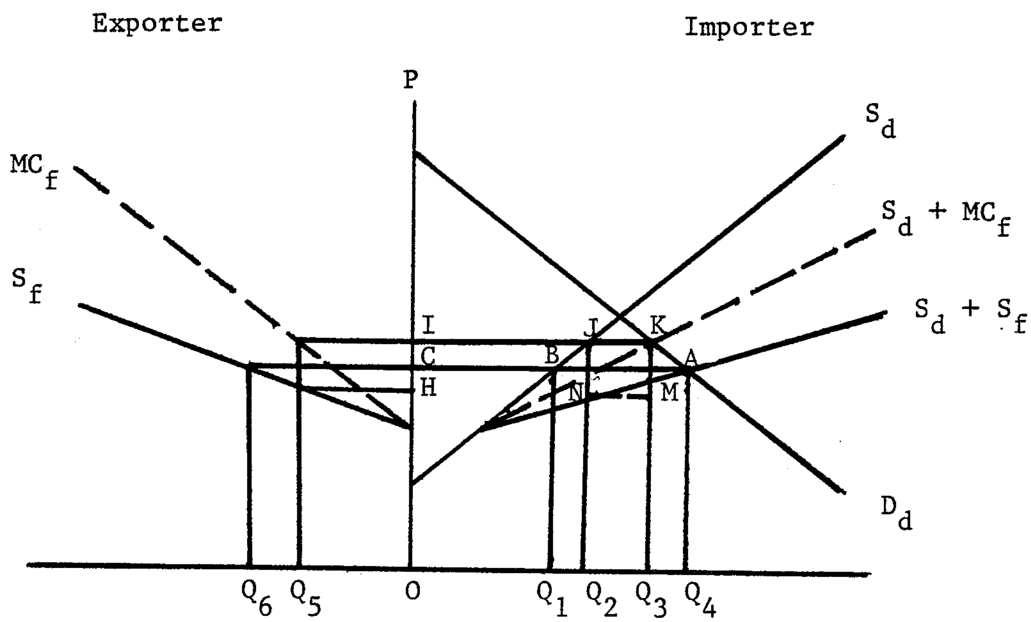

Figure 10

Monopsony Power Within the World Wheat Market

Source: Colin Carter and Andrew Schmitz, "Import Tariffs and Price formation in the World Wheat Market", AJAE, Vol. 61, Aug. 1979, p. 518.

tariff, exports to decline from BA to JK (which is equivalent to OQ_5). Prior to the tariff, the international price of wheat was equal to C. Under the optimal tariff, the importer's domestic price is equal to I and the exporter's price is H. The difference (I - H) is equal to the optimal per unit tariff.

Within the importing country, producers gain BCIJ, consumers lose IKAC and there is a tariff revenue equal to JKMN. The producer gain plus tariff revenue more than offsets the consumer loss. If the tariff revenue is redistributed to consumers, there may be an overall improvement in the welfare of the importing nation.

The monopsony power hypothesis put forward by Carter and Schmitz is able to explain how importing nations can reduce both the price and quantity of wheat exports, but does not explain how these reduced volumes will be allocated between exporters. It may well be that the export market share is decided through a duopoly mechanism with the U.S. behaving as the price leader.

3.6.3 <u>Price Determination in the U.S.</u>. A third variant of wheat pricing theory treats the U.S. market as the world's price determining mechanism. Since 1972, the Canadian Wheat Board has been hesitant to reduce prices for fear that U.S. retaliation will weaken Canada's competitive position.[75]

> A more competitive firm structure (private and public) dominated the market after 1972. The central element of this mechanism is the U.S. open market with the pricing of the state trading agencies (Australia and Canada) based upon these highly visible U.S. prices.[76]

---

[75] B.T. Oleson, op.cit., p. 161.

[76] Oleson, op.cit., pp. 176-177.

Groenewegen adheres to the same view stating that Canadian grain prices are a direct extension of U.S. prices after transportation, handling costs and quality differences have been accounted for.

> The U.S. grain price is often referred to as the world price of grain. This is so because the United States is the predominant exporter of grain and oilseeds, the price discovery mechanisms for grains are located in the United States (i.e., the futures markets), there are no barriers between domestic U.S. prices and world prices (i.e., f.o.b. or c.i.f. prices of U.S. exports) and the U.S. dollar is the most common currency used in international transactions. Changes in global supply or demand factors for grain are reflected in U.S. grain prices.[77]

Therefore, the translation of U.S. wheat prices into Canadian prices will depend on the Cdn./U.S. exchange rate, as well as certain locational, timing and quality factors.

The fact that a large proportion of Canadian wheat is sold under Long Term Agreements (LTA's) lends further credence to the idea that world wheat prices are determined in the U.S. During the 1983/84 crop year, Canada was committed to a minimum of 10.8 million metric tonnes[78] of wheat through LTA's. This works out to approximately 53 percent of Canada's total wheat exports during that year. The normal convention is for LTA's to guarantee the importer a minimum quantity of grain at a price which is adjusted every three to six months. During the past 10 years, the U.S. open market has acted as the determining mechanism for these prices.[79] When you add Canada's LTA's to the total quantity of grain exported out of

---

[77]Groenewegen, op.cit., p. 14.

[78]World Wheat Statistics, 1984, op.cit., pp. 52-53.

[79]Personal correspondence with Harvey Brooks, Market Analyst with the Canadian Wheat Board, June 17, 1985.

the U.S., it seems only logical to view the U.S. market as the major determinant of world wheat prices.

3.7 The Impact of Exchange Rates on Canadian Wheat Prices

If we accept the premise that the CWB sets its export price based on the U.S. open market, it is reasonable to assume that a change in the Cdn./U.S. exchange rate will directly affect Canada's domestic price of wheat. Figure 11 describes the structure of the Canadian wheat market. The federally administered two price system for wheat results in domestic demand (D) which is kinked at both a floor (P_f) and ceiling price (P_c). Since Canada is assumed to price its wheat based on the U.S. open market, the export demand curve facing Canada can be thought of as a horizontal line. The price level for Canada's export demand curve is equivalent to the U.S. price of wheat expressed in Canadian dollars. Meanwhile, the Canadian supply of wheat is assumed to be inelastic in the short run.

If the value of the Canadian dollar declines relative to the U.S. dollar, the U.S. (i.e., international) price of wheat as expressed in Canadian dollars will rise. Figure 11 illustrates that an increase in the Cdn./U.S. exchange rate will cause the Canadian price of wheat prices to increase from P to P'. Domestic consumption falls from OD to OD' and exports rise from OE - OD to OE' - OD'. The total amount of Canadian grain sold into the domestic and export markets increased by OE' - OE.

The theory described in Figure 11 suggests that an increase in the Cdn./U.S. exchange rate will lead to higher Canadian wheat prices, decreased domestic demand and increased exports. The magnitude of these adjustments will obviously depend on the elasticities of demand and supply. If the domestic demand and export supply curves are perfectly inelastic, a change in the Cdn./U.S. exchange rate will be captured

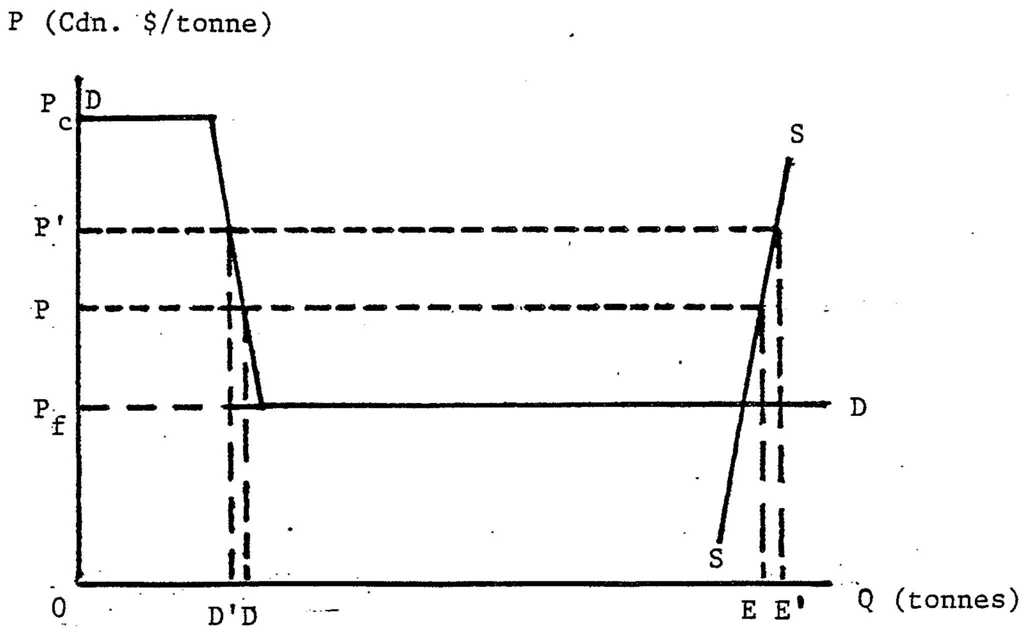

Figure 11

The Effect of the Cdn./U.S. Exchange Rate on the Canadian Wheat Market entirely by a shift in price. On the other hand, if the demand and supply curves are not perfectly inelastic, a change in the Cdn./U.S. exchange rate will affect both price and volume. Although it is hypothesized that the exchange rate will have a greater impact on price than on volume, final judgment is postponed until Chapter V when the relationships shown in Figure 11 will be estimated.

3.8 Net Revenue Considerations

This chapter has demonstrated some of the theoretical linkages between the macroeconomy and the components which comprise a wheat producer's net revenue. General macroeconomic considerations were described in Section 3.3, while input costs and gross revenue aspects were included in Sections 3.5 and 3.7, respectively. In order to assess whether a particular monetary shock leads to an increase or loss in net revenue, both input costs and gross revenue will have to be estimated. For the purposes of this study, net revenue will be used as a proxy for an individual producer's welfare.

CHAPTER IV

THE CONCEPTUAL MODEL

The general objective of this chapter is to outline a model which can be used to measure the effect of monetary shocks on the net revenue of Canadian wheat producers. The model is divided into a number of separate yet interrelated submodels. Figure 12 provides a flow chart of the individual submodels and their respective linkages.

4.1 The Macroeconomic Component

As depicted in Figure 12, the macroeconomic component drives the entire process. The purpose of this submodel is to generate monetary variables which can be fed into the Trade and Input Price Models. More specifically, the monetary variables generated within the macroeconomic submodel include: the interest rate, the inflation rate and the Cdn./U.S. exchange rate. The macroeconomic model must be able to accommodate the relationships which exist within the Canadian economy. All predicted values should be the result of an endogenous algorithm.

4.1.1 The Focus Model. The design and availability of the Focus Model made it a prime candidate for use in this study. Focus is an acronym for the Forecasting and User Simulation Model. The model was developed at the University of Toronto's Institute for Policy Analysis and is designed to provide quarterly forecasts over the short, medium and long run. Focus is a large scale macroeconomic model with over three hundred behavioural equations and identities.[80] Although its basic orientation is

[80]The description of the Focus Model is taken from: Institute for Policy Analysis, "Focus, Quarterly Forecasting and User Simulation Model of the Canadian Economy", mimeographed paper, University of Toronto, Toronto, Ont., January, 1982.

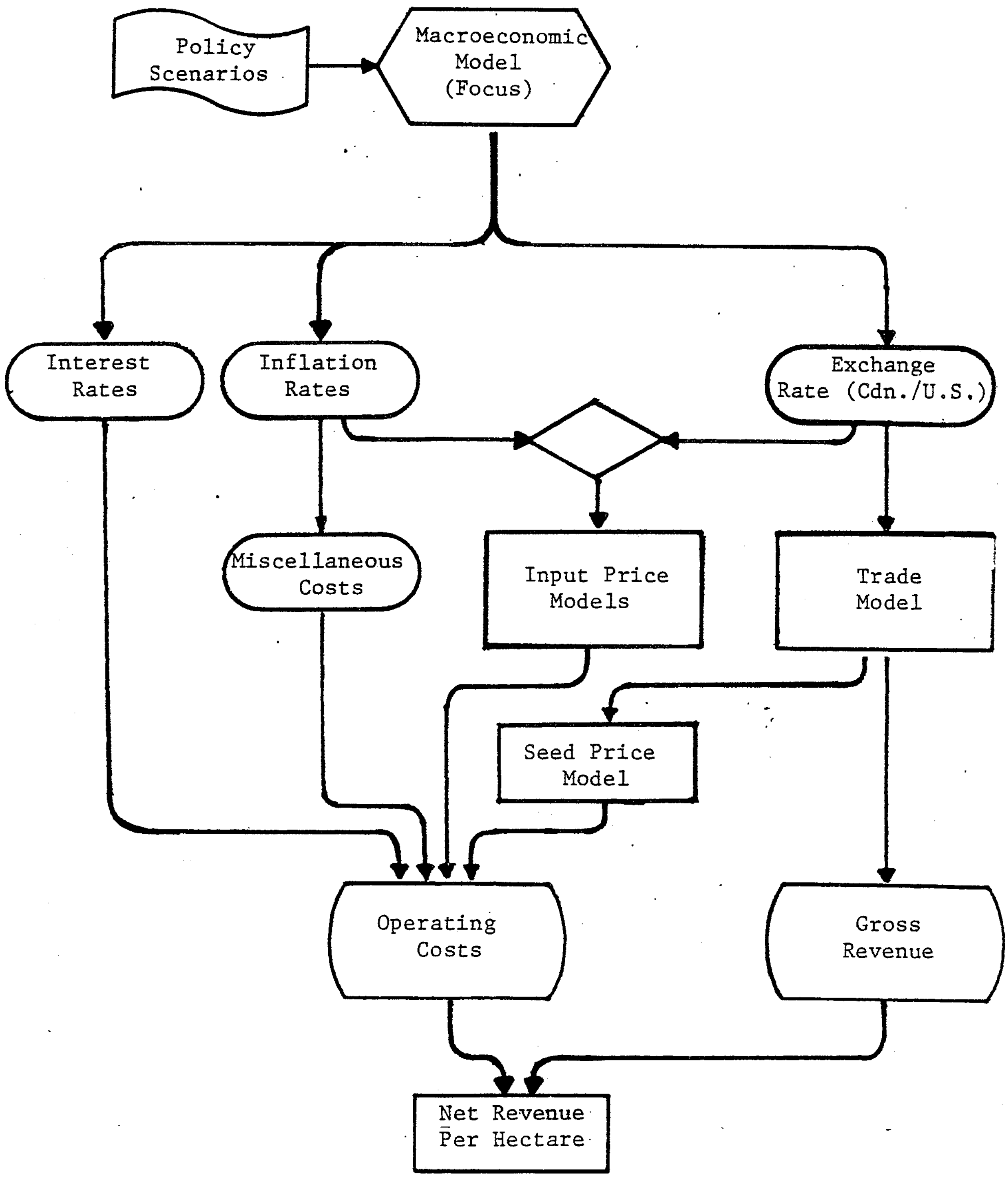

Figure 12

Flow Diagram of the Model

Keynesian, relationships within Focus can be adjusted to depict full employment (i.e., vertical aggregate supply).

The design of the Focus Model includes a number of features which will be particularly useful in this study. The first consideration is that Focus incorporates more than just an adaptive version of inflationary expectations. Expectational parameters are synthetically estimated by regressing the rate of price inflation against observed values such as the growth rate of the money supply, foreign prices, exchange rates, and past rates of price inflation. The designers of the Focus Model believe that their method of estimating expectations produces a result which is more accurate and consistent than estimates based solely on past inflation rates.

A second consideration is that the Focus Model links wages and prices together using a 'key' series approach. The 'key' wage equation measures the percentage change in the annual average wage rate of private sector employees. The wage rate variable is based on an extended Phillips Curve with the expected rates of inflation and unemployment represented as explanatory variables.[81] As such, the 'key' wage equation provides a link between real economic activity and inflationary pressure.

The wage rate equation allows a portion of the total expected inflation to be incorporated within current wage settlements. Focus assumes that 50 percent of all wage settlements are based on expected future prices, with the remaining 50 percent influenced by catch-up actions. Cost of Living Adjustments (COLA) represent a typical of catch-

[81] A detailed list of explanatory variables includes: (1) a moving average of actual unemployment, (2) a moving average of the natural rate of unemployment, (3) the rate of change in output prices, (4) the rate of change in CPI and (5) the expected future change in CPI.

up procedure whereby wages are adjusted to actual price movements after the fact. In the long run, this type of wage price spiral should result in nominal wage inflation which is equal to price inflation plus some constant which reflects labour productivity.

The link between the 'key' wage equation and the 'key' price equation is accomplished through a mark-up pricing rule. Implicit price deflators (i.e., 'key' prices) are determined through stochastic equations based on a mark-up of wages, imports, taxes and petroleum prices. Under the mark-up rule, real private domestic supply is adjusted to accommodate the economy's aggregate demand.

This brings us to a third feature of the Focus Model; namely, an integrated supply side. Cobb-Douglas production functions are used within Focus to derive the demand for labour and capital. If we assume that the economy is comprised of optimally sized plants, with each plant displaying decreasing returns to scale, supply side investment will be directly related to the number of firms required to satisfy demand. Positive net investment will occur when the change in the desired number of firms exceeds zero. Investment is further stimulated by a positive differential between the internal rate of return and the real after tax rate of interest on government bonds. The Focus Model's investment sector is designed to approximate the workings of a competitive industry. When profits are high, the number of firms entering an industry increases. Additional production eventually causes a price decline, which moderates incentive for further entry.

A fourth consideration deals with the determination of the Cdn./U.S. exchange rate, which is of particular interest in this study. Focus contains a disaggregated capital flows/balance of payments sector, which is capable of determining the Cdn./U.S. exchange rate as a market clearing price. The approach adopted by Focus is a fairly disaggregated with a separate treatment of merchandise trade, capital services and debt flows.

The participation of the Focus Model in Project LINK,[82] prompted a disaggregation of the components included within the Current Account. In the most recent Focus Model, merchandise trade is divided according to the Standard International Trade Classifications. The four major merchandise categories include: food and beverages; other crude materials; fuels and lubricants; manufactured goods. Within these groupings, special attention is paid to oil and natural gas, as well as to the auto industry. Also included in the Current Account is a special provision for capital servicing.

The Capital Account is also modelled in a disaggregated form. Long term direct investment in Canada, Canadian direct investment abroad, net issues of provincial and municipal bonds, net foreign issues of Canadian corporate bonds and net short term capital flows are all estimated separately. Once the estimates of the Current and Capital Accounts have been completed, the Focus Model solves for the Cdn./U.S. exchange rate, simulating the behavior of the foreign exchange market.

The Cdn./U.S. exchange rate is solved endogenously, according to the following process.[83] Changes in official reserves are added to Special Drawing Rights in order to derive an Official Settlements balance. The Current Account and long term Capital Account balances are then

---

[82]For a description of project LINK see R.J. Ball ed., The International Linkage of National Economic Models. (Amsterdam: North Holland, 1973).

[83]Institute for Policy Analysis, op.cit., p. E.2.14.C.

subtracted from the Official Settlements balance leaving us with a residual, which is equivalent to short term capital flow. By inverting the equation for short-term capital flow, it is possible to solve for the Cdn./U.S. exchange rate. However, since the Focus Model is simultaneous, the newly calculated exchange rate will affect both merchandise trade and long term capital flows, which in turn exert a further impact on the exchange rate. An iterative process continues until convergence is attained.

A fifth and final consideration deals with the monetary policy options available within Focus. Given that the Focus Model is Keynesian, interest rates form the main channel through which financial aggregates influence real quantities and prices. Since capital investment is sensitive to interest rates, such investments will also be affected by monetary policy. The Focus Model presents a number of different monetary options. By altering these options, it is possible to simulate how the Canadian economy reacts to changes in monetary policy.[84]

4.1.2 Linking the Macroeconomy. The linkage between the macroeconomy and the other submodels is shown in Figure 12. The macroeconomic variables which are of primary importance include interest rates, inflation, and the exchange rate. The interest rate variable is the Chartered Banks' prime rate on business loans. The inflation rate is designed to reflect the price of miscellaneous goods and services purchased by Canadian wheat producers. One half of the inflation index is comprised of the price of consumer durables with the other half related to the price of the

[84]The Focus Model also allows for changes in fiscal policy; however, this study is restricted to monetary policy considerations.

consumer services. A third and final link to the macroeconomy is through the Cdn./U.S. exchange rate.

The remainder of this chapter is devoted to examining how the macroeconomic variables feed into the Trade and Input Price submodels. At this stage, the discussion will revolve around conceptual considerations with the actual model specification and estimation included in Chapter V.

4.2 The Trade Model

The objective of the Trade Model is to estimate the gross revenue resulting from wheat production. The general design of the Trade Model follows from the theory presented in Chapter III. Specifically, the Trade Model is based on the hypothesis that Canada acts as a price taker with the world price of wheat established in the U.S. market. As such, the Cdn./U.S. exchange rate is expected to have a direct impact on the domestic price of Canadian wheat, but a very limited impact on the quantity of wheat exported out of Canada.

The Cdn./U.S. exchange rate is the only variable linking the Trade Model to the macroeconomy. Following the suggestion of Orcutt,[85] the exchange rate enters the Trade Model as a separate, exogenously determined regressor. In order to address both price and trade impacts, the Cdn./U.S. exchange rate variable is included in two behavioural equations. The first entry is through an equation which estimates the Canadian price of wheat. The second interaction is through an equation designed to measure export demand for Canadian wheat.

In addition to the equations mentioned above, other variables estimated in the Trade Model include: Canadian wheat production, export

[85] G.H. Orcutt, op.cit.

demand for Canadian wheat, export supply of Canadian wheat, domestic demand for Canadian wheat as well as the U.S. (world) price of wheat. Using these predicted variables it will be possible to calculate wheat prices and deliveries on a per hectare basis.

In order to convert from gross export volume to a per hectare equivalent, some simplifying assumptions are required. If we examine the historic pattern of Canadian wheat stocks, it appears that we are currently at or near a minimum level.[86] This places the Canadian wheat industry in a pipeline position,[87] whereby current demand must be satisfied out of current production. Given this, it is possible to calculate the deliveries per hectare by dividing the total disposition of Canadian wheat by the number of hectares seeded.[88] Once the price of wheat and the estimated deliveries per hectare has been established, the gross revenue per hectare can be calculated.

An estimate of average wheat yield is implicit in the previous discussion. Predicting wheat yield represents a very challenging proposition. The problem is that the main variable which determines yield, namely the weather, is difficult, if not impossible to measure. Weather is comprised of individual components, such as: soil moisture at

---

[86] As of July 31, 1984, Canadian wheat stocks stood at 8.962 million tommes. This compares to a 30 year (1954-1984) low of 7.979 million tonnes on July 31, 1976. Canada Grains Council, Canadian Grain Industry Statistical Handbook 84 (Winnipeg: Canada Grains Council, 1985), various issues; and Statistics Canada unpublished data.

87B.T. Oleson, statement made in a seminar presentation on the 1985 Wheat Outlook. Department of Agricultural Economics and Farm Management, University of Manitoba, Dec. 6, 1984.

[88] There is a problem with relating area seeded and quota on a one-to-one basis. Individual producers may allocate quota hectares in a way which does not directly related to seeded area.

time of seeding, the amount and timing of precipitation during the growing season, heat units, and the possible occurrence of frost. Even if all of these components could be aggregated, differences in weather between regions would still have to be accounted for. Adverse conditions in one region may be balanced by good growing conditions in another area.

For the purpose of this study, Canadian wheat yield will not be estimated from a structural model; instead it will be treated as a trend variable. Figure 13 illustrates the trend in Canadian wheat yields[89] from 1970/71 to 1983/84. As expected, there is a good deal of variation in yield from one year to the next. It is interesting to note that Canadian wheat yields do not appear to correspond directly with price. In 1974/75, when the Canadian price of wheat was high, Canadian wheat yield was at a 12-year low of 1.49 tonnes per hectare. By 1976/77, wheat prices had dropped by $61 per tonne but the average yield of wheat had increased to 2.1 tonnes per hectare. Although a direct relationship does not exist, it can be argued that a lagged price effect is possible. There does appear to be a certain degree of correlation between wheat yield and the price of wheat lagged one to two years. A lagged impact is reasonable since it will take a period of time for producers to react to changes in profitability.

Two other assumptions included in the Trade Model also deserve mention. The first is that wheat is treated as a single commodity, and as a result, the different types and grades of wheat are not specifically modelled. The theoretical attraction of segmenting the wheat market is

---

[89]The trend line is estimated using an Ordinary Least Squares procedure, with wheat yield regressed against time. The resulting t-statistic is significant at the .05 level, while the f-statistic is significant at the .10 level.

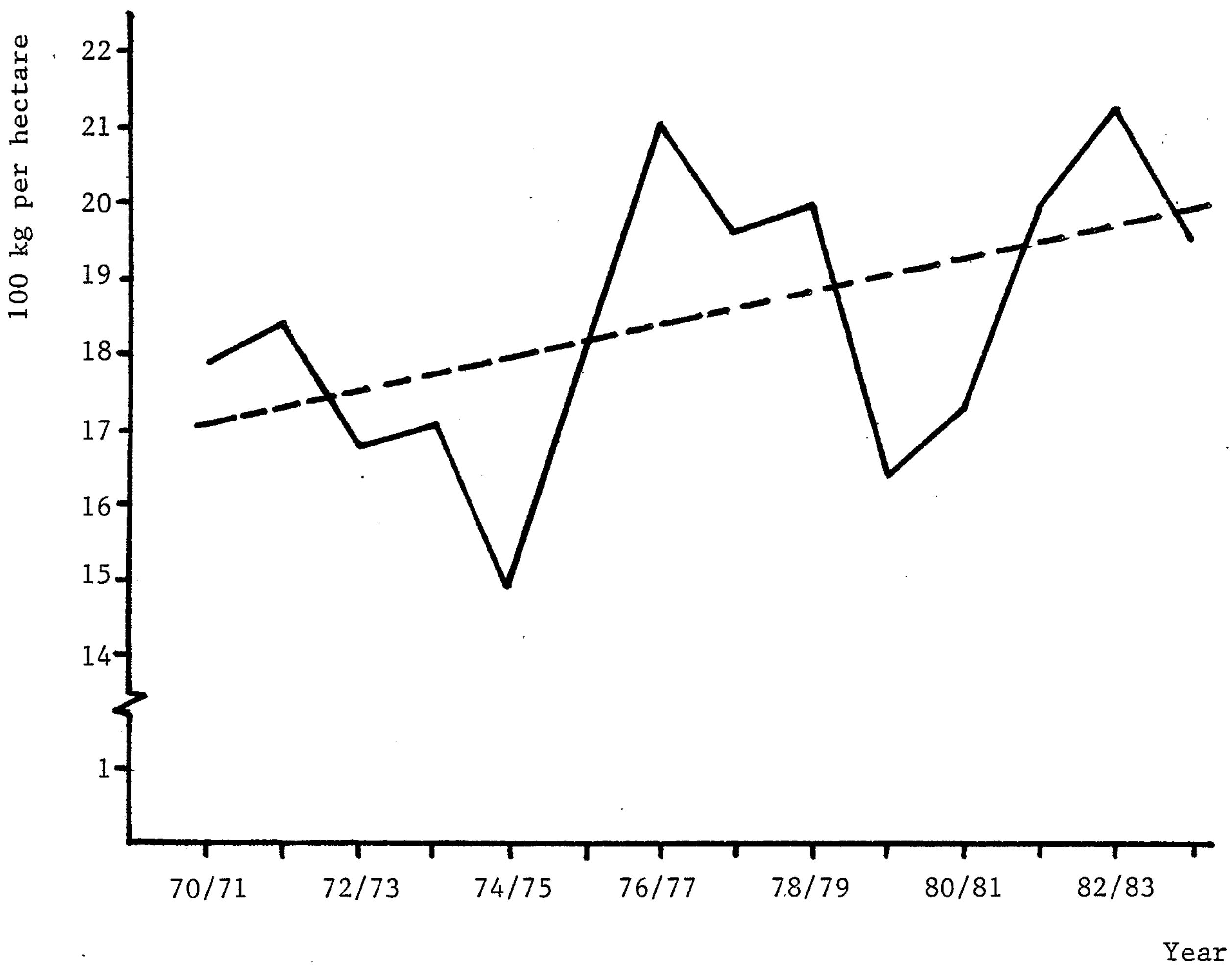

Figure 13

Canadian Wheat Yields

Source: International Wheat Council, World Wheat Statistics (London: IWC, 1984), various issues.

acknowledged, but in the aim of simplicity and in order to conserve degrees of freedom, wheat will be treated as a homogeneous commodity.

The second simplification relates to the formation of world wheat prices. Changes in the value of an importing nation's currency relative to the predominant world currency (U.S. dollar) should theoretically result in an income effect. Stated more explicitly, this means that an increase in the value of an importer's currency is equivalent to an increase in income. Traditional demand theory tells us that as long as the commodity in question is a normal good, the quantity demanded will increase as income increases.

It is accepted that international income effects brought about through changes in exchange rates may have an impact on the international demand for wheat; however, such impacts will not be accounted for within the Trade Model. In order to do justice to the question of international income effects, individual income elasticities would have to be estimated for the various importing nations. In addition, if we were to simulate future impacts, it would be necessary to construct a model capable of predicting the relative movement of various world currencies. Due to the complexity of such a task, it was decided that the time would be better spent by concentrating on the domestic rather than international side of the problem. Consequently, the only exchange rate variable which is included in the Trade Model is the conversion between Canadian and U.S. dollars.

4.3 Measuring the Cost of Wheat Production

As we move from the trade (output) side of the problem to the question of production costs, the linkage to the macroeconomy becomes more diverse. Refering back to Figure 12, we can see that interest, inflation and the Cdn./U.S. exchange rate are all tied to the cost of producing wheat. The objective of this section is to explain how these macro-micro linkages occur.

Using a 400 hectare Manitoba grain farm as an example, it is possible to estimate an average cost of wheat production.[90] Table 2 illustrates how total wheat production costs for our case farm can be separated into operating costs, machinery costs and a residual which encompasses labour, management and land.

Now that the cost of producing wheat has been outlined (Table 2), the problem becomes one of estimating the impact which will result from a change in the macroeconomic variables. In order to simplify the problem, the component describing labour, management and land costs will be dropped from the model. The reasons for omitting these costs are twofold. First of all, by eliminating land costs, problems associated with capital gains can be avoided. Secondly, it is debatable whether labour, management and land costs enter an individual producers short run decision process. In making the long run decision of whether to enter or remain in agriculture the opportunity cost associated with labour, management and land will obviously be relevent. However, once the long run decision has been made, the appropriate short run decision revolves around the quantity and type of grain to be produced.

After eliminating labour, management and land costs, we are left with approximately 68 percent of the total production costs specified in Table 2. By deleting the previously mentioned costs, we have in effect

---

[90]Wheat production costs are based on the estimates included in: Manitoba Agriculture, "Farm Planning and Organization--1984 Crop Planning Guide", Winnipeg, Man., Nov., 1983. For more information on the budgetting procedure refer to Appendix C.

Table 2

Estimated Cost of Producing Wheat--1984
(dollars per hectare)

OPERATING COSTS:		
Seed		$20.90
Fertilizer		64.35
Chemicals		45.70
Fuel		22.25
Miscellaneous		
Machinery operating	$17.30	
Insurance	11.75	
Overhead	12.35	41.40
Interesting on Operating		12.60
TOTAL OPERATING COSTS		$207.20
MACHINERY COSTS:		
Depreciation	34.60	
Investment	31.15	65.75
TOTAL COSTS INCLUDED IN THE MODEL		$272.95
LAND, LABOUR AND MANAGEMENT:		
Land Investment	86.50	
Labour and Management	39.50	126.00
TOTAL COST		$393.95

Source: Manitoba Agriculture, "Farm Planning and Organization--1984 Crop Planning Guide", Winnipeg, Manitoba, Nov. 1985.

adopted an approach which is based on cash costs and depreciation rather than economic (opportunity) cost. The net revenue which is available after operating and machinery costs have been paid, can in turn be applied to land, labour and management costs. Any residual which remains is considered to be profit.

4.4 Modelling Input Prices

The cost of producing wheat (as defined in Section 4.3) will be calculated by updating 1984 input costs. Individual forecasting models will be constructed for each of the following input prices:

1. agricultural machinery,
2. fertilizer,
3. agricultural chemicals,
4. fuel,
5. seed,
6. miscellaneous items.

These price indexes will be combined with interest rates (from the macroeconomic model) in order to predict wheat production costs.

Miscellaneous items such as hydro and telephone are treated as a separate cost component, and are assumed to be directly affected by the domestic price of durables and services (Figure 12). The argument here is that the miscellaneous items which go into the production of wheat are much more heavily weighted by domestic prices than by the price of imported goods. Therefore, it seems reasonable that any change in the price of miscellaneous goods should be tied closely to the domestic inflation rate.

Seed price is also treated as a separate item. As a general rule, one can assume that Canadian wheat varieties are mutually exclusive from those grown in the U.S. Since very little seed moves across the border, the Cdn./U.S. exchange rate should influence seed prices only through the domestic price of wheat. Seed prices will be estimated through a behavioural equation which includes wheat price as one of the explanatory variables.

As for the remaining four inputs, the hypothesized relationships are not as straight forward. Originally, it was thought that price indexes for machinery, fertilizer, chemicals and fuel could be estimated through the law of one price. This doctrine (as presented in Section 3.5) states that under perfect market clearing Canada and the U.S. will function as one rather than two separate markets. Any change in the Cdn./U.S. exchange rate should have a direct impact on Canada's domestic input prices.

The law of one price can be tested by examining the strength of the short run transmissions between the Cdn./U.S. exchange rate and Cdn./U.S. input price ratio. Study of this relationship has led to mixed results.[91] The law of one price is not successful in explaining the pricing of petroleum products, agricultural chemicals or fertilizer. The theory does, however, appear more appropriate in the case of agricultural machinery.

The mixed results obtained when analyzing the law of one price can be explained by the structure of the markets in question. Even though there are no significant inport tariffs on factor inputs, prices between Canada and the U.S. fail to equilibriate. The result is that there is a very little correlation between relative price ratios and movements in the exchange rate. Given that many of the same companies operate in Canada

---

[91] C.A. Carter and N. Hamilton, op.cit.

and the U.S., and that the structure of these markets is oligopolistic, it is not surprising to find that price discrimination is the norm rather than the exception.

The apparent breakdown of the law of one price when applied to wheat inputs leads to two possible conclusions. The Carter and Hamilton study examined only short run lags between exchange rates and relative prices. It could be that pricing parity exists only when examined over a longer run. Or, it could also be that the results of the Carter and Hamilton study are in fact accurate, and that the law of one price between Canada and the U.S. is a fallacy in regard to wheat inputs.

The study at hand draws upon the aforementioned possibilities, proposing alternative methods for measuring wheat input prices. If pricing parity exists in some distributed lag form, autoregressive procedures should not only be able to identify the lag, but should also be able to predict it. Assuming that input prices are set in the U.S., a bivariate ARIMA (autoregressive integrated moving average) procedure can be used to predict future input prices based on past input prices and the Cdn./U.S. exchange rate. Conceptually, this option appears in Figure 12 where the Cdn./U.S. exchange rate feeds into the Input Price Models.

An alternate approach is to assume that the law of one price does not hold between Canada and the U.S. The result is that Canadian input prices are "made in Canada" and as such are directly affected by Canadian inflation rates. If we assume mark-up pricing, any increase in inflation will translate into an increase in the cost of producing wheat inputs. The made in Canada option is shown in Figure 12 by linking the Input Price Models to inflation and exchange rates.

The Input Price Models are used to forecast individual price indexes for machinery, fertilizer, agricultural chemicals and fuel. After these indexes have been transformed into absolute dollar values, they can be added to seed costs and miscellaneous costs in order to calculate total operating cost before interest. The final step is to bring interest rates into the model through an interest expense category.[92]

4.5 Calculating Net Revenue

At this stage we are able to bring wheat production costs together with gross revenue in order derive an estimate of net revenue per hectare. As discussed in Section 4.3, the Trade Model multiplies deliveries by wheat prices to estimate gross revenue. Meanwhile, the cost side of the model described in Section 4.4, predicts the price of individual inputs and combines them in order to estimate operating costs on a per hectare basis. Matching gross revenue with operating costs yields a forecast of net revenue per hectare.

In order to assess what this estimate of net revenue actually means, it is necessary to list the cost items which are not included in the model. In addition to land, labour and management which were dealt with in Section 4.3, the model fails to account for off-farm handling and transportation costs. These charges include: CWB administration; elevation, handling and storage; as well as grain transportation rates.[93] To arrive at an estimate of net income at the farm level, handling and transportation charges should be deducted. However, before the charges can be deducted they must be estimated, and this would require cost predictions which are beyond the scope of this study.

---

[92]For a more detailed description of how the various cost components are combined to estimate operating cost per hectare refer to Appendix D.

[93]Transportation and handling charges will vary depending on location, mode of transportation and the route by which the grain is moved.

The model described in Figure 12 does not include these transportation and handling charges. As a result, Canadian wheat prices refer to #1 C.W.R.S. in store at Vancouver. The omission of handling and transportation charges will make it more difficult to relate the model's estimate of net revenue to net farm receipts; however, as long as the omission of these charges is recognized, valid comparisons are still possible. In the past, grain transportation and handling charges were relatively constant due to Statutory Freight Rates and Canadian Grain Commission's tariff regulations. However, when the Western Grain Transportation Act was adopted in 1983, Statutory Rates became a thing of the past. Western producers are now required to absorb an increasing portion of the cost of transporting grain.

CHAPTER V

MODEL ESTIMATION AND EVALUATION

5.1 Analytical Procedure

Using the conceptual framework presented in the previous chapter, it is possible to specify and estimate a model which can be used to project net revenue. The first step is to outline the relevant estimation procedures and data sources. Following this, the individual submodels will be estimated and tested for statistical significance.

5.1.1 Estimation Techniques. Given the diverse nature of the submodels incorporated in this study, a variety of estimation techniques will be used. For the Trade Model, two-stage least squares and ordinary least squares (OLS) will be applied. In the case of the Input Price Models, both regression and bivariate ARIMA procedures will be investigated.

Given that the theory of regression analysis is well accepted, discussion of this topic will be kept to a minimum. In its most basic form, regression analysis is nothing more than a statistical techniques which allows us to gauge relationships between individual variables. Ordinary least squares estimates are based on one-way causality, while the two-stage least squares procedure allows dependent variables to be determined through simultaneous interactions. The regression results presented in this study are derived using a Shazam computer package.[94]

---

[94]K.J. White, Shazam: An Econometric Computer Program (Houston: Rice University Press, 1979).

Unlike regression, bivariate ARIMA models are a fairly recent development in the field of quantitative analysis. As is the case in most time series techniques, the ARIMA model presume that an individual number series is generated by a stochastic process, and that the structure of that process can be described.[95] Such descriptions are not presented in terms of cause and effect relationships; instead, these descriptions relate to the way randomness is embodied within a particular number series.

ARIMA models tend to view a particular vector of numbers (Y_1, Y_2, . . . Y_n) as a set of jointly determined random variables. It is further assumed that there exists some hypothetical probability density function which is capable of assigning probabilities to all possible combinations of values within that vector. Although a complete specification of the probability density functions is impossible, we are often able to construct a simplified model of the time series which explains randomness in a way which is useful for forecasting.[96]

Box and Jenkins[97] originally suggested that Autoregressive Integrated Moving Average (ARIMA) models could be used to forecast current values of a particular number series based on only a few of the proceeding values in that same number series. A simplified version of this process is shown below.

$$Y_t = \emptyset_1 Y_{t-1} + \emptyset_2 Y_{t-2} + a_t - \theta_1 a_{t-1} - \theta_2 a_{t-2}$$

---

[95]R.S. Pindyck and D.L. Rubenfield, Econometric Models and Economic Forecasts. (New York: McGraw Hill, Inc., 1966), p. 421.

[96]Ibid., p. 431.

[97]G.E.P. Box and G.M. Jenkins, Time Series Analysis Forecasting and Control (San Fransisco: Holden Day Inc., 1976).

where:

Y_t = the dependent variable

a_t = other influences on Y_t (i.e., random shocks).

The most important assumption of an ARIMA model is that recent events (Y and a) have a greater impact on the forecast than the more distant events. This means that 0_i must be a fraction where:

$$1 > \theta_1 > \theta_2 \quad \ldots. > \theta_n.$$

The same logic applies to past occurrences of the dependent variable where:

$$1 > \emptyset_1 > \emptyset_2 \quad \ldots. > \emptyset_n.$$

Another guiding principle behind the Box-Jenkins approach is in regard to the parsimonious use of parameters. This reflects the view that a social science time series can be predicted by using a limited number of past random shocks and time series observations.[98] ARIMA procedures should be parsimonious not only in their use of time lags but also in regard to the complexity of the parameters included in the model.

As shown in Figure 14, autoregressive and moving average components can be combined within the same system. The first step in constructing a univariate ARIMA model is to difference the raw data in order to attain stationarity in trend and variance. The lagged error pattern displayed in the autocorrelation function can then be used to predict which form of ARIMA model best fits the data. Once the model has been identified and estimated, the final step is to diagnose the results in order to evaluate whether the model is statistically acceptable.

---

[98] R. McCleary and R.A. Hay, Jr., Applied Time Series Analysis for the Social Sciences (Beverly Hills: Sage Publications, Inc., 1980), p. 20.

Adding an independent variable to a univariate model produces a bivariate ARIMA process. Figure 15 portrays the case where the dependent variable (Y) is determined by: past occurrences of the dependent variable and its related random shocks (a); as well as by past occurrences of an exogenous variable (X), and the random shocks associated with that exogenous variable (b).

When building a bivariate model, the first step is to estimate individual univariate models for both the dependent and independent (exogenous) variables. The cross-correlation function between the prewhitened dependent and independent variables can be used to identify the transfer function. Once the parameters of the bivariate model have been estimated and are deemed to be statistically significant, the model building process

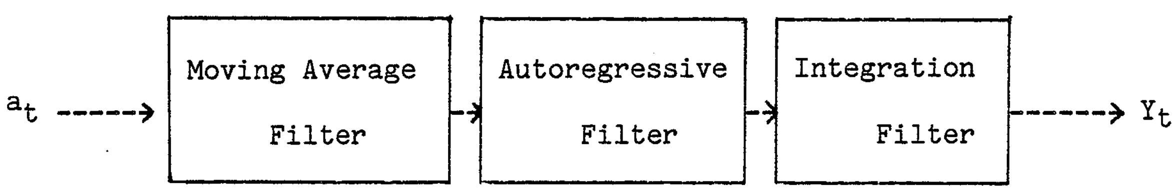

Figure 14

Flow Diagram of a Univariate ARIMA Model

Source: R. McCleary and R.A. Hay, Jr., *Applied Time Series for the Social Sciences* (Beverly Hills: Sage Publications, Inc., 1980), p. 133.

is complete. Within this study, bivariate ARIMA models will be estimated using the Statistical Analysis System (SAS) computer package.[99]

The major difference between bivariate ARIMA models and regression analysis is in regard to the model building process. The relationships posited by regression analysis are based on prior research and theory. On the other hand, ARIMA models are based solely on existing data and, and as such, are forced to incorporate a trial and error approach to model building.

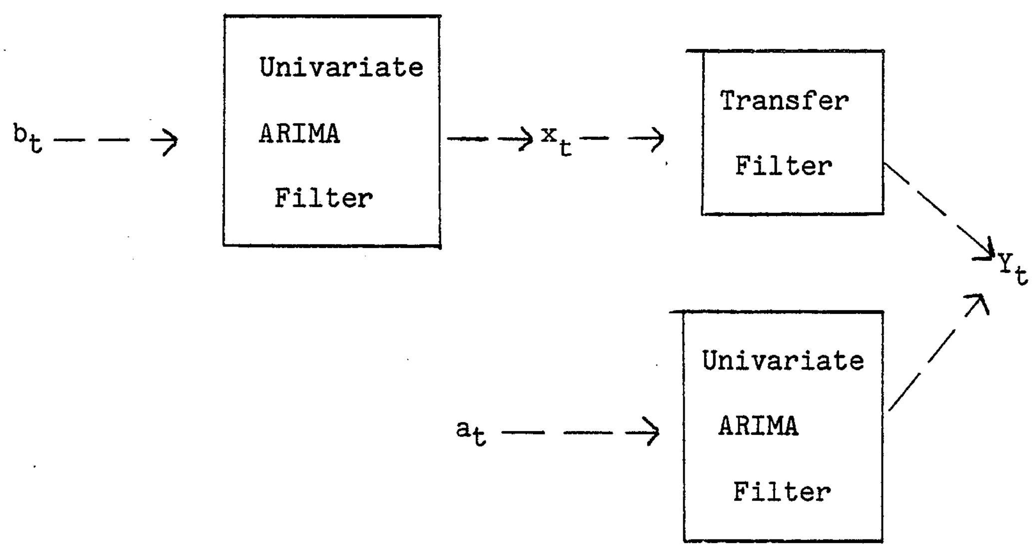

Figure 15

Flow Diagram of a Bivariate ARIMA Model

Source: Derived from R. McCleary and R.A. Hay, Jr., Applied Time Series Analysis for the Social Sciences (Beverly Hills: Sage Publications, Inc., 1980) p. 241.

---

[99]SAS Institute Inc., SAS/ETS Users Guide, 1982 Edition (Cary, N.C.: SAS Institute Inc., 1982).

5.1.2 Evaluating the Estimates. Given that regression and ARIMA models are based on different premises, they will have to be evaluated according to different criterion. In the case of regression analysis, the estimated model must be assessed for both economic meaning and statistical significance. The statistical component is further divided between statistical (first order) and econometric (second order) tests.

First order tests examine the statistical reliability of the estimated parameters. Consideration is given to the coefficient of determination and the statistical significance of individual variables. Second order tests determine statistical reliability by concentrating on the standard errors associated with individual parameter estimates. Statistical reliability is detected by examining the validity of various error assumptions. The three specific error assumptions which will be tested within this study include: constant variance (homoscedasticity); zero linear relationship between independent variables (multicollinearity); and serial independence of error terms between time periods (autocorrelation).

If heteroscedasticity exists in a single equation model, the standard tests of significance are invalid. The coefficients remain statistically unbiased but are inefficient in small samples (i.e., lack minimum variance). Consequently, any predictions which are based on these coefficients will be subject to variances which exceed the minimum case. The estimates derived within this study will be examined for heteroscedasticity using the Goldfeld-Quandt Test.[100]

---

[100] A. Koutsoyiannis, Theory of Econometrics, An Introductory Exposition of Econometric Methods, second edition (London: MacMillan Press Ltd., 1977), p. 233.

As stated above, the existence of multicollinearily represents a second error related problem. Perfect collinearity between independent variables will invalidate the regression procedure, making it impossible to obtain accurate estimates for individual parameters. In practice, most econometric models fall somewhere between the extremes of perfect and zero collinearity. It is not clear as to what degree of collinearity can be present before parameter estimates begin to be seriously affected.[101] However, as long as the degree of multicollinearity lies between certain statistical limits, it is not perceived to be a serious problem. These limits will be assessed through the implementation of the Farrar-Glauber Test.[102]

The third statistical problem to be considered when evaluating the regression results is autocorrelation. The assumption of zero autocorrelation requires that there is no significant temporal covariance between error terms. If autocorrelation exists, parameter estimates will remain statistically unbiased, but the variance attached to those estimates may be greatly enlarged. The existence of autocorrelation will be examined using the Durbin-Watson and Durbin-h Tests,[103] as well as by assessing the strength of the relationship between past and current error terms.[104]

The problem of autocorrelation (which are inherent within many time series) can be used to best advantage in the ARIMA process.

---

[101] Ibid., p. 185.

[102] D.E. Farrar and R.R. Glauber, "Multicollinearity in Regression Analysis", Review of Economics and Statistics, Vol. 49, 1967, pp. 92-107.

[103] J. Durbin, "Testing for Serial Correlation in Least-Squares When Some of the Regressors are Lagged Dependent Variables", Econometrica, Vol. 38, 1970, pp. 410-421.

[104] A. Koutsoyiannis, op.cit., pp. 216-217.

Generally speaking, the statistical problems encountered in an ARIMA model are far less onerous than the ones encountered in regression models. ARIMA parameters must be statistically significant, with univariate moving average estimates lying within the bounds of stationarity-invertibility. If these criteria are met, model diagnosis proceeds with the residuals being checked for white noise. As long as the autocorrelation function (ACF) exhibits only a limited number of unexplained variations, and the Chi-Square statistic lies within theoretical bounds, the ARIMA model is deemed to be statistically acceptable.

5.1.3 Data Sources. Published time series data is used in all segments of this analysis. The Trade Model is constructed from annual data which is converted to a Canadian crop year basis (August 1 - July 31). The 14 individual observations which are included in the Trade Model, span the period from 1970/71 to 1983/84. Trade data originates from three main sources: The International Wheat Council's World Wheat Statistics; Canada Grains Council's Canadian Grain Industry Statistical Handbook; and the Bank of Canada Review.

Data included in the Input Price and Seed Price Models originate from Statistics Canada publications. With the exception of seed prices, all other costs are collected on a quarterly basis, beginning in the first quarter of 1971 and ending in the second quarter of 1984. This equals a total of 54 individual observations. Seed prices are collected on an annual basis and are designed to correspond with the time frame used in the Trade Model.

5.2 Estimating the Trade Model

Two different approaches will be investigated before arriving at the final Trade Model. The first option is to estimate the model using a simultaneous framework. Following this, the interaction between individual variables will be restricted so as to transpose the simultaneous model into a recursive form. Due to space limitations, a full disclosure of statistical tests is included only for the final model.

5.2.1 Simultaneous Approach. Using a simple model, we will attempt to approximate some of the interactions which affect Canada's wheat trade. A two-stage least squares (2SLS) technique is used to estimate the model coefficients and their corresponding t-statistics (shown in brackets). An asterisk denotes those variables which are significant at the 5 percent level. The coefficients of determination[105] are included for each equation.

$$\hat{CEXPS}_t = \underset{(1.20)}{-5537.2} + \underset{(1.43)}{16.267}\ \hat{CPC}_t + \underset{(4.87)}{.646}\ CPROD_t^* + \underset{(2.79)}{.428}\ CESTK_{t-1}^* \quad (5.1)$$

$$R^2 = .77$$

$$\hat{CEXPD}_t = \underset{(9.54)}{379.75} - \underset{(3.85)}{35.952}\ \hat{CPC}_t^* + \underset{(.47)}{3872.1}\ CUEX_t + \underset{(4.02)}{.243}\ WEXP_t^* \quad (5.2)$$

$$R^2 = .89$$

$$\hat{CPC}_t = \underset{(9.54)}{-209.18^*} + \underset{(30.04)}{1.103}\ UPU_t^* + \underset{(5.60)}{191.28}\ CUEX_t^* + \underset{(0.79)}{.0008}\ \hat{CEXPS}_t \quad (5.3)$$

$$R^2 = .99$$

$$\hat{CEXPS}_t = \hat{CEXPD}_t \quad (5.4)$$

where:

CEXPS = Export supply of Canadian wheat, in thousands of tonnes

CEXPD = Export demand for Canadian wheat, in thousands of tonnes

---

[105]In 2SLS, the coefficients of determination (R^2) refer only to the second stage of estimation.

CPC = Export price of Canadian wheat (#1 C.W.R.S. loaded out of the Pacific Ports), in Cdn. dollars per tonne

CPROD = Canadian wheat production, in thousands of tonnes

CESTK = Canadian ending stocks of wheat (July 31), in thousands of tonnes

CUEX = Cdn./U.S. exchange rates

WEXP = World wheat exports, in thousands of tonnes

UPU = Export price of U.S. wheat (#2 D.N.S. loaded out of the Pacific Ports), in U.S. dollars per tonne

t = Crop years (1970/71 - 1983/84)

^ = Variables estimated in the model (endogenous).

The model described above is based on the assumption that world wheat prices are determined in the U.S. market. Although separate supply and demand equations are estimated for Canadian wheat, their equilibrium cannot be expected to be the sole determinant of Canadian wheat prices. The model suggests that U.S. prices and the Cdn./U.S. exchange rate are major influences on the Canadian price. The Canadian price in turn impacts on the amount of Canadian wheat which is produced and sold. Demand for Canadian wheat is influenced by the world price of wheat (which is reflected in a combination of U.S. prices and the Cdn./U.S. exchange rate) plus a variable representing total world trade. The importance of maintaining market share is captured by the world trade variable.

The model is deemed to be simultaneous due to a joint determination of Canadian export supply (CEXPS), Canadian export demand (CEXPD) and Canadian export price (CPC). The model was found to be identified, with the signs of all variables consistent with economic theory. The individual coefficients were significant at the .05 level with only three exceptions. These include: the price variable in the export supply equation; the exchange rate variable in the export demand equation; and the export supply variable in the price equation.

Although statistically insignificant, theory requires that the price and exchange rate variables remain in the model. The argument for maintaining a price variable within a supply equation is straightforward. However, some additional explanation is required for the case of exchange rates. As originally mentioned in Section 3.5, the Cdn./U.S. exchange rate enters the Trade Model through the export demand and export price equations. The motive for including the exchange rate as a separate regressor within the demand equation revolves around the idea that foreign buyers are influenced by Canadian prices as expressed in U.S. dollars. For this reason, Canadian prices (CPC) and the Cdn./U.S. exchange rate (CUEX) are both included within the export demand equation (5.2).

The construction of the simultaneous model allows for a partial test of price determination. The fact that Canadian export supply (CEXPS) is not significant in explaining variations in Canadian export price lends some support to the hypothesis that Canadian prices are established in the U.S. market. This is reinforced by the fact that both the U.S. price as expressed in U.S. dollars (UPU) and the Cdn./U.S. exchange rate (CUEX) are very significant in terms of explaining Canada's export price of wheat.

If the variable depicting Canadian export supply is dropped from the price equation, the model ceases to be simultaneous. Instead, causation runs in only one direction, with the U.S. price and the Cdn./U.S. exchange rate determining the price of Canadian wheat. The Canadian price of wheat in turn feeds into Canada's export supply and export demand equations. Before we can attempt to estimate a recursive model, we must first assess whether simultaneous equation bias poses a serious problem.

This can be accomplished by comparing the 2SLS estimates (shown above) to the following OLS estimates.

$$\hat{CEXPS}_t = \underset{(1.21)}{-5549.6} + \underset{(1.44)}{16.321}\ CPC_t + \underset{(4.87)}{.646}\ CPROD^*_t + \underset{(2.80)}{.428}\ CESTK^*_{t-1} \qquad (5.5)$$

$$R^2 = .77 \qquad f = 10.9^*$$

$$\hat{CEXPD}_t = \underset{(.05)}{303.704} - \underset{(3.80)}{35.290}\ CPC^*_t + \underset{(.49)}{4005.1}\ CUEX_t + \underset{(3.99)}{.239}\ WEXP^*_t \qquad (5.6)$$

$$R^2 = .89 \qquad f = 26.8^*$$

$$\hat{CPC}_t = \underset{(10.60)}{-211.60^*} + \underset{(30.90)}{1.101}\ UPU^*_t + \underset{(6.75)}{196.08}\ CUEX^*_t + \underset{(.78)}{.0007}\ CEXPS_t \qquad (5.7)$$

$$R^2 = .99 \qquad f = 678.8^*$$

In terms of the coefficient values, the difference between the 2SLS estimates and OLS estimates range from .3 to 14.0 percent. If we disregard the export supply variable (CEXPS), the maximum deviation between techniques is reduced to 3.4 percent. The intercept terms exhibit a similar degree of variation, with the export demand equation recording a maximum change of 76,000 tonnes. If examined alone, this difference appears fairly large; however, when its magnitude is considered relative to the total export volume, the variation is minimal. Other criterion such as the signs of individual coefficients and R^2 values remain virtually unchanged between the 2SLS and OLS estimates.

It appears that simultaneous equation bias does not pose a serious problem. This allows us to move from a simultaneous model to a recursive system of single equations without incurring a significant increase in bias. Recursive models have advantages in terms of forecasting which prove be particularly useful in this study. Instead of having to produce preliminary forecasts of all exogenous and endogenous variables as is the case in 2SLS, the recursive approach requires the prediction of only a limited number of exogenous factors. We are then able to solve for future values of the endogenous variables using an iterative procedure.

5.2.2 Recursive Approach. The simultaneous model described above will be used as a nucleus for the recursive model. Once the Canadian export supply variable is dropped from equation 5.6, it becomes possible to estimate the model from a recursive set of single equations. In order to provide a more complete description of Canadian wheat trade, the three original equations will be expanded to a set of ten equations. Four of these are identities, while the remaining six equations are behavioral and as such will be estimated using an OLS procedure.

The recursive approach calls for the model to be segmented into blocks, which are solved sequentially. Three separate blocks will be estimated. They include: Canadian wheat production; U.S. and Canadian wheat prices; and the supply and demand for Canadian wheat. The coefficient estimates for the three separate blocks are included below. The estimated mean elasticities for the model are included in Appendix I (Table I1).

Canadian Wheat Production:

$$\hat{HECT}_t = \underset{(1.03)}{2139.2} + \underset{(5.64)}{28.50}\ CPC^*_{t-1} + \underset{(1.98)}{1569.9}\ DEL^*_{t-1} \qquad (5.8)$$

$$R^2 = .74 \qquad F = 15.9^*$$

$$\hat{CPROD}_t = \hat{HECT}_t \times YIELD_t \qquad (5.9)$$

$$CSUP_t = \hat{CPROD}_t + CESTK_{t-1} \qquad (5.10)$$

U.S. and Canadian Wheat Prices:

$$\hat{UPU}_t = \underset{(1.89)}{-90.644^*} - \underset{(9.02)}{.009}\ \hat{CSUP}^*_t + \underset{(10.68)}{.128}\ WPOP^*_t \qquad (5.11)$$

$$R^2 = .93 \qquad F = 73.1^*$$

$$\hat{CPC}_t = -251.15^{*} + 1.092\ \hat{UPU}_t^{*} + 215.07\ CUEX_t^{*} \qquad (5.12)$$
$$\quad (14.31) \qquad (33.10) \qquad (13.93)$$

$R^2 = .99 \quad F = 1055.9^{*}$

<u>Supply and Demand for Canadian Wheat</u>:

$$\hat{CEXPS}_t = -5549.6 + 16.321\ \hat{CPC}_t + .646\ \hat{CPROD}_t^{*} + .428\ CESTK_{t-1}^{*} \qquad (5.13)$$
$$\quad (1.21) \qquad (1.44) \qquad (4.87) \qquad (2.80)$$

$R^2 = .77 \quad F = 10.9^{*}$

$$\hat{CEXPD}_t = 303.04 - 35.290\ \hat{CPC}_t^{*} + 4005.1\ CUEX_t + .239\ WEXP_t^{*} \qquad (5.14)$$
$$\quad (.05) \qquad (3.80) \qquad (.49) \qquad (3.99)$$

$R^2 = .89 \quad F = 26.8^{*}$

$$\hat{CEXP}_t = (\hat{CEXPS}_t + \hat{CEXPD}_t)/2 \qquad (5.15)$$

$$\hat{CDOMD}_t = -1499.6 - 1.776\ \hat{CPC}_t + .587\ CDOMD_{t-1}^{*} + .168\ CPOP_t^{*} \qquad (5.16)$$
$$\quad (1.11) \qquad (1.57) \qquad (2.40) \qquad (2.22)$$

$R^2 = .79 \quad F = 12.9^{*}$

$$\hat{CESTK}_t = \hat{CSUP}_t - \hat{CEXP}_t - \hat{CDOMD}_t \qquad (5.17)$$

where:

CEXPS, CEXPD, CPC, CPROD, CESTK, CUEX, WEXP and UPU are as previously defined

HECT = Area seeded to wheat in Canada, in thousands of hectares

DEL = Wheat deliveries (CEXP + CDOMD)/HECT, in tonnes per hectare seeded

YIELD = Average Canadian wheat yields, expressed in hundreds of kg. per hectare

WPOP = World population, in millions of people

CEXP = Represents an equilibrium between the estimated export demand and export supply of Canadian wheat

CDOMD = Canadian domestic demand for wheat, in thousands of tonnes. This includes wheat used for food, feed and seed.

CPOP = Canadian population, in thousands of people.

Canadian wheat production is calculated by multiplying average wheat yields by the estimated number of hectares seeded to wheat. Average yield is treated as an exogenous variable, while the number of hectares seeded is specified to be a function of both lagged wheat prices and deliveries. Within the designated Canadian Wheat Board region, a quota system serves to regulate producer deliveries. Consequently, the ability to deliver (quota) is an important consideration in regard to seeding intentions. Including both price and deliveries in a lagged form represents a crude measure of expected gross revenue. The assumption is that producers react to changes in gross revenue in an adaptive manner. An increase in gross revenue during year t is expected to result in an increase in the number of hectares seeded to wheat in year t + 1.

The delivery variables (DEL) used in this model should not be identified with official CWB quotas. CWB quotas differ in that they are based on quota hectares rather than seeded hectares. As a rule, quota hectares and seeded hectares do not correspond. The difference comes about because producers are able to allocate quota hectares as they see fit rather than being constrained to allocating quota in accordance to actual seeding intentions. Additional discrepancies can be explained by the fact that deliveries against official CWB quotas may originate from stocks as well as from current production.

Once Canadian wheat production has been estimated it can be added to carryover stocks in order to arrive at the total Canadian supply of wheat (5.10). The variable representing Canadian supply (CSUP) is then fed into the second block of the Trade Model which is designed to estimate Canadian and U.S. wheat prices. The assumption within the second block is that the U.S. market functions as the discovery mechanism for world wheat prices. This does not suggest that the U.S. price is determined in isolation. Given that the U.S. price is established in an open market which reflects world demand and supply conditions, a change in the supply of Canadian wheat should have an impact on U.S. price. This interaction will be very important in terms of simulating future events. If Canadian wheat supply was not linked to the U.S. price, it would be possible for Canadian wheat stocks to increase dramatically without having any effect on price.

The second explanatory variable included in the U.S. price equation is world population. In a sense, world population can be considered as a proxy for world wheat demand. When world population is combined with Canadian wheat supply, both the demand and supply aspects have been accounted for to some extent.

Meanwhile, the Canadian price equation (5.12) remains essentially the same as it was in the simultaneous model. The U.S. wheat price and the Cdn./U.S. exchange rate are included as separate regressors, with both variables exhibiting a significant positive relationship. Overall, the U.S. price of wheat and the Cdn./U.S. exchange rate were able to explain approximately 98 percent of the variation in Canadian wheat prices from 1970/71 to 1983/84.

The third and final block of the model accounts for wheat trade and inventories. As was the case for the Canadian price equation, the Canadian export supply and demand equations maintain the same specifications as presented in the simultaneous model. Export supply (5.13) is stated as a function of price, production and carryover stocks. The signs of the variables included in the export supply equation prove to be consistent with economic theory. All variables, with the exception of price are found to be significant at the 5 percent level.

Export demand for Canadian wheat (5.14) has the Canadian wheat price, the Cdn./U.S. exchange rate and the total world trade in wheat as explanatory variables. Based on the estimated equation, it appears that

Canada has satisfied approximately 23.9 percent of total world wheat demand over the past 14 years. In addition to the trade variable, the Canadian price of wheat is also significant in explaining export demand. The exchange rate variable included in the export demand equation displays the expected sign but is not found to be statistically significant.

Domestic demand (5.16) is explained by the Canadian price of wheat, lagged domestic demand and a variable reflecting Canadian population. Together, the aforementioned variables account for 79 percent of the variation in Canada's domestic demand for wheat. The statistical insignificance of the price variable is not surprising when you consider that food consumption makes up a relatively small proportion of Canada's per capita income. Since wheat products are a staple, the derived demand curve for wheat should be both income and price inelastic.

The two identities shown in equations 5.15 and 5.17 close the model. The first identity equates export supply with export demand. Although economic theory calls for a separate treatment of supply and demand, when these equations are actually estimated, Canadian wheat exports must be used as the dependent variable in both cases. Given this, it becomes necessary to reconcile any differences which exist between the estimated supply and demand variables. The second identity (5.17) is simply an accounting procedure whereby Canada's ending stock of wheat is derived by subtracting Canadian exports and Canadian domestic demand from the total Canadian wheat supply.

Thus far, the discussion has centered around theoretical consistency and first order statistical tests. Before the estimated results can be used, the second order (econometric) tests must also be examined. Only a brief summary of these tests is included in the text. For a complete statistical discussion, readers should refer to Appendix C.

The results of the Trade Model are deemed to be free from heteroscedasticity. In terms of multicollinearity, all equations pass the Farrar-Glauber Test at the 10 percent level but at the 5 percent level the Canadian export demand equation (5.14) displays some degree of correlation. Specifically, collinearity is present between the Cdn./U.S. exchange rate and the variable depicting total world trade in wheat. Since both these variables are important for theoretical reasons, and since the degree of multicollinearity is not significant at the 10 percent level, the model will not be adjusted.

The same situation does not hold for autocorrelation. Durbin-Watson Tests were carried out on all of the equations which do not include a lagged dependent variable. The results of this analysis show that the U.S. price equation (5.11) and the Canadian export supply equation (5.13) are free from autocorrelation. However, in the case of hectares seeded (5.8), Canadian prices (5.12) and Canadian export demand (5.14) the Durbin-Watson test proved inconclusive.

The three aforementioned equations (5.8, 5.12 and 5.14) together with the equation for Canadian domestic demand (5.16) were subjected to the Residual Regression Test for autocorrelation. Hectares seeded proved to be the only equation where the past error terms were significant in explaining current error terms, and where the overall regression coefficient (F-statistic) was statistically significant. The error terms resulting from the hectares seeded equation were found to be related through a pattern of second order autocorrelation.

The hectares seeded equation was adjusted using the information gained from the autocorrelation tests. A second order Cochrane-Orcutt procedure was applied, and the revised results are shown below:

$$HECT_t = \underset{(3.20)}{3766.3^*} + \underset{(12.49)}{30.853}\ CPC^*_{t-1} + \underset{(3.44)}{1130.0}\ DEL^*_{t-1} \qquad (5.18)$$

$$R^2 = .98$$

Econometric tests were conducted on the adjusted hectares seeded equation (5.18). As shown in Appendix C, the new equation appears to have no heteroscedasticity or multicollinearity. Autocorrelation need not be tested for since an adjustment has already been made. Given the improved statistical properties of the revised equation, it will be used in place of the original hectares seeded equation in the final Trade Model.

5.3 Estimating Seed Costs

Seed costs were estimated using a single equation approach. The two exogenous variables which enter the seed cost equation are the price of Canadian wheat and the lagged price of seed. The ordinary least squares estimate for the seed equation is stated below.

$$SEED_t = \underset{(.41)}{-10.94} + \underset{(3.79)}{.726}\ CPC^*_t + \underset{(3.98)}{.492}\ SEED^*_{t-1} \qquad (5.19)$$

$$R^2 = .89 \qquad f = 45.4^*$$

where:

SEED = the price index for seed

CPC = the Canadian price of wheat (as previously defined).

The positive signs displayed in the above equation are consistent with a priori expectations. In addition, both of the explanatory variables were found to be significant at the 5 percent level. The estimated seed equation is acceptable in terms of heteroscedasticity and multicollinearity, but the Residual Regression Test revealed a significant degree of first order autocorrelation.

Given the above information, the seed model was reestimated using a first order Cochrane-Orcutt procedure. The revised results are shown below.

$$SEED_t = \underset{(.45)}{-11.51} + \underset{(3.97)}{.724}\ CPC_t^* + \underset{(4.10)}{.496}\ SEED_{t-1}^* \qquad (5.20)$$

$$R^2 = .91$$

When the revised seed equation (5.20) was examined, it was found to be acceptable in terms of both the first and second order statistical tests.

5.4 Estimating Input Prices Using Bivariate ARIMA Models

Now that the Trade and Seed Cost Models have been specified, it is possible to discuss the remaining input costs. As mentioned in Section 5.1.1, bivariate ARIMA models and regression analysis will be employed in order to estimate fertilizer, machinery, petroleum and chemical prices. The bivariate ARIMA models are presented in this section, with the regression version of the Input Price Model discussed in Section 5.5.

The first step in building the bivariate ARIMA models was to specify individual univariate ARIMA models for fertilizer, machinery, petroleum, chemicals and the Cdn./U.S. exchange rate.[106] Once the univariate models were specified and tested, they were combined to form bivariate models. In each case, the particular price index was specified

[106] For a complete specification of the bivariate models, including their univariate components, refer to Appendix D.

as a function of the Cdn./U.S. exchange rate. The time lags were determined by examining the cross-correlation coefficients.

Chemicals (CHEM) and petroleum (PETR) were found to be related to current movements in the Cdn./U.S. exchange rates (EX), while fertilizer (FERT) and machinery (MACH) are correlated with a one and four period lag in the exchange rate, respectively. Before the bivariate results can be interpreted, the following definitions are required:

d = degree of differencing

sd = degree of seasonal differencing

ϕ_i = estimated autoregressive parameter (p) of order i

θ_i = estimated moving average parameter (q) of order i

θ_{ij} = estimated seasonal moving average parameter (sq) of order i with a j period seasonal component

B = backward shift operator

b^j = seasonal backward shift operator of j periods

Ψ = transfer function between dependent and independent variables

a_t = random shocks associated with the dependent series

t = time period (in quarters).

Using the above definitions, the results of the final bivariate models can be stated as:

$$FERT_t^A = (1 - \Psi B)(1 - b)(1 - \phi_1 B^{-1})(1 - 2B + b^2)^{-1} \cdot EX_{t-1} + (1 - \phi_1 B)^{-1} (1 - 2B + B^2)^{-1} \cdot a_t \quad (5.21)$$

	estimated parameters	calculated t-statistics
Ψ	159.55	1.58
ϕ_1^*	-4.59	3.49

Std. error = 14.62 $\quad$ $^*X_{17}$ = 21.62

$$MACH_t^A = (1 - \Psi B)(1 - B^4)^{-1} \cdot EX_{t-4} + (1 - \theta_1 B - \theta_{1,4} B^4)(1 - 2B + B^2)^{-1}$$

$$(1 - B^4)^1 \cdot a_t \qquad (5.22)$$

	estimated parameters	calculated t-statistics
Ψ	29.034	1.06
θ^*	.759	7.00
$\theta^*_{1,4}$	.693	5.07

std. error = 3.46 $\quad *X^2_{17}$ = 17.10

$$PETR_t^A = (1 - \Psi B)(1 - B)(1 - 2B + B^2)^{-1} \cdot EX_t + (1 - \theta_1 B) \qquad (5.23)$$

$$(1 - 2B + B^2)^{-1} \cdot a_t$$

	estimated parameters	calculated t-statistics
Ψ	54.780	28.60
θ^*_1	1.037	20.25

std. error = 11.12 $\quad *X_{17}$ = 21.28

$$CHEM_t^A = (1 - \Psi B)(1 - \emptyset_1 B - \emptyset_2 B)^{-1}(1 - 2B + B^2)^{-1} \cdot EX_t + (1 - \emptyset_1 B - \emptyset_2 B)^{-1}$$

$$(1 - 2B + B^2)^{-1} \cdot a_t \qquad (5.24)$$

	estimated parameters	calculated t-statistics
$\Psi*$	23.077	59.88
$\emptyset^*_1$	-.708	4.40
$\emptyset^*_2$	-.648	3.96

std. error = 8.87 $\quad *X_{17}$ = 16.69

The four models displayed above are said to exhibit white noise since their calculated Chi-square values (*x) fall within acceptable statistical limits. All estimated parameters with the exception of the transfer functions in the fertilizer and machinery equations are statistically significant at to the 5 percent level. In addition, the absolute values of the second order autoregressive and moving average parameters are smaller than their corresponding first order estimates. The univariate moving average parameters were also found to be acceptable when examined on the grounds of invertibility.

Normally, a minimum of 50 observations is required to establish a stable ARIMA process. In the case of agricultural chemicals, the Canadian price indexes were first published in 1977, which makes for a total of 30 observations. However, given that all of the estimated parameters are statistically significant, and that white noise is present, the estimated chemical price equation (5.24) is considered to be acceptable.

5.5 Estimating Input Prices Using Regression Analysis

Regression analysis represents the second method for measuring input prices. As was the case for the bivariate ARIMA models, individual equations will be estimated for fertilizer, machinery, petroleum and chemicals. However, unlike the empirical nature of the ARIMA models, regression analysis is designed to be explanatory. The regression models which will be presented in this section follow from the idea that input prices can be explained and predicted from a combination of past price levels, the inflation rate and the exchange rate. In other words, farm input markets are assumed to function under a "made in Canada" pricing system rather than simply representing U.S. prices adjusted for the Cdn./U.S. exchange rate.[107]

Numerous lag structures were examined before the final model specification was determined.[108] In the case of fertilizer, a one-quarter

---

[107]The discussion of "made in Canada" pricing vs. the law of one price was included in Section 4.4.

[108]Some of the other equations which were examined are included in Appendix D.

lag was deemed to be most appropriate. Meanwhile, machinery, petroleum and chemicals were shown to exhibit one, two and four-quarter lags, respectively. The estimated coefficients for the four input price equations are shown below. Once again, the calculated t-statistics are displayed in brackets with an asterisk denoting statistical significance at the .05 level. The estimated elasticities for each of the regression equations are included in Appendix I (Table I2).

$$FERT_t = \underset{(1.68)}{8.549} + \underset{(35.41)}{.966}\ FERT^*_{t-1} + \underset{(.42)}{43.436}\ (EX_t - EX_{t-1}) + \underset{(3.33)}{4.045}\ (I_t - I_{t-1})^* \qquad (5.25)$$

$$R^2 = .98 \qquad f = 810.4^*$$

$$RMACH^R_t = \underset{(2.33)}{.207^*} + \underset{(8.93)}{.792}\ RMACH^*_{t-1} + \underset{(.49)}{.078}\ (EX_t - EX_{t-1}) \qquad (5.26)$$

$$R^2 = .87$$

$$PETR^R_t = \underset{(1.66)}{-9.58} + \underset{(42.91)}{.981}\ PETR^*_{t-2} + \underset{(.64)}{38.609}\ (EX_t - EX_{t-2}) + \underset{(5.41)}{3.499}\ (I_t - I_{t-2})^* \qquad (5.27)$$

$$R^2 = .97$$

$$CHEM^R_t = \underset{(.87)}{17.993} + \underset{(15.95)}{.920}\ CHEM^*_{t-4} + \underset{(2.84)}{1.705}\ (I_t - I_{t-4})^* \qquad (5.28)$$

$$R^2 = .90$$

where:

FERT = fertilizer price index for Western Canada

RMACH = the "real" agricultural machinery price index for Western Canada ($MACH_t/I_t$)

PETR = refined petroleum products price index for Western Canada

CHEM = agricultural chemical price index for Western Canada

EX = the Cdn./U.S. exchange rate

I = the Canadian inflation rate (CPI is used as a proxy)

t = time period in quarters.

All of the final regression equations were statistically significant, with R^2 values ranging from 87 to 98 percent. Autocorrelated error terms produced statistical problems in the machinery, petroleum and chemical equations. Therefore, equations 5.26, 5.27 and 5.28 were adjusted for autocorrelation (as denoted by the superscript R) using a first order Cochrane-Orcutt procedure. It should be noted that F-statistics are not reported for equations which have been estimated using an autoregressive process.

In addition to autocorrelation, the final regression equations were also tested for heteroscedasticity and multicollinearity. The test statistics included in Appendix C show that the real machinery price equation (5.26) and the chemical price equation (5.28) are free from heteroscedasticity at the .05 level. Fertilizer and petroleum (5.25 and 5.27, respectively) exhibit heteroscedasticity at the five percent but not at the one percent level. In terms of multicollinearity, real machinery prices, petroleum, and chemicals all pass the Farrar-Glauber Test at the .05 level. If the level of tolerance is increased from five to ten percent, the fertilizer equation also falls within acceptable bounds.

The input price equations which are specified above, deserve some additional discussion. Fertilizer prices (5.25) are described by past fertilizer prices (lagged one quarter) plus the change in inflation and exchange rates over the past quarter. The signs are all estimated to be positive. In addition, the lagged price variable and the change in the exchange rate are both statistically significant.

The equation describing machinery prices (5.26) differs from fertilizer in that inflation becomes the denominator in the dependent variable. When inflation was included in the machinery equation as a separate regressor (Appendix D, Table D6) the estimated coefficient for the lagged dependent variable was greater than one. In other words, the lagged price variable was picking up a type of built in inflation. Given that these results will eventually be used to simulate the reaction to changes in the rate of inflation, it was decided that machinery prices should be divided by inflation in order to yield an approximation of real machinery prices (RMACH). Once the real machinery price is estimated, it can be multiplied by the inflation rate in order to derive an absolute machinery price index.

Petroleum prices are estimated using a two quarter lag rather than the one quarter lag which prevails in both the fertilizer and real machinery price equations. When a one period lag was attempted, the estimated sign on the Cdn./U.S. exchange rate was negative. A negative sign also occurred when a two quarter lag was first instituted; however, when the equation was corrected for autocorrelation, the sign on the exchange rate variable became positive.

Chemical prices represent an anomoly among the four inputs examined. In each case where a change in exchange rates was included, the sign of the exchange rate coefficient was negative. When both the exchange rate and inflation were stated in absolute terms rather than as differences, their signs agreed with a priori expectations but a high degree of multicollinearity was present. As a result, the exchange rate was excluded from the chemical equation (5.28). This leaves chemical prices to be explained by past chemical prices (lagged four quarters) as well as by the difference in inflation over the past four quarters.

When examined relative to the actual nature of the agricultural chemical industry, the final form of the chemical equation appears to be fairly consistent. Canadian agricultural producers are not allowed to import formulated chemical from the U.S. The result is that Canadian prices appear to be more dependent on the domestic cost of production (inflation) than on the Cdn./U.S. exchange rate. A four period lag was selected in order to accommodate both the time involved in producing chemicals and the seasonal nature which is prevalent in the pricing of agricultural chemicals.

5.6 Goodness of Fit

Prior to using the models estimated in this chapter, each individual equation will be evaluated in regard to its goodness of fit. Two of the more prevalent methods for measuring goodness of fit include mean squared error (MSE) and mean absolute percent error (MAPE).[109] The disadvantage in using MSE is that the size of the error is directly related to the magnitude of the dependent variable being predicted. To avoid the problem of varying magnitudes, the equations will also be evaluated in terms of MAPE.

$$MAPE = \left[\frac{1}{n} \sum_{t=1}^{n} \frac{|A_t - P_t|}{A_t} \right] \times 100$$

where:

A_t = the actual value

---

109 A.A. Weiss and A.P. Anderson, "Estimating Time Series Models Using Relevant Forecast Evaluation Criterion", Journal of the Royal Statistical Society, Vo. 147, March 1984, pp. 484-487.

P_t = the predicted value

n = number of observations

Table 3 presents the estimates of MSE and MAPE for each of the equations included in the final model. The MSE terms range from .0004 for the real machinery price equation (5.26) to a high of 3.3 million in the case of the Canadian export supply equation (5.13). In percentage terms, the absolute size of the error ranges from 1.92 for real machinery price to 18.36 for the ARIMA version of petroleum prices (5.23). With the exception of the ARIMA petroleum price equation and the seed cost equation (5.20) the mean absolute percent error for each equation is below 10 percent. Therefore, it is possible to conclude that the estimated equations fit the data reasonably well.

Table 3

Evaluating the Goodness of Fit of the Final Model

Dependent Variable	Equation Number	Mean Squared Error (MSE)	Mean Absolute Percent Error (MAPE)
Trade Model:			
HECTR	5.18	378,200	9.79
UPU	5.11	198	8.35
CPC	5.12	27	2.21
CEXPS	5.13	3,319,300	7.53
CEXPD	5.14	1,569,000	5.69
CDOMD	5.16	22,800	1.88
Seed Cost Model:			
SEEDR	5.20	1,069	12.71
Input Costs Using Bivariate ARIMA Models:			
FERTA	5.21	1,210	8.50
MACH^{A}	5.22	560	5.52
PETR^{A}	5.23	6,013	18.36
CHEM^{A}	5.24	271	3.06
Input Costs Using Regression Analysis:			
FERT	5.25	215	3.43
RMACH^{R}	5.26	.0004	1.92
PETR^{R}	5.27	124	5.45
CHEM^{R}	5.28	84	3.72

CHAPTER VI

SIMULATION RESULTS AND ANALYSIS

The models presented in Chapter V can now be used to simulate how a change in monetary policy will impact on the net revenue of western Canadian wheat producers. An explanation of the scenarios is included in the first section of this chapter. Following this, the simulation procedure is discussed. The remainder of the chapter is devoted to presenting and analyzing the results of the simulations. Given that the explanation of individual scenarios is a very tedious, those readers who are more interested in general results should concentrate on the summary (Section 6.4).

6.1 Explanation of the Scenarios

One of the main ways in which financial variables (such as the money supply) influence the economy through the interest rate. Within the Focus Model interest rates are determined by equating the supply and demand for money. Although both the M1 and M2 definitions of money are available in the Focus Model, our discussion will be limited to M1 (currency, coin and demand deposits).[110]

With the exception of the Base Scenario, all other scenarios included in this study can be thought of in terms of a change in money supply (M1). The first and second scenarios examine the impacts which result from a change in the level and growth rate of M1. In the third scenario interest rate targets are achieved through a manipulation of the

[110] In addition to the variables included in the definition of M1, M2 includes all other notice deposits and personal term deposits. For modelling purposes, the authors of the Focus Model recommend using M1.

money supply. Meanwhile, the fourth and final scenario requires that M1 be adjusted in order to attain an interest rate which will cause the Foreign Exchange Market to clear at a previously set target exchange rate. The aforementioned scenarios can be specified as follows:

Scenario 1--The Bank of Canada is deemed to control the supply of narrowly defined money (M1).

Scenario 1A -- 2% increase in M1.

Scenario 1B -- 2% decrease in M1.

Scenario 2 --The Bank of Canada is deemed to set a target growth rate for the money supply (M1).

Scenario 2A -- 2% increase in the growth of M1.

Scenario 2B -- 2% decrease in the growth of M1.

Scenario 3--The Bank of Canada is deemed to set target values for short term nominal interest rates and adjust money supply (M1) in order to achieve these targets.

Scenario 3A -- 1% increase in the target interest rate.

Scenario 3B -- 1% decrease in the target interest rate.

Scenario 4--The Bank of Canada is deemed to set target values for the Cdn./U.S. exchange rate. Managers of the Foreign Exchange Fund are assumed to regulate changes in Official Foreign Reserves[111] so as to maintain the exchange rate at its target level. The Focus Model simulates the behavior of these managers by searching out an interest rate which creates the required flow of capital.

Scenario 4A -- 2% increase in the Cdn./U.S. exchange rate.

Scenario 4b -- 2% decrease in the Cdn./U.S. exchange rate.

---

[111]The sum of the Current Account and the Short and Long Term Capital Accounts (which are at least partially determined by the prevailing exchange rate) equals the Official Settlements Balance. Unless there is a change in Special Drawing Rights, the Official Settlements Balance is equal to the change in Official Foreign Reserves (expressed in Canadian dollars).

The results of these scenarios will be compared relative to the Focus Models baseline projection. Periodically, the staff at the Institute for Policy Analysis establish what they consider to be the most likely combination of events facing the Canadian economy. The Base Scenario used in this study represents the Institute's view as of December, 1984.[112]

6.2 Simulation Procedure

The Trade, Seed Cost and Input Price Models described in Chapter V will be combined to simulate net revenue. The Trade Model simulates gross revenue on a per hectare basis, while the Seed Cost and Input Price Models (ARIMA and Regression) predict the price of seed, fertilizer, agricultural chemicals, fuel and machinery. When the aforementioned prices are combined with interest rates and miscellaneous costs (which are directly affected by inflation) wheat production costs can be estimated.[113]

The time frame for the simulation spans the three crop years from 1984/85 to 1986/87. In terms of wheat production, a time lapse obviously exists between seeding and sales dates. A crop seeded in the spring of 1984 is not available for sale until the 1984/85 crop year. In order to make meaningful comparisons, sales revenue and crop production

---

[112] A full description of the Base Scenario is presented in Appendix F.

[113] Fertilizer, agricultural chemicals, fuel and machinery prices are predicted (by the Input Price Model) as quarterly price indexes. The predicted price index for the second quarter of each year is then converted to an absolute price level by updating the crop budget shown in Table 2. For example, if fertilizer costs $20 per hectare with a corresponding price index of 100 at time t, and the price index rises to 115 at time t + 1, the cost of fertilizer will increase to (115/100 x $20) = $23.00 per hectare. This process assumes that the quantity of each input remains unchanged.

costs must be related to each other. For instance, when discussing net revenue for 1984/85, we will actually be comparing wheat sales made during the 1984/85 crop year to wheat production costs incurred in the spring of 1984.

Before we can simulate net revenue, a number of exogenous variables must be predicted. In the case of the Trade Model, the exogenous variables include: the Cdn./U.S. exchange rate (CUEX); world population (WPOP); Canadian population (CPOP); world wheat exports (WEXP) and average Canadian wheat yields (YIELD). Lagged independent variables are not considered to be exogenous since their values are known with certainty. Given that the Trade Model is recursive, the endogenous variables will be estimated using a stepwise procedure. For example, once Canadian wheat supply has been estimated (5.10), it will become a known (exogenous) value within the U.S. price equation (5.11).

The exchange rate represents an anomoly among Trade Model variables in that it originates from the Focus Model.[114] All other exogenous variables entering the Trade Model are predicted using trend analysis. Ordinary least squares regressions are estimated by running each of the exogenous variables against time. The estimated equations are used to derive the predicted values shown in Table 4.

Once the exogenous variables have been determined, it is possible to use the Trade Model in order to simulate results for the 1984/85 to 1986/87 period. The Canadian price of wheat (CPC) which is derived in the Trade Model, becomes an exogenous variable within the Seed Cost Model. Results for the Trade and Seed Cost Models are included in Appendixes G and H, respectively.

---

[114]The Focus Model predictions are included in Appendix E.

The seed cost projections are then combined with the other estimated input costs. If the ARIMA model is used to predict input prices, the only exogenous variable required is the Cdn./U.S. exchange rate. However, if the regression version of the Input Price Model is in place, both the Cdn./U.S. exchange rate and the Canadian inflation rate are required.

The Trade, Seed Cost and Input Price Models will be combined in two different ways. In both cases, the structure of the Trade and Seed Cost Models remains the same, but the way in which the input price variables are predicted differs. The Focus-ARIMA combination specifies that the Focus Model's predictions for exchange, inflation and interest rates be used with the ARIMA version of the Input Price Model. Meanwhile, the Focus-Regression combination calls for the Focus predictions to be used in conjunction with the Regression version of the Input Price Model.

Table 4

Forecasted Values for the Exogenous Variables

Year	World Population	Canadian Population	World Wheat Exports	Canadian Wheat Yields
	..........'000	....	...'000t....	....t/ha....
1984/85	4,756,900	25,064	101,130	2.0196
1985/86	4,841,500	25,343	105,310	2.0440
1986/87	4,926,000	25,622	109,490	2,0683

6.3 Simulating Net Revenue

As stated in Section 6.1, four individual scenarios will be run using the Focus-ARIMA and Focus-Regression options. This section presents the results of these scenarios in a fairly detailed form. A summmary of the results is included in Section 6.4.

6.3.1 Scenario 1--Changing the Level of the Money Supply. If the Bank of Canada changes the size of the money supply, interest rates will be directly affected. Figure 16 indicates how nominal interest rates react to a 2 percent change in the monetary base. As economic theory predicts, increasing the money supply (Scenario 1a) reduces interest rates relative to the Base Scenario. Reducing the money supply will have an opposite effect on interest rates. Given that a change in the money supply is viewed as a one shot event, the initial divergence in interest rates tends to be reduced as time goes on. By the fourth quarter of 1985, interest rates appear to be moving in a parallel fashion.

The change in interest rate differentials between Canada and the U.S. invokes an adjustiment in short term capital flow. A decrease in the Canadian interest rate (Scenario 1A) results in a net outflow of Canadian capital. As the supply of Canadian dollars begins to exceed the demand for Canadian dollars, the value of the Canadian dollar drops (i.e., the Cdn./U.S. exchange rate begins to rise). Figure 17 illustrates how the Cdn./U.S. exchange rate reacts to a 2 percent change in Canada's money supply. Unlike interest rates, the Cdn./U.S. exchange rate (as forecast by the Focus Model) continually diverges from the Base Scenario. This is due to the lagged trade or J-curve effect. A period of time must elapse before merchandise trade reacts to an exchange rate change. Until the adjustment takes place, the exchange rates will continue to diverge.

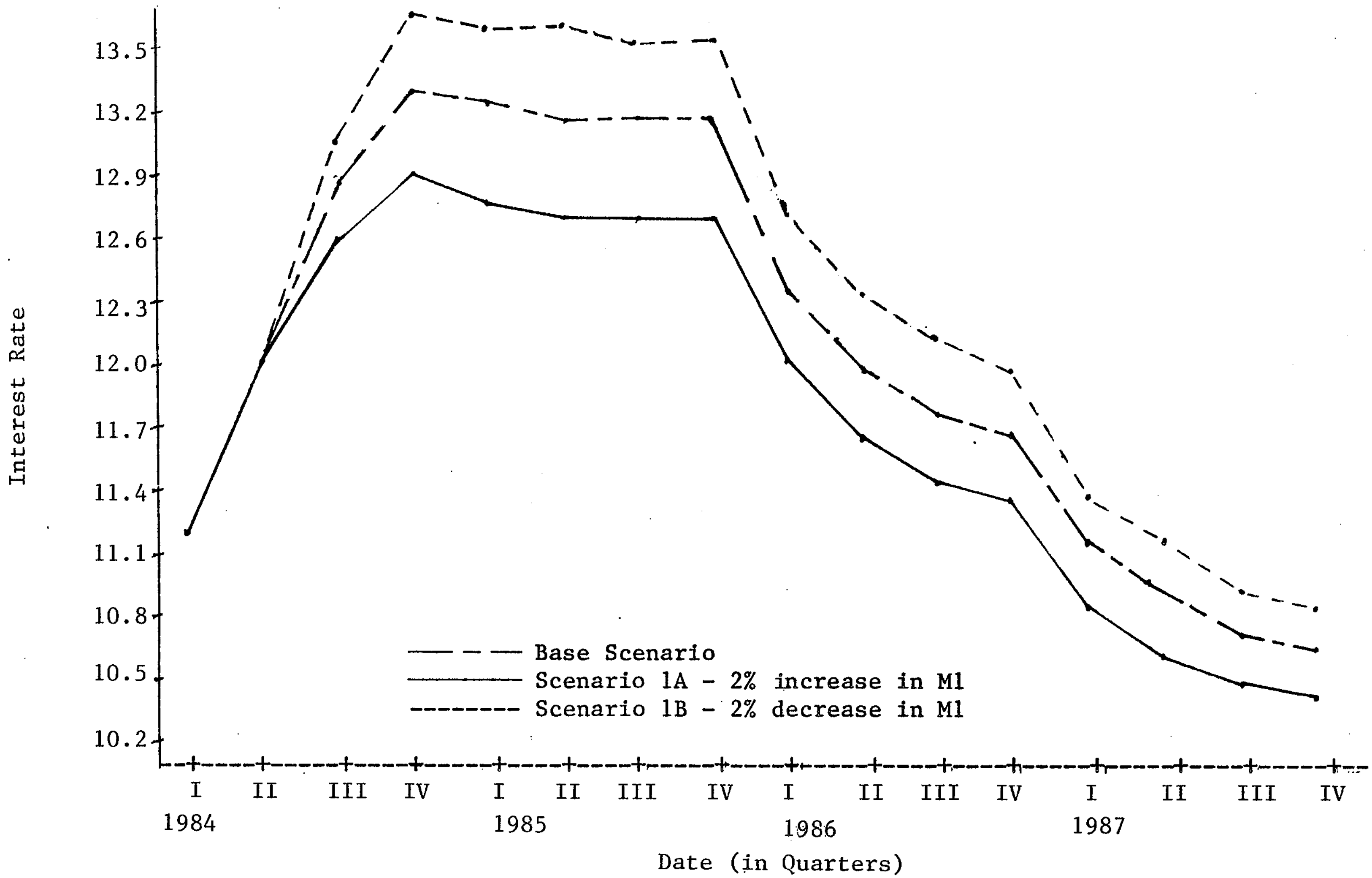

Figure 16

Interest Rate Forecasts for Scenario 1

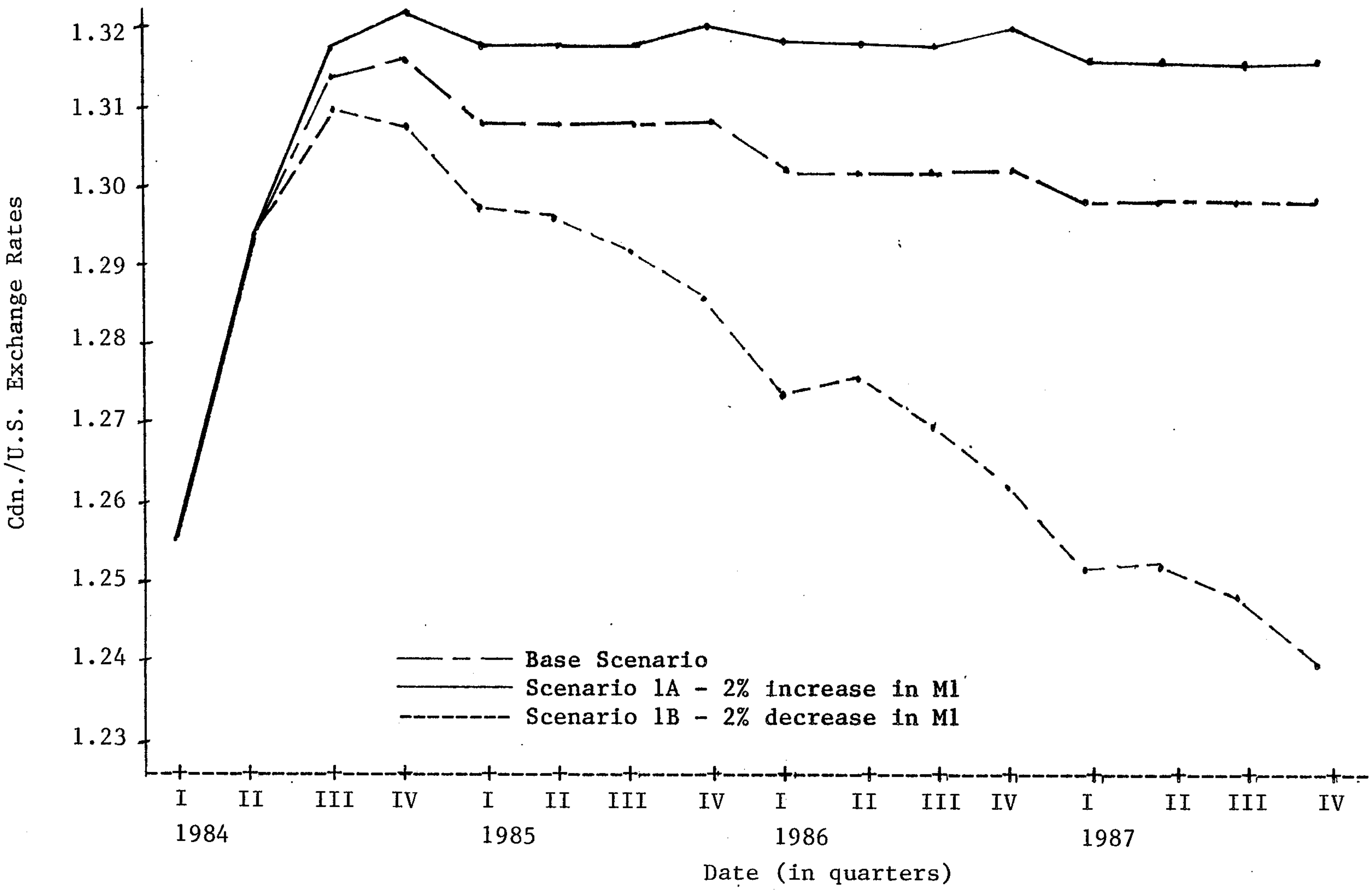

Figure 17

Cdn./U.S. Exchange Rate Forecasts for Scenario 1

Inflation rates are also affected by a change in the money supply. As interest rates decline, investment and consumption begin to rise. This increases economic activity producing a classic case of demand-pull inflation. In addition, increases in the Cdn./U.S. exchange rate (which were initially caused by a decrease in the interest rate) will evenually lead to imported inflation. As shown in Figure 18, the divergence in inflation rates between scenarios is not very great, but does continue to grow as we move toward the end of 1987.

The Focus Model predictions for Scenario 1 will be combined with the exogenous variables included in Table 4 in order to generate a set of results. The explanation of each scenario is simplified by restricting the discussion to net revenue considerations. However, should more information be desired, a complete list of the simulated results for the Trade and Input Price Models is included in Appendixes G and H.

As shown in Figure 17, a 2 percent increase in the money supply (Scenario 1A) leads to an increase in the Cdn./U.S. exchange rate. The result is that the Canadian price and production of wheat begins to rise. This increase in price leads to a increase in the total dispostion (exports plus domestic demand) of Canadian wheat when compared to the Base Scenario. Given that the increase in wheat disposition is exceeded by the increase in seeded area, the estimated level of producer deliveries are projected to decline (relative to the Base Scenario). The increase in price overshadows the decrease in deliveries with gross revenue as expressed on a per hectare basis recording an increased as the Canadian money supply is increased. As shown in Table 5, gross revenue per hectare is estimated to be $519.35 in 1986/87 compared to the Base Scenario

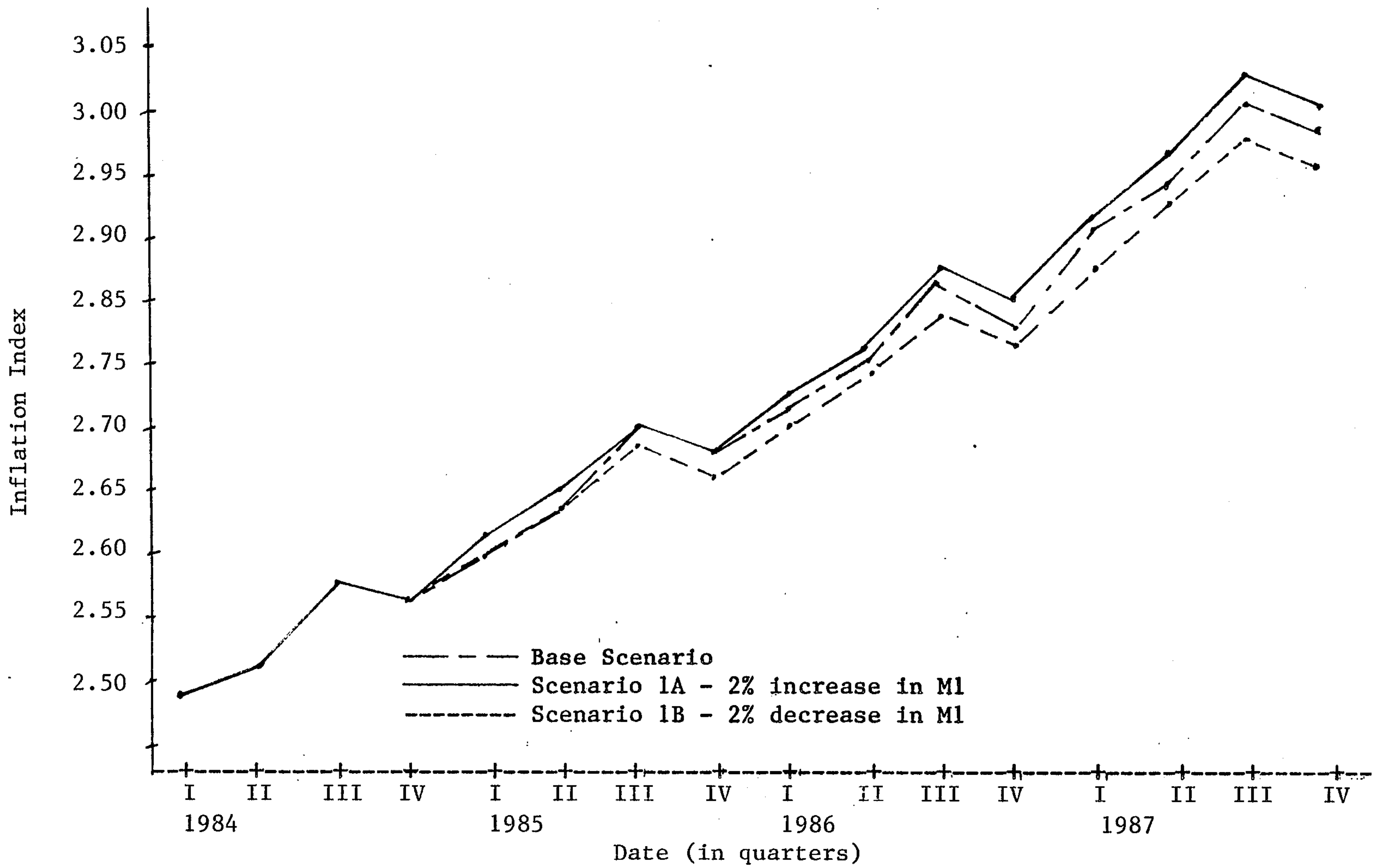

Figure 18

Inflation Forecasts for Scenario 1

estimate of $515.95. On average, a 2 percent increase in the money supply is expected to raise gross revenue by only $2.96 per hectare.

Examining Scenario 1B (a 2 percent decrease in money supply), we find that the 1986/87 gross revenue is estimated to be $513.16 per hectare (Table 5). This is $2.79 per hectare below the Base Scenario and $6.19 per hectare below Scenario 1A. Changes in the price of wheat are moderated by an opposite movement in deliveries. Consequently, gross revenue cannot be considered to be a straight multiple of price.

Turning to the cost side, the Focus-ARIMA option will be examined first. As the money supply increases, both the Cdn./U.S. exchange rate and the Canadian inflation rate increase (relative to the Base Scenario), while the interest rate declines. The aforementioned changes result in a decrease in the estimated cost of producing wheat. For 1986/87, the Base Scenario estimate for total cost is $313.00 per hectare; however, as we move to Scenario 1A, total cost falls to $311.67 per hectare. The decrease in interest rates more than offsets the combined influence embodied within the Cdn./U.S. exchange rate and the Canadian inflation rate. It is important to note that the exchange rate effect, as measured through the bivariate ARIMA process has virtually no impact on the predicted input costs.[115] The change in total cost is due to the impact of inflation on miscellaneous costs and the interest rate effect which is felt through interest expense and machinery investment.

As shown in Table 5, the Focus-ARIMA model predicts that by 1986/87, the difference in total costs between Scenario 1A and Scenario 1B will be $5.47 per hectare. This compares to a Focus-Regression difference

---

[115] Information on the bivariate ARIMA predictions is included in Table G1, Appendix G.

Table 5

Simulated Revenue for Scenario 1

Crop Year	Canadian Wheat Price	Estimated Deliveries	Gross Revenue	Total Cost	Net Revenue	Deflated Net Revenue
	($/t)	(t/ha)	($/ha)	($/ha)	($/ha)	($/ha)
Base Scenario						
Focus-ARIMA Option:						
84/85	253.78	1.971	500.20	277.21	222.99	222.99
85/86	243.01	1.983	481.89	299.99	181.90	173.49
86/87	248.65	2.075	515.95	313.00	202.95	185.91
Focus-Regression Option:						
84/85	253.78	1.971	500.20	277.21	222.99	222.99
85/86	243.01	1.983	481.89	296.05	185.84	177.25
86/87	248.65	2.075	515.95	300.29	215.66	197.55
1A-2% Increase in M1						
Focus-ARIMA Option:						
84/85	255.50	1.970	503.34	277.21	226.13	226.13
84/85	244.71	1.979	484.24	298.19	186.05	176.89
86/87	250.65	2.072	519.35	311.67	207.68	189.32
Focus-Regression Option:						
84/85	255.50	1.970	503.34	277.21	226.13	226.13
85/86	244.71	1.979	484.24	295.57	188.71	179.39
86/87	250.65	2.072	519.35	300.51	218.84	199.50
1B-2% Decrease in M1						
Focus-ARIMA Option:						
84/85	252.06	1.971	496.81	277.21	219.60	219.60
85/86	240.88	1.988	478.87	301.76	177.11	169.30
86/87	246.71	2.080	513.16	314.30	198.86	182.93
Focus-Regression Option:						
84/85	252.06	1.971	496.81	277.21	219.60	219.60
85/86	240.88	1.988	478.87	296.62	182.25	174.21
86/87	246.71	2.080	513.16	299.41	213.75	196.64

of only $1.63 per hectare. The reason why total costs vary less under the Focus-Regression option than under the Focus-ARIMA option is because the input prices predicted by the Focus-Regression Model are affected by both the inflation rate and the exchange rate. In the Focus-ARIMA Model, not only is the Cdn./U.S. exchange rate the only independent variable, but sensitivity of input prices to changes in the exchange rate is extremely limited. Given that both the Cdn./U.S. exchange rate and the inflation rate are predicted to move in an opposite direction to the interest rate, their respective impacts will be partially offset. As the sensitivity of input prices to changes in the exchange rate and the inflation rate increases, a greater proportion of the interest rate effect will be cancelled. This is exactly what happens in the Focus-Regression Model. Estimates for Scenario 1B show that in 1986/87, the increased input costs are more than offset by the decline in interest. The end result is that total cost increases from $300.29 in the Base Scenario to $300.51 in Scenario 1A.

Since gross revenue remains the same regardless of whether the Focus-ARIMA or Focus-Regression options are in place, the variations in net revenue which appear in Table 5 are a direct result of differences in estimated costs. As discussed in the previous paragraph, total costs are more variable under the Focus-ARIMA option than they are under the Focus-Regression option. Consequently, the estimates for net revenue and deflated net revenue will also be more variable. In the final simulation year, deflated net revenue for Scenario 1A (Focus-ARIMA) is $194.80, which is $18.97 above the estimate for Scenario 1B. The Focus-Regression estimate for 1986/87 is $203.30 per hectare in Scenario 1A and $191.08 per hectare in scenario 1B, a difference of $12.12.

Compared to the Base Scenario, a 2 percent increase in the money supply causes an increase in deflated net revenue. Focus-ARIMA estimates for the 1986/87 crop year show that increasing the money supply pushes the deflated net revenue estimate up from $185.91 (Base Scenario) to $189.32 per hectare. Meanwhile, the Focus-Regression Model predicts that deflated net revenue will increase from $197.55 to $199.50 per hectare. A 2 percent decrease in the money supply (Scenario 1B) results in a lower estimate of deflated net revenue. Predictions for 1986/87 show deflated net revenue declining to 182.93 per hectare under the Focus-ARIMA option, and $196.64 per hectare under the Focus-Regression option.

6.3.2 <u>Scenario 2--Changing the Growth Rate the Money Supply</u>. The direction of change in monetary variables will be the same in Scenario 2 as it was in Scenario 1. By adjusting the growth rate of the money supply, we are in effect continually changing the size of the monetary base. The fact that the change is continual rather than being a one shot event (as in Scenario 1) will lead to greater divergence of results.

The change in the Cdn./U.S. exchange rate between Scenario 2 and Scenario 1 causes Canadian price of wheat to rise. Comparing Table 6 to Table 5, we can see that in 1986/87, Scenario 2A predicts that the Canadian price of wheat to be $253.90 per tonne versus $250.65 per tonne under Scenario 1A. As wheat prices increase (from Scenario 1A to 2A), estimated deliveries decline from 2.072 to 2.066 tonnes per hectare. However, the increase in the price once again compensates for the decline in deliveries, with gross revenue increasing from $518.35 per hectare (Scenario 1A) to $524.56 per hectare (Scenario 2A).

Production costs also follow a pattern similar to the one discussed in Scenario 1. In the case of the Focus-ARIMA Model, an

Table 6

Simulated Revenue for Scenario 2

Crop Year	Canadian Wheat Price	Estimated Deliveries	Gross Revenue	Total Cost	Net Revenue	Deflated Net Revenue
	($/t)	(t/ha)	($/ha)	($/ha)	($/ha)	($/ha)
Base Scenario						
Focus-ARIMA Option:						
84/85	253.78	1.971	500.20	277.21	222.99	222.99
85/86	243.01	1.983	481.89	299.99	181.90	173.49
86/87	248.65	2.075	515.95	313.00	202.95	185.91
Focus-Regression Option:						
84/85	253.78	1.971	500.20	277.21	222.99	222.99
85/86	243.01	1.983	481.89	296.05	185.84	177.25
86/87	248.65	2.075	515.95	300.29	215.66	197.55
2A-2% Increase in M1 Growth Rate						
Focus-ARIMA Option:						
84/85	255.29	1.970	502.92	277.21	225.71	225.71
85/86	246.79	1.979	488.40	298.39	190.01	180.66
86/87	253.90	2.066	524.56	310.24	214.32	194.80
Focus-Regression Option:						
84/85	255.29	1.970	502.92	277.21	225.71	225.71
85/86	246.79	1.979	488.40	295.69	192.71	183.23
86/87	253.90	2.066	524.56	301.00	223.56	203.20
2B-2% Decrease in M1 Growth Rate						
Focus-ARIMA Option:						
84/85	252.06	1.971	496.81	277.21	219.60	219.60
85/86	239.16	1.988	475.45	301.60	173.85	166.18
86/87	242.87	2.085	506.38	315.71	190.67	176.01
Focus-Regression Option:						
84/85	252.06	1.971	496.81	277.21	219.60	219.60
85/86	239.16	1.988	475.45	296.63	178.82	170.92
86/87	242.87	2.085	506.38	299.37	207.01	191.08

increase in the growth rate of the money supply leads to a reduction in both interest rates and total production costs. For the Focus-Regression Model, the impact of inflation and the increase in the Cdn./U.S. exchange rate tend to overshadow the drop in interest costs. As a result, total production costs increase by only a minimal amount as the growth rate of the money supply is increased.

Increasing the growth rate of the money supply by 2 percent (Scenario 2A) causes the Focus-ARIMA estimate of deflated net revenue to increase from the Base Scenario level of $185.91 per hectare (Table 6) to $194.80 per hectare. Meanwhile, the Focus-Regression option predicts that deflated net revenue will increase to $203.20 per hectare. Similar magnitudes of change are recorded when the growth rate of the money supply is reduced. Estimates for 1986/87 show Scenario 2B at $176.01 per hectare for the Focus-ARIMA option and $191.08 per hectare for the Focus-Regression option. Once again, these estimates should be compared to the Focus-ARIMA and Focus-Regression base predictions of $185.91 and $197.55 per hectare, respectively.

6.3.3 <u>Scenario 3--Changing the Target Interest Rate</u>. Unlike the first two Scenarios, the primary motive behind Scenario 3 is to control interest rates. However, since interest rates are regulated by changes in the money supply, the end result will be similar to the previous scenarios. In order for interest rates to rise above the Base Scenario, the money supply (M1) is reduced. Such a change in the money supply results in a decrease in both the Cdn./U.S. exchange rate and the Canadian inflation rate.

Although the general direction of results is the same for Scenario 3A as it was in Scenario 2A, the magnitude of change is greater. In order for the target interest rate to increase by 1 percent,[116] the annual growth rate in the money supply must decrease by more than 2 percent. On the other hand, a 1 percent drop in the target interest rate requires M1 to grow at a rate which exceeds the 2 percent increase experienced in Scenario 2.

As interest rates increase, the Focus Model predicts that the Cdn./U.S. exchange rate will decline. The Trade Model translates the declining exchange rate into a reduction of gross revenue. As depicted in Table 7, an increase of 1 percent in the target interest rate reduces gross revenue from its Base Scenario level of $515.95 to $505.42 per hectare by 1986/87. At the same time, a 1 percent decrease in the target interest rate (Scenario 3B) increases gross revenue to $527.24 per hectare.

The cost response is consistent with the events recorded in Scenarios 1 and 2. In the Focus-ARIMA Model, interest rate changes once again overshadow the impact of the exchange and inflation rates. For 1986/87, a 1 percent increase in target interest rates causes the Focus-ARIMA cost estimate to increase from $313.00 to $316.57 per hectare (Table 7). In terms of the Focus-Regression Model, production cost estimates continue to move in an opposite direction to those eminating from the Focus-ARIMA Model. The combined effects of the Cdn./U.S. exchange rate and the Canadian inflation rate produce an influence on cost which exceeds the impact of interest rates.

---

[116]The target interest rate which is included in the Focus Model is the yield on 90-day financial company paper. As the target rate increases by 1 percent, the interest rate on prime business loans increases by less than 1 percent. For example, if we examine Scenario 3A, we find that the interest rate on prime business loans increases from the base level of 13.089 percent to 14.029 percent (an increase of .94 percent) the aforementioned interest rates are taken from Appendix E.

Table 7

Simulated Revenue for Scenario 3

Crop Year	Canadian Wheat Price	Estimated Deliveries	Gross Revenue	Total Cost	Net Revenue	Deflated Net Revenue
	($/t)	(t/ha)	($/ha)	($/ha)	($/ha)	($/ha)
Base Scenario						
Focus-ARIMA Option:						
84/85	253.78	1.971	500.20	277.21	222.99	222.99
85/86	243.01	1.983	481.89	299.99	181.90	173.49
86.87	248.65	2.075	515.95	313.00	202.95	185.91
Focus-Regression Option:						
84/85	253.78	1.971	500.20	277.21	222.99	222.99
85/86	245.01	1.983	481.89	296.05	185.84	177.25
86/87	248.65	2.075	515.95	300.29	215.66	197.55
3A-1% Increase in the Target Interest Rate						
Focus-ARIMA Option:						
84/85	250.12	1.971	492.99	277.21	215.78	215.78
85/86	237.38	1.993	473.10	303.66	169.44	162.62
86/87	242.06	2.088	505.42	316.57	188.85	175.47
Focus-Regression Option:						
84/85	250.12	1.971	492.99	277.21	215.78	215.78
85/86	237.38	1.993	473.10	296.75	176.35	169.25
86/87	242.06	2.088	505.42	297.39	208.03	193.29
3B-1% Decrease in the Target Interest Rate						
Focus-ARIMA Option:						
84/85	252.22	1.970	506.72	277.21	229.51	229.51
85/86	248.57	1.974	490.68	296.31	194.37	184.10
86/87	255.57	2.063	527.24	309.35	217.89	196.63
Focus-Regression Option:						
84/85	252.22	1.970	506.72	277.21	229.51	229.51
85/86	248.57	1.974	490.68	295.41	195.27	184.95
86/87	255.57	2.063	527.24	303.20	224.04	202.19

The combined results of the Trade, Seed and Input Price Models show that deflated net revenue decreases relative to the Base Scenario as the target interest rate is increased. The opposite trend appears to hold true when target interest rates decline. For the Focus-ARIMA Model, deflated net revenue decreases from $185.91 to $175.47 per hectare as the target interest rate rises by 1 percent. Focus-Regression estimates record a smaller drop, falling from the base level of $197.55 to $196.63 per hectare. As the target interest rate increases (Scenario 3B), the Focus-ARIMA and Focus-Regression estimates for the 1986/87 crop year reach $196.63 and $202.19 per hectare, respectively.

6.3.4 <u>Scenario 4--Changing the Target Exchange Rate</u>. Given that the Focus Model considers foreign interest rates to be constant, capital flows can be altered by changing Canadian interest rates. Scenario 4 is based on the premise that the Bank of Canada will intervene in the foreign exchange market in order to maintain a target Cdn./U.S. exchange rate. In order for the Bank of Canada to increase the Cdn./U.S. exchange rate, the supply of Canadian dollars must exceed the demand for Canadian dollars. By decreasing interest rates (through an increase in money supply), the Bank of Canada in effect increases the net outflow of Canadian capital. The result is an increase in the supply of Canadian dollars and a decline in the value of the Canadian dollar.

Therefore, it appears that if the Cdn./U.S. exchange rate is to be increased above the level attained in the Base Scenario, Canadian interest rates must decrease. As was the case in the first three scenarios, the Cdn./U.S. exchange rate and the Canadian inflation rate continue to move in a direction which is opposite to the interest rate. Comparing Scenario

4B to the Base Scenario (Appendix E), we see that the target exchange rate and the inflation rate decline while the interest rate increases.

Of the four scenarios which have been examined, changing the target exchange rate leads to the sharpest initial adjustment in interest rates. However, once the initial adjustment has occurred, the interest rates converge back toward the Base Scenario. As is the case for interest rates, the change in the Cdn./U.S. exchange rate is also greatest between the second and third quarters of 1984. Proceeding beyond this point, the exchange rate predictions for Scenario 4A and 4B form 2 percent bands on either side of the Base Scenario. By the fourth quarter of 1985, Scenario 4A predicts that the Cdn./U.S. exchange rate will be 1.333, which is approximately 2 percent above the Base Scenario forecast of 1.307 (Appendix E, Table E3).

The increase in the Cdn./U.S. exchange rate which is experienced in Scenario 4A causes wheat prices and gross revenue to increase relative to Base Scenario. Table 8 shows that by 1986/87, gross revenue is estimated to be $521.03 per hectare given a 2 percent increase in the target exchange rate. Should the target exchange rate decrease by 2 percent (Scenario 4B), gross revenue is predicted to fall to $510.84 per hectare. After the estimates for total cost have been deducted, net revenue is shown to move in concert with changes in the target exchange rate.

In terms of the Focus-Regression option, the change in net revenue between Scenario 4A and Scenario 4B is very slight ($.96 per hectare as of 1986/87). This small degree of difference between the two modelling options produces a situation whereby the deflated net revenue estimates for the Focus-ARIMA and Focus-Regression Models move in opposite directions. As the target exchange rate increases, the Focus-ARIMA estimate for deflated net revenue rises from its 1986/87 Base Scenario level of

Table 8

Simulated Revenue for Scenario 4

Crop Year	Canadian Wheat Price	Estimated Deliveries	Gross Revenue	Total Cost	Net Revenue	Deflated Net Revenue
	($/t)	(t/ha)	($/ha)	($/ha)	($/ha)	($/ha)
Base Scenario						
Focus-ARIMA Option:						
84/85	253.78	1.971	500.20	277.21	222.99	222.99
85/86	243.01	1.983	481.89	299.99	181.90	173.49
86/87	248.65	2.075	515.95	313.00	202.95	185.91
Focus-Regression Option:						
84/85	253.78	1.971	500.20	277.21	222.99	222.99
85/86	243.01	1.983	481.89	296.05	185.84	177.25
86/87	248.65	2.075	515.95	300.29	215.66	197.55
4A-2% Increase in the Target Cdn./U.S. Exchange Rate						
Focus-ARIMA Option:						
84/85	259.37	1.970	510.96	277.21	233.75	233.75
85/86	245.05	1.969	482.50	296.62	185.88	175.76
86/87	251.10	2.075	521.03	312.97	208.06	188.53
Focus-Regression Option:						
84/85	259.37	1.970	510.96	277.21	233.75	233.75
85/86	245.05	1.969	482.50	296.48	186.02	175.89
86/87	251.10	2.075	521.03	304.91	216.12	195.83
4B-2% Decrease in the Target Cdn./U.S. Exchange Rate						
Focus-ARIMA Option:						
84/85	248.19	1.971	489.18	277.21	211.97	211.97
85/86	240.97	1.998	481.46	303.00	178.46	171.50
86/87	246.19	2.075	510.84	312.63	178.21	183.64
Focus-Regression Option:						
84/85	248.19	1.971	489.18	277.21	211.97	211.97
85/86	240.97	1.998	481.86	295.68	186.18	178.54
86/87	246.19	2.075	510.84	295.78	215.06	199.25

$185.91 per hectare to its new level of $188.53 (Table 8). Meanwhile, estimates from the Focus-Regression Model fall from their 1986/87 Base Scenario level of $197.55 to $195.83 per hectare. A similar situation prevails for Scenario 4B. As the target exchange rate decreases, the Focus-ARIMA Model forecasts a decline in deflated net revenue, while the Focus-Regression Model predicts an increase relative to the Base Scenario.

6.4 Summary of the Simulation Results

Up to this point, the analysis has concentrated on the interactions which occur between the variables comprising net revenue. These results provide an idea of the trends which may develop from a specific monetary policy but they are not particularly useful in terms of formulating conclusions. In order to simplify the interscenario comparisons, the estimates of deflated net revenue will be averaged over the three simulation years. The averaged results are displayed in Table 9.

In each scenario, the Focus-Regression estimate of average deflated net revenue exceeds the Focus-ARIMA estimate. The reason for this difference is that the bivariate ARIMA models which produce the cost estimates for the Focus-ARIMA option are based on historic price trends, while the regression models found in the Focus-Regression option are directly influenced by the variables derived in the Focus Model. Given that the Focus Model predicts price changes which are below past trends, it is not surprising that the Focus-Regression costs are lower than the Focus-ARIMA costs. If the Focus-Regression costs are lower, it only stands to reason that the Focus-Regression estimates for deflated net revenue will be higher than their Focus-ARIMA counterpart.

In addition to being higher in value, the Focus-Regression estimates of deflated net revenue are also less variable. Under the

Table 9

Summary of Average Deflated Net Revenue
(1984/85 - 1986/87)

Scenario	Focus-ARIMA		Focus-Regression	
	3-Year Average	Change Relative to the Base	3-Year Average	Change Relative to the Base
	($/ha)			
Base Scenario	194.13	-	199.26	-
Scenario 1 -- Changing the Level of the Money Supply:				
A) 2% increase	197.45	+3.32	201.67	+2.41
B) 2% decrease	190.61	-3.52	196.82	-2.44
Scenario 2 -- Changing the Growth Rate of the Money Supply:				
A) 2% increase	200.39	+6.26	204.05	+4.79
B) 2% decrease	187.26	-6.87	193.87	-5.39
Scenario 3 -- Changing the Target Interest Rate:				
A) 1% increase	184.62	-9.51	192.77	-6.49
B) 1% decrease	203.41	+9.28	205.55	+6.29
Scenario 4 -- Changing the Target Exchange Rate:				
A) 2% increase	199.35	+5.22	201.82	+2.56
B) 2% decrease	189.04	-5.09	196.59	-2.67

Focus-Regression Model, changes in the domestic inflation rate and the Cdn./U.S. exchange rate more than offset the impact of an interest rate change. The situation is different for the Focus-ARIMA Model, where the cost of producing wheat is always predicted to move in the same direction as the interest rate.

If we expand the argument to include the determination of gross revenue, some further generalizations are possible. The Cdn./U.S. exchange rate is shown to exert a direct influence on the Canadian price of wheat. Increasing the exchange rate (i.e., lowering the value of the Canadian dollar) causes the domestic price of wheat to increase. Higher wheat prices prompt an increase in the number of hectares seeded to wheat, and a subsequent decrease in the quantity of wheat which can be delivered per hectare seeded. Despite the decline in deliveries, the increase in the price of wheat is sufficient to produce an increase in the estimated level of gross revenue per hectare. Stated more succinctly, an increase (decrease) in the Cdn./U.S. exchange rate is expected to produce an increase (decrease) in the gross revenue received by Canadian wheat producers.

When the difference between gross revenue and production cost is divided by the prevailing inflation rate, an estimate of deflated net revenue is produced. Any monetary policy which serves to increase the Canadian money supply is estimated to have a positive effect on deflated net revenue of wheat producers. If we take Scenario 1 as an example, a 2 percent increase in the money supply exerts negative pressure on interest rates. As the Canadian interest rate begins to decline, an increase in the net amount of capital flowing out of the country causes the Cdn./U.S. exchange rate to appreciate. The positive relationship between Cdn./U.S.

exchange rates and average deflated net revenue now comes into effect. Table 9 shows that an increase in the money supply has a positive impact on the deflated net revenue of western Canadian wheat producers.

The changes in average deflated net revenue which appear in Table 9 are not that large. However, we must bear in mind that we are dealing with deflated (i.e., real) changes rather than nominal changes. Also, the monetary shocks which initiate the change in net revenue are only small adjustments in themselves. If the monetary shocks were doubled or tripled, the change in deflated net revenue would be much more prominent.

As discussed in Section 6.1, all of the scenarios included in this study revolve around adjustments in the money supply. The manner and degree to which the money supply is shocked determines how the monetary variables react. Changing the target interest rate by 1 percent (Scenario 3) requires the greatest adjustment in the money supply and hence, initiates the greatest response in deflated net revenue (Table 9). The second largest impact is brought about by a 2 percent change in the growth rate of the money supply (Scenario 2). Meanwhile, changes in the target exchange rate (Scenario 4) and adjustments in the level of the money supply itself (Scenario 1) create the second smallest and smallest impacts on deflated net revenue, respectively.

CHAPTER VII

CONCLUSIONS AND POLICY IMPLICATIONS

Declining profit margins and an increase in the number of farm financial failures have prompted agricultural economists to examine the linkages which exist between monetary policy and individual farming operations. Previous studies, such as those cited in Chapter II have devoted a considerable amount of effort toward researching the impact of exchange rates on agricultural trade. Concerns have also been voiced in regard to the impact of interest rates. However, the prices of other factor inputs such as fertilizer, machinery and chemicals have generally been ignored.

Given that inflation, interest rates, and the Cdn./U.S. exchange rate change simultaneously, it seems only logical that the impacts of such changes should be measured in a simultaneous fashion. Instead of limiting the analysis to how exchange rates affect domestic prices and export volumes, this study also measures some of the adjustments which occur due to the corresponding changes in inflation and interest rates. In addition, part of this study is specifically devoted to measuring how changes in monetary variables affect input prices.

In order to convey a complete description of these interactions, it was necessary to focus on a single commodity. Wheat production was selected due to its importance within the Canadian economy. The general objective of the thesis was to establish a connection between a change in monetary policy at the macro level and its resulting microeconomic impact on the net revenue of wheat producers. As outlined in Chapter I, the four specific objectives of this study were:

1. to examine the theoretical linkages between monetary variables and the Canadian wheat industry;

2. to build an econometric model which can be used to estimate the impact of monetary shocks;

3. to use the estimated model to simulate how the net revenue of wheat producers is affected by changes in monetary policy; and

4. to analyze the results of the simulations in order to provide policy prescriptions.

The remainder of this chapter is separated into five sections. A brief summary of the study is included in the first section. The second section presents the conclusions which stem from the model simulations, while the third section discusses the resulting policy implications. The limitations of the study and suggestions for further research are included in the fourth and fifth sections, respectively.

7.1 Linking Monetary Policy to Net Revenue

This study links the net revenue of western Canadian wheat producers to the monetary policy pursued by the Bank of Canada. The macro-micro linkages are traced out using both economic theory and modelling techniques. From a theoretical perspective, the Cdn./U.S. exchange rate, interest rates, and the inflation rate all have a direct impact on the profitability of wheat production. As discussed in Chapter III, increasing the Cdn./U.S. exchange rate will have a positive impact on both the domestic price of wheat and the price of wheat inputs, as well as causing an increase in Canadian wheat exports. Meanwhile, increases in interest rates and inflation rates will lead to higher production costs, which in turn reduce the net revenue resulting from the production and sale of wheat. It is only after all of these impacts have been measured that we can begin to evaluate how the net revenue of wheat producers is affected.

The problem at hand is not limited to assessing how gross revenue and production costs react to changes in monetary variables. It is also necessary to estimate how these monetary variables (interest, exchange and inflation) react to a change in the Bank of Canada's strategy. In order to accomplish this, we solicited the use of the Focus Model, which was developed by the University of Toronto's Institute for Policy Analysis. The monetary variables generated by the Focus Model are entered into the Trade and Input Price Models which in turn predict gross revenue and the price of wheat inputs.

Two different Input Price Models are used within this study. The Focus-ARIMA version is based on the notion that Canadian input prices are determined by a combination of U.S. prices and Cdn./U.S. exchange rates. The second way of predicting input prices is through the Focus-Regression Model. The assumption behind the Focus-Regression Model is that Canadian input prices are more dependent on domestic production costs than on U.S. prices.

Once interest expense and miscellaneous costs have been added to the results of the Trade and Input Price Models, a measure of deflated net revenue is derived. The period over which net revenue is simulated spans the three crop years from 1984/85 to 1986/87. The specific monetary policies which are examined include: a change in the size of the money supply, a change in the growth rate of the money supply, as well as a change in both the target interest rate and the target Cdn./U.S. exchange rate. In each scenario, the chain of events begins with a manipulation of the money supply which in turn affects the interest rate, the exchange rate, and the domestic inflation rate. For example, an increase in money supply causes Canadian interest rates to decline, which subsequently leads to a net outflow of Canadian capital and a drop in the value of the Canadian dollar (i.e., an appreciation in the Cdn./U.S. exchange rate).

As the exchange rate rises, Canada suffers from imported inflation due to an increase in the domestic price of imports. The direction and rate of change in the money supply (M1) depends on the particular monetary policy which is in place. For example, decreasing the target interest rate by 1 percent (Scenario 3B) requires a more acute increase in the money supply than Scenario 2A, where the annual growth rate of the money supply is increased by 2 percent. However, the scenarios included in this study should not be compared solely on the basis of what happens to the money supply. Each scenario produces a unique pattern of change, not only in the money supply (M1), but also in terms of the Cdn./U.S. exchange rate, interest rates and the domestic inflation rate.

7.2 Conclusions from the Study

The results of the four scenarios were presented at length in Chapter VI. Those monetary policies which lead to an increase in the money supply exert negative pressure on interest rates while at the same time increasing the Cdn./U.S. exchange rate and the domestic inflation rate. In regard to the cost of producing wheat, increased input prices which result from higher exchange and inflation rates cancel out at least some of the reduction in interest expense. Since only part of the change in interest expense is offset in the Focus-ARIMA Model, production costs are shown to move in the same direction as interest rates. In the case of the Focus-Regression Model, the impact which interest rates exert on production costs is more than offset by changes in the Cdn./U.S. exchange rate and the domestic inflation rate. The end result is that Focus-Regression model predicts that production cost will move in an opposite direction to the interest rate.

In regard to gross revenue, the Trade Model predicts that domestic wheat prices will increase and that the quantity of wheat delivered per hectare will decrease as the Cdn./U.S. exchange rate appreciates. The change in wheat prices outweighs the change in deliveries; consequently, an increase in the Cdn./U.S. exchange rate will cause an increase in both the domestic price of wheat and the gross revenue per hectare seeded to wheat. Once production costs are subtracted from gross revenue, a per hectare estimate of net revenue is available. Given that the projected inflation rates differ across scenarios, deflated (real) net revenue is used as the basis for comparison.

The simulated impacts of the various policy shocks are shown in Table 10. Instead of describing the results in terms of dollars per hectare as in Chapter VI, the estimates included in Table 10 have been converted to elasticities. These elasticities represent the percentage change in average deflated net revenue over the 1984/85 to 1986/87 period, which is brought about by a 1 percent change in a particular monetary parameter.

As shown in Table 10, the direction of change in average deflated net revenue is consistent between the Focus-ARIMA and Focus-Regression Models. Where the results differ is in regard to the degree to which average deflated net revenue responds to a particular monetary shock. The cancelling effect which is present within the Focus-Regression Model causes its estimates to be less responsive than the ones generated by the Focus-ARIMA Model. Regardless of this difference, the ranking of the scenarios does not change between models. A 1 percent change in the target interest rate creates the greatest change in deflated net revenue. Adjusting the growth rate of the money supply accounts for the second largest response. The third and fourth largest responses are produced by

Table 10

The Elasticity of Average Deflated Net Revenue to Changes in Monetary Policy

Scenario	% Change Relative to the Base Scenario	
	Focus-ARIMA	Focus-Regression
	................(in percent)............	
Scenario 1--Changing the Level of the Money Supply:		
(a) 1% increase	+ .86	+ .61
(b) 1% decrease	- .91	- .62
Scenario 2--Changing the Growth Rate of the Money Supply:		
(a) 1% increase	+1.61	+1.20
(b) 1% decrease	-1.77	-1.36
Scenario 3--Changing the Target Interest Rate:		
(a) 1% increase	-4.90	-3.26
(b) 1% decrease	+4.78	+3.16
Scenario 4--Changing the Target Exchange Rate:		
(a) 1% increase	+1.35	+ .64
(b) 1% decrease	-1.31	- .67

a 1 percent change in the target exchange rate and a 1 percent change in the level of the money supply, respectively.

Referring once again to Table 10, we see that the response to a 1 percent increase in a particular monetary parameter is not completely symmetric to a 1 percent decrease. The explanation for this is that the Focus Model does not yield entirely linear results. If we go back to Figure 17, we see that the projected response of the Cdn./U.S. exchange rate to a 2 percent increase in the money supply is opposite but not equal to what is predicted to happen should the money supply decrease by 2 percent. Since the exchange rate is predicted to be more flexible on the downside, it is not surprising that the net revenue response to a decrease in money supply outpaces the response which results from a corresponding increase in money supply.

The results of the study lead to the general conclusion that in the short run there is a positive relationship between the deflated net revenue of wheat producers and changes in the size of the money supply. When the underlying relationships are examined, the deflated net revenue of wheat producers is found to be negatively related to interest rates and positively related to movements in the Cdn./U.S. exchange rate. The manner in which domestic wheat prices respond to a change in the Cdn./U.S. exchange rate overshadows the impact which interest and inflation rates exert on the cost of producing wheat.

A systems approach is necessary in order to produce a comprehensive assessment of how deflated net revenue reacts to a change in monetary policy. Examining only how exchange rates impact on the trade, or how interest and inflation rates impact on cost will produce biased results. The most logical way of approaching the problem is through a model such as the one presented in this study where the interaction of monetary variables and their corresponding impacts on net revenue are analyzed simultaneously.

7.3 Policy Implications

At first glance, a wheat producer's deflated net revenue does not appear to be overly sensitive to a change in monetary policy. When compared to the increase in farm income experienced during the commodity price boom of the early 1970's, the magnitudes of change shown in Table 10 do not appear to be very significant. However, when you compare wheat producers to the average wage earner in Canada, a 2 to 3 percent change in deflated net revenue takes on an entirely different perspective. During the 1980's individuals have been hardpressed to maintain their real income positions. A 2 to 3 percent change in deflated net income can be crucial if a producer is operating at or near the break-even point.

The Focus-Regression estimates of deflated net revenue which were presented in Chapter VI (Table 9), show that a 1 percent decrease in the target interest rate produces a $6.29 per hectare rise in deflated net revenue. When this increase is spread over the entire land base of our case farm (400 hectares), the producer's total deflated net revenue increases by an average of $2,516 per year. This means that in each year, the producer will have an additional $2,516 which can either be applied to land costs or else used to increase his real level of consumption. Increasing the target interest rate leads to a similar decline in an individual producer's deflated net revenue. Under such a scenario, the producer will either suffer a decline in consumption or else be unable to meet his land payments.

Throughout this analysis, net revenue has been defined as the difference between gross revenue and operating costs. Out of net revenue the producer must pay his land costs in addition to receiving a return on labour and management. It is logical to assume that a change in the level of net revenue received per hectare should lead to an adjustment in the price of land. If the price of land is bid up or down by the full amount of the change in net revenue, the residual amount of money which is available to cover labour and management will remain unchanged. On the other hand, if land prices respond slowly or not at all to a slight change in net revenue, the returns to labour and management (farm family income) will be directly affected by a change in monetary policy.

If we assume that land costs remain constant over the three simulation years at $85 per hectare, a $6.29 per hectare increase in deflated net revenue is equivalent to a 5.5 percent increase in real farm family income. When income is used as the basis of comparison instead of deflated net revenue, the elasticities included in Table 10 have to be increased by approximately 75 percent. It is important to note that these elasticities refer to a before-tax position.

The above discussion points out that wheat producers are subject to other sources of income variation in addition to prices and yields. Canada's monetary policy also has a major role to play. Within this study, the Bank of Canada is assumed to manipulate the money supply in order to attain a specific monetary objective whether it be a decline in interest rates, a reduction in inflation or a realignment of the Cdn./U.S. exchange rate.

Out of the four scenarios examined in this study, the best thing the Bank of Canada can do from a wheat producer's perspective is to decrease the target interest rate. The second best alternative is for the

Bank of Canada to increase the growth rate of the money supply. The third and fourth best policies call for increases in the target exchange rate and the size of the money supply, respectively. What is deemed to be most advantageous will conversely be most disadvantageous if an opposite policy stance is adopted. For example, the worst monetary policy from a wheat producer's standpoint is for the Bank of Canada to increase the target interest rate.

In making policy decisions, it is important for the Bank of Canada to examine the implications which result from the simultaneous adjustment of monetary variables. Examining the problem from a partial equilibrium setting may shed some light on how exchange rates affect export prices or how interest rates impact on production costs, but it tells us relatively little about how net revenue or farm family income is affected. This study has attempted to bridge the macro-micro gap by outlining a model which can be used to assess the microeconomic impacts of a particular monetary policy.

The reaction of individual subsectors of the economy to changes in monetary policy will differ depending on how involved they are in international trade, the degree to which their inputs are affected by domestic inflation and import prices, as well as their general ability to pass cost increases along to the consumer. Accounting for the interactions within one subsector represented a fairly onerous task. Expanding the analysis to include all subsectors of the economy would be difficult but useful in that it would provide a better idea of how different groups are affected by monetary policy. If one subsector is found to be disadvantaged by a particular policy, some type of compensation such as a subsidy or a reduction in taxes could be implemented to alleviate the disparity.

7.4 Limitations of the Study

The model presented in this study is based on a number of simplifying assumptions. Although these assumptions are required in order to make the model more comprehensible, they also serve to diminish the model's representation of reality. The linear equations included in the Trade and Input Price Models represent a prime example of a simplifying assumption. The result is that an equal but opposite change in a particular parameter (i.e., sensitivity testing) will produce symmetric results. Given that the real world does not function under perfect market clearing, symmetric results are unlikely. This problem can be rectified either by specifying a system of non-linear equations or by estimating the model using a variable parameter technique. Although non-linear estimation is theoretically attractive, it tends to be cumbersome when included within an integrated model. On the other hand, estimating variable parameters is possible only when there is a sufficient number of positive and negative observations. In the case of the Cdn./U.S. exchange rate this is not possible since there has not been a period of extended decline since 1976. Parameters estimated from the 1971-76 period would hardly be appropriate for predicting future events.

The inability to measure the overall forecasting power of the model represents a second limitation. Given that the model is a combination of three individual submodels, assessing the cumulative forecasting accuracy is a difficult task. The situation is further complicated by the fact that the Focus Model was borrowed, and as a result, its predictive power is not known.

The use of the Focus Model presents a third limitation in that we are restricted to analyzing the policy options available within that model. We are further restricted by the degree to which the Focus Model can be perturbed from its baseline scenario. The authors of the Focus Model put confidence in their predictions only when the monetary targets are adjusted in a minor way. For this reason, we were not able to experiment with how net revenue would react to a more extreme change in monetary policy. Therefore, we cannot be completely confident that the net revenue elasticities established in this model can be applied over a wide range of policy shocks.

At one point during the development of this thesis, exogenous monetary shocks were examined. This option included of a number of scenarios where the interest rate, the exchange rate, and the inflation rate were varied by 5 and 10 percent. The results of the exogenous scenarios were interesting in that they allowed net revenue to be simulated using a more extreme series of shocks, but the scenarios suffered from a conceptual drawback since they could not be identified with a specific monetary policy. If the macroeconomic interactions are ignored, we will simply be reverting back to a partial equilibrium setting where net revenue is assessed relative to a change in only one of the monetary variables. Given that the primary objective of this study was to trace how a change at the macroeconomic level affects the net revenue of an individual wheat producer, the exogenous shock option was not reported.

A fourth limitation is that the study falls short of providing a completely simultaneous system. Although the Focus Model estimates the monetary variables in a simultaneous fashion, there is no feed-back mechanism. Causation runs in only one direction, with monetary policy affecting the monetary variables which in turn influence gross revenue and production costs. There is no provision for feeding the changes in net revenue and export earnings back into the Focus Model. One-way causation is counter-intuitive given the importance of wheat within Canada's Current Account balance and in regard to the Canadian economy in general.

A fifth problem is that the analysis has been limited to wheat production, which means that the results may not be directly applicable to the average western Canadian grain producer. If we were able to assume that all grains and oilseeds react to monetary variables in a similar way, the results would be generally applicable. Unfortunately, such an assumption is not obvious. The way in which exports and prices of various crops react to changes in the exchange rate may differ. Similarly, if a different mix of inputs is required to produce a particular crop, and the relative price those inputs changes(due to a change in monetary policy), the amount of net revenue which can be recovered from that crop will also change.

A sixth problem with the model deals with input utilization and supply response. Throughout this analysis, producers were assumed to follow a constant production pattern regardless of changes in output and input prices. Consequently, yield is treated as an exogenous factor which is influenced only by technology. Imparting such rigidities results in an under-estimation of supply response.

7.5 Suggestions for Further Research

The results of this study depend on the predicted values for interest, inflation and exchange rates. Although the forecasts generated by the Focus Model appear to be logically consistent, there is always the possibility that they could be somewhat inaccurate. An obvious extension of this research is examine how predictions from other macroeconomic models affect the net revenue of wheat producers. The Bank of Canada's RDX2 model and the Chase Econometrics model represent two alternatives which could be used to forecast the behavior of various monetary aggregates. In addition to being of interest from a modelling perspective, the examination of forecasts from various models would also allow a higher degree of confidence to be attached to the final results.

Although the examination of various macroeconomic models is helpful, it still falls short of making the process completely simultaneous. As noted in Section 7.4, the simulated change in foreign exchange earnings resulting from wheat exports and the adjustment in economic activity which is due to an increase or decrease in the net revenue of wheat producers should be fed back into the macroeconomic model. The major problem is that most large macroeconomic models do not allow for any re-entry of information once the results have been generated.

The easiest way to design a completely simultaneous system is to adopt a monetary model of exchange rate determination. The feed-back between agriculture and the rest of the economy can be accomplished through an induced change in the monetary base. Higher foreign exchange earnings due to an increase in the value of wheat exports will cause an expansion in the monetary base. The money supply will also have to be adjusted in order to accommodate an increase in consumption and investment demand created by an increase in the net revenue received by wheat producers. Once the impacts which agriculture exerts on the monetary base have been measured, exchange and inflation rates can be solved simultaneously.

A third way in which the current research could be extended is to apply the methodology outlined in this thesis to other sectors of agriculture. Each commodity is expected to have a different sensitivity to changes in monetary policy. For instance, the net revenue position of

Canadian hog and cattle producers is heavily dependent on both the interest rate and the Cdn./U.S. exchange rate. As a result, these sectors should be reasonably sensitive to changes in Canada's monetary policy. By evaluating a number of agriculture's subsectors and aggregating the results, it should be possible to establish how changes in monetary policy affect the agricultural sector in general.

A final suggestion for further research calls for a more indepth analysis of the input markets. As agriculture becomes more intensive and specialized, producers become more vulnerable to changes in input prices. Despite the importance of these markets, very little research has been devoted to their study. Within this thesis, the prices of inputs are predicted using some rather naive methods. Lack of adequate data is the predominant reason why a more detailed analysis has not been undertaken. It would be much more appealing to analyze the input markets based on supply and demand characteristics rather than relying on the assumption that past price trends will repeat themselves.

BIBLIOGRAPHY

BIBLIOGRAPHY

Aizenman, J. "Modelling Deviations from Purchasing Power Parity (PPP)", International Economic Review, Vol. 25, February, 1984, pp. 175-191.

Alaouze, C.M., A.S. Watson and N.H. Sturgess. "Oligopoly Pricing in the World Wheat Market", AJAE. Vol. 60, 1978, pp. 173-185.

Ball, R.J. The International Linkage of National Economic Models. Amsterdam: North Holland, 1973.

Bank of Canada. Bank of Canada Review. Ottawa: Bank of Canada, various issues.

Barber, C.L. and J.C.P. McCallum. Unemployment and Inflation: The Canadian Experience. Toronto: James Lorimer & Co. in association with the Canadian Institute for Economic Policy, 1980.

Bilson, J.F.O. "The Monetary Approach to the Exchange Rate: Some Empirical Evidence", IMF Staff Papers. Vol. 25, 1978, pp. 50-54.

Binkley, J.K. and B. Harrer. "Major Determinants of Ocean Freight Rates for Grains: An Econometric Analysis", AJAE. Vol. 63, No. 1, February 1981, pp. 47-57.

Box, G.E.P. and G.M. Jenkins. Time Series Analysis, Forecasting and Control. San Fransisco: Holden Day Inc., 1976.

Branson, W.H. and J.M. Litvac. Macroeconomics. New York: Harper & Row Publishers, 1976.

Bredahl, M.E., W.H. Meyers and K.J. Collins. "The Elasticity of Foreign Demand for U.S. Agricultural Products: The Importance of Price Transmission Elasticity", AJAE. Vol. 61, Feb. 1979, pp. 58-63.

Bressler, R.G. and R.A. King. Markets, Prices and Interregional Trade. New York: John Wiley & Sons, Inc., 1970.

Cameron, N.E. Money, Financial Markets and Economic Activity. Don Mills, Ont.: Addision-Wesley Publishers, 1984.

Carter, C.A. and N. Hamilton, "The Law of One Price in Wheat Inputs", unpublished paper, University of Manitoba, 1984.

Carter, C. and A. Schmitz. "Import Tariffs and Price Formation in the World Wheat Market", AJAE. Vol. 61, No. 3, Aug. 1979, pp. 517-522.

Canadian Grains Council. Canadian Grain Industry Statistical Yearbook. Winnipeg: Canada Grains Council, various issues.

Cagan, P. "The Monetary Dynamics of Hyperinflation", Studies in the Quantity Theory of Money. Edited by Milton Friedman. Chicago: University of Chicago PRess, 1956.

Cassel, G. "Abnormal Deviations in International Exchanges", Economic Journal. Vol. 28, December, 1918.

Chambers, R.G. and R.E. Just. "A Critique of Exchange Rate Treatment in Agricultural Trade Models". AJAE. Vol. 61, May 1979, pp. 250-257.

________. "An Investigation of the Effect of Monetary Factors on Agriculture", Journal of Monetary Economics. Vol. 9, 1982, pp. 236-247.

Collins, K.J., W.H. Meyers and M.E. Bredahl. "Multiple Exchange Rate Changes and U.S. Agricultural Commodity Prices", AJAE. Vol. 62, Nov. 1980, pp. 656-666.

Crockett, A.D. and M. Goldstein. "Inflation Under Fixed and Flexible Exchange Rates", IMF Staff Papers. Vol. 23, 1976, pp. 509-543.

Day, W.H. "Flexible Exchange Rates: A Case for Official Intervention", IMF Staff Papers. Vol. 24, 1977, pp. 330-343.

Department of Finance. "Foreign Exchange Market Intervention in Canada", a report submitted to the Working Group on Exchange Market Intervention at the Economic Summit Meetings. Ottawa, Sept. 1982.

Deppler, M.C. "Some Evidence on the Effects of Exchange Rate Changes on Trade", IMF Staff Papers. Vol. 21, 1974, pp. 605-636.

Dooley, M.P. and J.R. Schafer, "Analysis of Short-Run Exchange Rate Behavior: March, 1973 to Sept. 1974", International Finance Discussion Paper No. 76. Washington: Federal Reserve Board, Feb., 1976.

Dornbusch, R., and P. Krugman. "Flexible Exchange Rates in the Short Run", Brookings Papers on Economic Activity. Vol. 3, 1976, pp. 537-584.

Durbin, J. "Testing for Serial Correlation in Least Squares When Some of the Regressors are Lagged Dependent Variables", Econometrica. Vol. 38, 1970.

Emminger, O. Exchange Rate Policy Reconsidered. Occasional Paper No. 10. New York: The Group of Thirty, 1982.

Farrar, G.E. and R.R. Glauber, "Multicollinearity in Regression Analysis", Review of Economics and Statistics. Vol. 49, 1967.

Fleming, M.J. "Domestic Financial Policies Under Fixed and Under Floating Exchange Rates", IMF Staff Papers, Vol. 9, 1962, pp. 369-379.

Floyd, J.E. "The Effects of Farm Price Supports on the Returns to Land and Labor in Agriculture", Journal of Political Economy, Vol. 73, 1965(a), pp. 148-158.

Food and Agriculture Organization. F.A.O. Production Yearbook. Rome: Food and Agriculture Organization, various issues.

Freedman, C. and D. Longworth. Some Aspects of the Canadian Experience with Exchange Rates in the 70's. Ottawa: Bank of Canada, July, 1980.

Freidman, M. "The Role of Monetary Policy", American Economic Review. Vol. 58, March, 1968, pp. 7-11.

Gordon, M.J. The Post-Keynesian Debate, a Practical Guide to Current Economic Policy Trends in Canada. The Canadian Institute for Economic Policy Series, Occasional Paper No. 2. Ottawa: Canadian Institute for Economic Policy, 1980.

Groenewegen, J.R. Market Commentary. Ottawa: Agriculture Canada, June, 1984.

Grubel, H.G. International Economics. Homewood, Ill.: Richard D. Irwin, Inc., 1977.

Gujarati, D. Basic Econometrics. New York: MacGraw Hill Books Inc., 1978.

Hamilton, Hon. A. "Wheat and Policy Making", Seminar on Wheat. University of Manitoba, 1970, pp. 113-125.

Hillman, J.S. and A. Schmitz (editors). International Trade and Agriculture: Theory and Policy. (Boulder, Colo.: Westview Press, 1979).

Hernshaw, R.C., Jr. "Testing Single Equation Least Squares Regression Models for Autocorrelated Disturbances", Econometrica. Vol. 34, 1966.

Institute for Policy Analysis. "Focus, Quarterly Forecasting and User Simulation Model of the Canadian Economy", mimeographed paper. University of Toronto, Toronto, Jan. 1982.

International Wheat Council. World Wheat Statistics. London, various issues.

Isard, P. "How Far Can We Push the Law of One Price", American Economic Review. Vol. 67, No. 5, Dec. 1977. pp. 942-948.

________. Exchange Rate Determination: A Survey of Popular Views and Recent Models. Princeton Studies in International Finance No. 42. Princeton, N.J.: Princeton University Press, 1978.

Johnson, P.R. "The Elasticity of Foreign Demand for U.S. Agricultural Products", AJAE. Vol. 59, 1977, pp. 619-627.

________, T. Grennes and M. Thursby. "Devaluation, Foreign Trade Controls and Domestic Wheat Prices". AJAE. Vol. 59, 1977, pp. 619-627.

Kenen, P.B. "Exchange Rate Variability: Measurement and Implications", mimeographed paper. International Finance Section, Princeton University, June 1979.

________ and C. Pack. Exchange Rates, Domestic Prices and the Adjustment Process. Occasional Paper No. 1. New York: The Group of Thirty, 1980.

Keynes, J. A Tract on Monetary Reform. London: MacMillan Publishers, 1923.

Kost, W.E. "Effects of Exchange Rate Change on Agricultural Trade", Agricultural Economics Research. Vol. 28, No. 3, July 1976, pp. 99-106.

Koutsoyiannis, A. Theory of Econometrics, An Introductory Exposition of Econometric Methods. London: MacMillan Press Ltd., 1977.

Kravis, I.B. and R.E. Lipsey. "Price Competitiveness in World Trade". National Bureau of Economic Research Studies in Economic Relations. Vol. 6, 1971.

Lee, W.F. "A Capital Budgeting Model for Evaluating Farm Real Estate Purchases", Canadian Farm Economics. Vol. II, No. 3, 1976.

Lin, S. "A Macro Policy Simulation Model of the Canadian Agricultural Sector", unpublished Ph.D. thesis, Carleton University, Ottawa, May 1980.

McKinnon, R.I. "Impact of Macroeconomic Policies Upon Agricultural Trade and International Agricultural Development". AJAE. Vol. 64, Dec. 1964, pp. 861-867.

Manitoba Department of Agriculture. "Farm Planning and Organization--1984 Crop Planning Guide", Winnipeg, Man., November, 1983.

McCalla, A.F. "A Duopoly Model of World Wheat Pricing", Journal of Farm Economics. Vol. 48, No. 3, Aug. 1966, pp. 711-727.

________. "Wheat and the Price Mechanism: or Duopoly Revisited and Abandoned", Seminar on Wheat. University of Manitoba, 1970.

________. "Impact of Macroeconomic Policies Upon Agricultural Trade and International Agricultural Development", AJAE. Vol. 64, Dec. 1982, pp. 861-868.

McCleary, R. and R.A. Hay, Jr. Applied Time Series Analysis for the Social Sciences. Beverly Hills: Sage Publications, Inc., 1980.

Mundell, R.A. International Economics. New York: MacMillan, 1968.

Officer, L.H. "Purchasing Power Parity Theory of Exchange Rates: A Review Article", IMF Staff Papers. Vol. 23, Mar. 1976, pp. 1-60.

________. "Effective Exchange Rates and Price Ratios Over the Long Run: A Test of Purchasing-Power-Parity Theory", Canadian Journal of Economics, Vol. 13, May 1980, pp. 206-230.

Oleson, B.T. "Price Determination and Market Share Formation in the International Wheat Market", unpublished Ph.D. thesis. University of Minnesota, Aug. 1979.

Orcutt, G.H. "Measurement of Price Elasticities in International Trade", Review of Economics and Statistics. Vol. 32, 1950, pp. 117-132.

Reddaway, W.B. "Limitations of the Law of One Price", Cambridge Journal of Economics. Vol. 6, 1982, pp. 79-84

Richardson, J.D. "Some Emperical Evidence of Commodity Arbitrage and the Law of One Price", Journal of International Economics, Vol. 8, 1978, pp. 341-351.

Robinson, H.L. Canada's Crippled DOllar: An Analysis of International Trade and Our Troubled Balance of Payments. Toronto: James Lorimer & Co. in association with the Canadian Institute for Economic Policy, 1980.

Santomero, A.M. and J.J. Seater. "The Inflation-Unemployment Trade-off", Journal of Economic Literature. Vol. 16, 1978, pp. 499-544.

SAS Institute Inc. SAS/ETS Users Guide. Cary, N.C.: SAS Institute Inc., 1982.

Schmitz, A., A.F. McCalla, D.O. Mitchell and C.A. Carter. Grain Export Cartels. Cambridge, Mass.: Balinger Publishing Co., 1981.

Schuh, E.G. "The Exchange Rate and U.S. Agriculture", AJAE. Vol. 56, Feb. 1974, pp. 1-12.

________. "The New Macroeconomics of Agriculture", AJAE. Vol. 56, Feb. 1984, pp. 1-12.

Statistics Canada. Consumer Prices and Price Indexes. Ottawa, Catalogue Number 62-004, various issues.

________. Exports by Commodity. Ottawa, Catalogue Number 65-004, December, 1983.

________. Farm Cash Receipts. Ottawa, Catalogue Number 21-001, Feb. 1984.

________. Farm Input Price Indexes. Ottawa, Catalogue Number 62-004, various issues.

________. Farm Net Income - 1983. Ottawa, Catalogue Number 21-202, 1984.

________. Grain Trade of Canada. Ottawa, Catalogue Number 22-201, various issues.

________. Imports by Commodity. Ottawa, Catalogue Number 65-007, December, 1983.

Thiel, H. and A.L. Nagar. "Testing the Independence of Regressive Disturbances", Journal of the American Statistical Association. Vol. 56, 1961.

Thiessen, G.G. "The Canadian Experience with Monetary Targeting", a paper presented to the International Conference on Monetary Targeting. New York, May 2-5, 1983.

Tobin, J. Asset Accumulation and Economic Activity. Chicago: University of Chicago Press, 1980.

U.S.D.A. Wheat Situation. Washington, various issues.

________. Wheat Outlook and Situation. Washington, various issues.

U.S. Bureau of Commerce. Statistical Abstracts of the United States 1985. Washington D.C.: U.S. Government Printing Office, 1984.

Vellianitis-Fidas, A. "The Impact of Devaluation on U.S. Agricultural Exports", Agricultural Economics Research. Vol. 28, No. 3, July 1976, pp. 107-116.

Weiss, A.A. and A.P. Anderson, "Estimating Time Series Using Relevent Forecast Evaluation Critereon", Journal of the Royal Statistical Society, Vol. 147, March, 1984, pp. 484-487.

White, K.F. Shazam: An Econometric Computer Program. Houston: Rice University Press, 1979.

APPENDIX A

DATA USED IN THE ANALYSIS

Table A1

Wheat Market Data

Crop Years	Canadian Wheat Price[a] (Cdn. $/tonne)	U.S. Wheat Price[b] (U.S. $/tonne)	Exchange Rate[c] (Cdn. $/U.S. $)
1969/70	68	61	1.016
1970/71	67	64	1.015
1971/72	66	63	0.999
1972/73	99	93	0.933
1973/74	204	190	0.985
1974/75	205	199	1.001
1975/76	193	185	1.001
1976/77	143	136	1.020
1977/78	151	129	1.108
1978/79	191	151	1.170
1979/80	236	186	1.168
1980/81	272	210	1.189
1981/82	244	184	1.219
1982/83	235	174	1.232
1983/84	238	176	1.260

[a]Price of # 1 C.W.R.S. wheat at 13.5 percent protein in store at Vancouver. International Wheat Council, World Wheat Statistics, London, various issues.

[b]Price of # 2 D.N.S. wheat at 14 percent protein in store at the Pacific Ports. International Wheat Council, World Wheat Statistic, London, various issues.

[c]Bank of Canada, Bank of Canada Review (Ottawa: Bank of Canada), Table 65, various issues.

Table A1 (Continued)

Crop Years	Canadian Seeded Area[a] ('000 hectares)	Canadian Wheat Yields[a] ('00 kg/ hectare)	Canadian Wheat Production[a] ('000 tonnes)	Canadian Ending Stocks[a] ('000 tonnes)	Canadian Domestic Demand[b] ('000 tonnes
1969/70	10,104	18.4	18,267	27,452	4,568
1970/71	5,052	17.9	9,024	19,980	4,650
1971/72	7,854	18.4	14,413	15,887	4,786
1972/73	8,640	16.8	14,515	9,945	4,765
1973/74	9,430	17.1	16,162	10,089	4,572
1974/75	8,934	14.9	13,304	8,038	4,576
1975/76	9,474	18.0	17,081	7,979	4,804
1976/77	11,252	21.0	23,587	13,318	4,812
1977/78	10,114	19.6	19,862	12,115	5,052
1978/79	10,584	20.0	21,145	14,911	5,265
1979/80	10,488	16.4	17,184	10,721	5,485
1980/81	11,098	17.3	19,292	8,570	5,181
1981/82	12,427	20.0	24,803	9,758	5,168
1982/83	12,554	21.3	26,790	10,098	5,082
1983/84	13,697	19.6	26,914	11,212	5,300

[a]International Wheat Council, World Wheat Statistics, London various issues.

[b]Canada Grains Council, Canadian Grain Industry Statistical Handbook (Winnipeg: Canada Grains Council), various issues.

Table A1 (Continued)

Crop Years	Canadian Wheat Exports[a] ('000 tonnes)	U.S. Wheat Exports[a] ('000 tonnes)	Total Wheat Trade[a] ('000 tonnes)	Canadian Population[b] ('000)	World Population[c] ('000)
1969/70	9,430	16,491	45,709	21,182	3,546
1970/71	11,846	20,085	45,423	21,465	3,616
1971/72	13,720	17,200	45,499	21,710	3,686
1972/73	15,692	32,223	61,949	21,942	3,758
1973/74	11,446	31,271	57,008	22,235	3,831
1974/75	10,770	28,277	57,175	22,567	3,905
1975/76	12,336	31,921	65,063	22,884	3,951
1976/77	13,436	25,841	59,689	23,158	4,026
1977/78	16,040	30,588	61,986	23,417	4,182
1978/79	13,084	32,496	70,264	23,645	4,258
1979/80	15,889	37,421	82,153	23,912	4,335
1980/81	16,262	41,095	84,747	24,221	4,437
1981/82	18,447	48,253	97,285	24,512	4,513
1982/83	21,368	41,068	94,764	24,784	4,591
1983/84	20,500	38,781	96,831	25,016	4,670

[a]International Wheat Council, World Wheat Statistics, London, various issues.

[b]Bank of Canada, Bank of Canada Review (Ottawa: Bank of Canada), various issues.

[c]Food and Agriculture Organization of the United Nations, F.A.O. Production Yearbook (Rome: Food and Agriculture Organization), various issues.

Table A 2

Seed Price Data

Crop Year	Price Index for Western Canadian Seed
1969/70	102.2
1970/71	94.0
1971/72	94.3
1972/73	89.4
1973/74	112.6
1974/75	242.6
1975/76	293.9
1976/77	220.8
1977/78	215.0
1978/79	222.3
1979/80	296.0
1980/81	344.3
191/82	318.3
1982/83	293.3
1983/84	303.2

[a]Statistics Canada, Farm Input Price Indexes, Catalogue Number 62-004, various issues.

Table A 3

Farm Input Price Data

Date (in quarters)		Fertilizer Price Index[a]	Chemical Price Index[a]	Petroleum Price Index[a]	Machinery Price Index[a]
1971	I	105.1	-	98.6	99.6
	II	105.6	-	99.2	100.2
	III	107.9	-	99.6	100.4
	IV	110.2	-	101.3	100.4
1972	I	111.4	-	102.0	102.4
	II	115.8	-	102.3	102.3
	III	115.5	-	102.8	103.3
	IV	117.7	-	103.1	103.4
1973	I	120.7	-	105.7	104.7
	II	122.3	-	105.9	105.1
	III	124.7	-	108.4	105.5
	IV	130.8	-	112.6	107.6
1974	I	141.6	-	114.1	111.1
	II	143.5	-	111.1	114.1
	III	165.9	-	123.2	119.2
	IV	183.9	-	125.2	128.2
1975	I	199.4	-	126.1	134.9
	II	200.8	-	130.2	136.1
	III	229.2	-	155.4	137.9
	IV	234.3	-	162.8	143.2
1976	I	231.8	-	164.9	146.5
	II	237.1	-	164.2	147.7
	III	211.7	-	164.8	147.7
	IV	210.9	-	172.7	152.6
1977	I	212.7	244.3	172.3	156.3
	II	219.4	241.7	180.9	157.7
	III	219.5	241.7	182.8	159.7
	IV	223.1	243.8	189.2	164.8
1978	I	223.1	247.0	190.5	171.1
	II	229.9	253.5	189.2	172.8
	III	241.2	255.7	189.8	175.2
	IV	243.5	257.5	191.8	183.5
1979	I	253.9	266.8	194.3	191.4
	II	266.0	281.6	195.2	194.2
	III	276.5	285.5	196.2	198.5
	IV	274.7	288.7	208.0	209.5

Table A 3 (Continued)

Date (in quarters)		Fertilizer Price Index[a]	Chemical Price Index[a]	Petroleum Price Index[a]	Machinery Price Index[a]
1980	I	300.4	317.5	213.6	217.6
	II	317.7	327.4	228.3	220.4
	III	320.5	330.1	240.5	224.4
	IV	310.1	334.9	263.1	230.8
1981	I	356.7	337.1	292.3	237.6
	II	366.6	359.9	317.0	244.4
	III	387.1	364.1	341.6	250.4
	IV	376.2	363.5	357.2	259.3
1982	I	350.2	387.7	359.9	265.3
	II	342.3	389.0	380.6	270.3
	III	347.3	391.2	381.9	259.8
	IV	327.7	394.7	407.7	264.1
1983	I	314.1	406.9	395.9	271.2
	II	320.0	412.2	410.4	278.4
	III	325.6	408.0	413.0	278.4
	IV	326.0	406.9	414.0	279.4
1984	I	329.7	418.9	423.2	285.0
	II	343.1	415.0	415.6	284.2

[a]Statistics Canada, Farm Input Price Indexes, Catalogue Number 62-004, various issues.

Table A4

Exchange and Inflation Rates

Date (in quarters)		Exchange Rate[a] (Cdn. $/U.S. $)	Inflation Rate[b] (CPI)
1971	I	100.85	98.1
	II	101.25	99.4
	III	101.58	100.9
	IV	100.24	101.6
1972	I	100.30	102.8
	II	98.79	103.7
	III	98.30	105.8
	IV	98.88	106.8
1973	I	99.70	108.8
	II	100.00	111.3
	III	100.40	114.4
	IV	100.00	116.5
1974	I	98.00	119.3
	II	96.50	123.3
	III	98.10	127.0
	IV	98.60	130.5
1975	I	99.90	133.3
	II	102.20	136.2
	III	103.10	140.8
	IV	101.80	143.7
1976	I	99.50	145.6
	II	97.90	147.8
	III	97.80	150.0
	IV	99.20	152.2
1977	I	103.00	155.5
	II	105.20	159.1
	III	107.00	162.6
	IV	110.20	166.1
1978	I	111.30	169.2
	II	112.70	173.3
	III	114.40	176.3
	IV	117.80	180.3
1979	I	118.60	184.6
	II	115.80	189.4
	III	116.60	193.1
	IV	117.50	194.4

Table A4 (Continued)

Date (in quarters)		Exchange Rate[a] (Cdn. $/U.S. $)	Inflation Rate[b] (CPI)
1980	I	116.40	202.0
	II	117.00	207.6
	III	115.90	213.5
	IV	118.40	219.5
1981	I	119.40	226.6
	II	121.20	233.7
	III	121.20	240.6
	IV	119.20	246.6
1982	I	120.90	252.8
	II	124.50	260.5
	III	125.00	266.1
	IV	123.10	270.4
1983	I	122.73	272.1
	II	123.11	275.9
	III	123.28	280.3
	IV	123.85	282.8
1984	I	125.54	286.2
	II	129.25	288.6

[a]Bank of Canada, Bank of Canada Review (Ottawa: Bank of Canada), Table 65, various issues.

[b]Statistics Canada, Consumer Prices and Price Indexes, Catalogue Number 62-010, various issues.

APPENDIX B

DETAILS ON WHEAT PRODUCTION COSTS

APPENDIX B

DETAILS ON WHEAT PRODUCTION COSTS

The wheat production costs used in this study are based on Manitoba Agriculture's estimate of average production costs on a 400 hectare grain farm.[1] The assumptions behind the cost estimates are outlined in this appendix.

1. Seeding Rate: 84.2 kg/hectare

2. Fertilizer Use: 79 kg of nitrogen and 37 kg of phosphorus per hectare

3. Chemical Control: Post emergent herbicides for broadleaf weeds, wild oats and millet

4. Machinery Operating Expense:

   Includes repairs, licences, insurance, etc. This estimate will vary from farm to farm depending on management, machine age, machine use and farm size. This figure averages between $20 and $45 per hectare.

5. Crop Insurance: Risk area # 6 at the 60 percent high dollar coverage rate plus hail insurance.

6. Miscellaneous: Overhead expenses such as hydro, telephone, accounting, etc., assumed to be $12.35 per hectare.

7. Interest on Operating:

   Interest charges on operating costs are calculated over a six month period at the prevailing chartered bank interest rate for prime business loans.

8. Machinery:

   Depreciation: Based on a straight line life of eight years and a 20 percent salvage rate.

---

[1]Manitoba Agriculture, "Farm Planning and Organization--1984 Crop Planning Guide", op.cit.

Investment: Opportunity cost is assumed to be 1.5 percent below the prime business loan rate.[2] In the case of wheat production, the capital invested in machinery is estimated at $346 per hectare.

Example: Depreciation: $\dfrac{\$346 - 69.2}{8 \text{ years}} = \$34.60/\text{hectare}$

Investment: $346 x .09 = $31.15/hectare

9. Labour and Management, Land Investment and Taxes:

These costs are not accounted for within the cost of production.

---

[2]From 1981 to 1984, the Chartered Bank interest rate on prime business loans averaged 14.61 percent. Over the same period, the average yield on 3 - 5 year Government of Canada Bonds was 13.11 percent. This results in a difference between the two rates of 1.5 percent. Bank of Canada, Bank of Canada Review (Ottawa: Bank of Canada, March, 1985), Table F1, pp. 582-583.

APPENDIX C

ECONOMETRIC TESTS

APPENDIX C

ECONOMETRIC TESTS

The equations contained in the final model will be tested for econometric acceptability. The Goldfeld-Quandt Test is used to detect heteroscedasticity; the Farrar-Glauber Test is used to uncover the presence and severity of multicollinearity; while the Durbin-Watson, Durbin-h, and Residual Regression Tests are used to examine autocorrelation.

Heteroscedasticity

As noted in Section 5.1.2, the term heteroscedasticity refers to error terms which are not constant in variance. The result is that the estimated coefficients are unbiased, but inefficient. Goldfeld and Quandt[3] derived a test for heteroscedasticity which is applicable to any equation where the number of observations is at least twice the number of parameters being estimated. The null hypothesis for the Goldfeld-Quandt Test is set up as follows:

H_0: the u's (error terms) are homoscedastic

H_A: the u's are heteroscedastic (with increasing variance)

The series of error terms being tested is separated into two groups. The normal procedure is to omit a certain number (c) of central observations; however, if there is only a limited number of degrees of freedom (as in the Trade Model), all observations can be used. The mean squared error terms for the two subsets are divided in order to derive an F* statistic.

---

[1]A. Koutsoyiannis, op.cit., pp. 185-186.

$$F^* = \frac{\Sigma e_2^2 \;/\; {(n-c)}/{2} - k}{\Sigma e_1^2 \;/\; {(n-c)}/{2} - k} = \frac{\Sigma e_2^2}{\Sigma e_1^2}$$

where:

n = the number of observations

k = the number of explanatory variables

c = the number of central obsertvations omitted

Σe_1^2 = mean squared error for the first subset

Σe_2^2 = mean squared error for the second subset

The calculated F* statistic follows an f distribution with $V_1 = V_2 = (n - c - 2k)/2$ degrees of freedom. If F* exceeds the critical F value we reject the null hypothesis and conclude that there is heteroscedasticity in the estimated equation. Table C1 presents the calculated and critical F statistics for each equation included in the final model.

Multicollinearity

Multicollinearity exists to some degree in all economic relationships. The problem is to determine whether the multicollinearity which is present is severe enough to bias the estimates. Farrar and Glauber consider collinearity between explanatory variables as a departure from an orthogonal state. The Farrar Glauber Test will be applied in order to detect the presence and severity of multicollinearity.[4]

The standard value of the determinant is calculated from the correlation coefficients. The closer the value of the determinant is to zero, the stronger the degree of multicollinearity. In order to statistically test the relationship, the following hypothesis is established.

H_0: the x's are orthogonal

H_A: the x's are not orthogonal

---

[4]Ibid., pp. 242-245.

Table C1

Goldfeld-Quandt Test for Heteroscedasticity

Dependent Variable	Equation Number	k	Mean Squared Error Σe_1^2	Σe_2^2	$F^* = \Sigma e_2^1 / \Sigma e_1^2$	F - critical $\alpha = .05$	$\alpha = .01$
HECT	5.8	2	9492098	6436923	0.7	5.05	11.0
UPU	5.11	2	1718	470	0.3	5.05	11.0
CPC	5.12	2	135	164	1.2	5.05	11.0
CEXPS	5.13	3	18761938	14431270	0.8	6.39	16.0
CEXPD	5.14	3	2960774	12729516	4.3	6.39	16.0
CDOMD	5.16	3	48554	179462	3.7	6.39	16.0
HECT	5.18	2	2660712	1862243	0.7	5.05	11.0
SEED	5.19	2	9944	1868	0.2	5.05	11.0
SEED[R]	5.20	2	9921	1883	0.2	5.05	11.0
FERT	5.25	3	924	3728	4.0[a]	2.69	4.16
RMACH[R]	5.26	2	.0036	.0042	1.2	2.60	3.96
PETR[R]	5.27	3	683	2164	3.2[a]	2.69	4.16
CHEM[R]	5.28	2	506	318	0.6	2.60	3.96

[a]Significant at the .05 level.

where:

the x's represent the explanatory variables.

An $*X^2$ statistic can be calculated which reflects the degree of multicollinearity present within the sample.

$$*X^2 = -\left[n - 1 - \frac{1}{6}(2k + 5)\right]\cdot\log\left[\text{Value of the Standardized Determinant}\right]$$

where:

n = the number of observations

k = the number of explanatory variables.

The calculated $*X^2$ statistic should follow a X^2 (chi-square) distribution with $V = 1/2[k(k-1)]$ degrees of freedom. If the calcuated $*X^2$ value exceeds the critical X^2 value, we reject the null hypothesis and accept that there is a significant degree of multicollinearity in the equation. The results of the Farrar-Glauber Test are presented in Table C2.

Autocorrelation

In terms of autocorrelation, there is no one single test which can be applied in every case. The Durbin-Watson Test[5] is appropriate for detecting first order autocorrelation so long as the set of explanatory variables does not include a lagged dependent variable. The null hypothesis for the Durbin-Watson test is set up as:

H_0: the u's are not correlated with a first order scheme.

H_A: the u's are correlated with a first order scheme.

Testing of the null hypothesis is carried out by comparing the calculated d* statistic with its theoretical value.

---

[5]Ibid., pp. 212-216.

Table C2

Farrar-Glauber Test for Multicollinearity

Dependent Variable	Equation Number	k	Value of the Std. Determinant	*X^2	X^2 - critical = .05	= .10
HECT	5.8	2	0.861	0.75	3.84	6.63
UPU	5.11	2	0.865	0.72	3.84	6.63
CPC	5.12	2	0.804	1.09	3.84	6.63
CEXPS	5.13	3	0.316	5.74	7.81	11.34
CEXPD	5.14	3	0.098	11.27[a]	7.81	11.34
CDOMD	5.16	3	0.222	7.30	7.81	11.34
HECTR	5.18	2	0.986	0.07	3.84	6.63
SEED	5.19	2	0.555	2.94	3.84	6.63
$SEED^R$	5.20	2.	0.543	3.07	3.84	6.63
FERT	5.25	3	0.583	11.03	7.81	11.34
$RMACH^R$	5.26	2	0.995	0.09	3.84	6.63
$PETR^R$	5.27	3	0.833	3.73	7.81	11.34
$CHEM^R$	5.27	2	0.998	0.02	3.84	6.63

[a]Significant at the .05 level.

$$d^* = \frac{\sum_{t=2}^{n} (e_t - e_{t-1})^2}{\sum_{t=1}^{n} e_t}$$

The critical regions for the Durbin-Watson Test are shown in Figure C1. Instead of having only one basis of comparison, the d* statistic is compared to four separate criterion.

1. If $d^* < d_L$, we reject the null hypothesis and accept that there is positive autocorrelation.

2. If $d^* > (4 - d_L)$, we reject the null hypothesis and accept that there is negative autocorrelation.

3. If $d_u < d^* < (4 - d_u)$, we accept the null hypothesis.

4. If $d_L < d^* < (4 - d_L)$, the test in inconclusive.

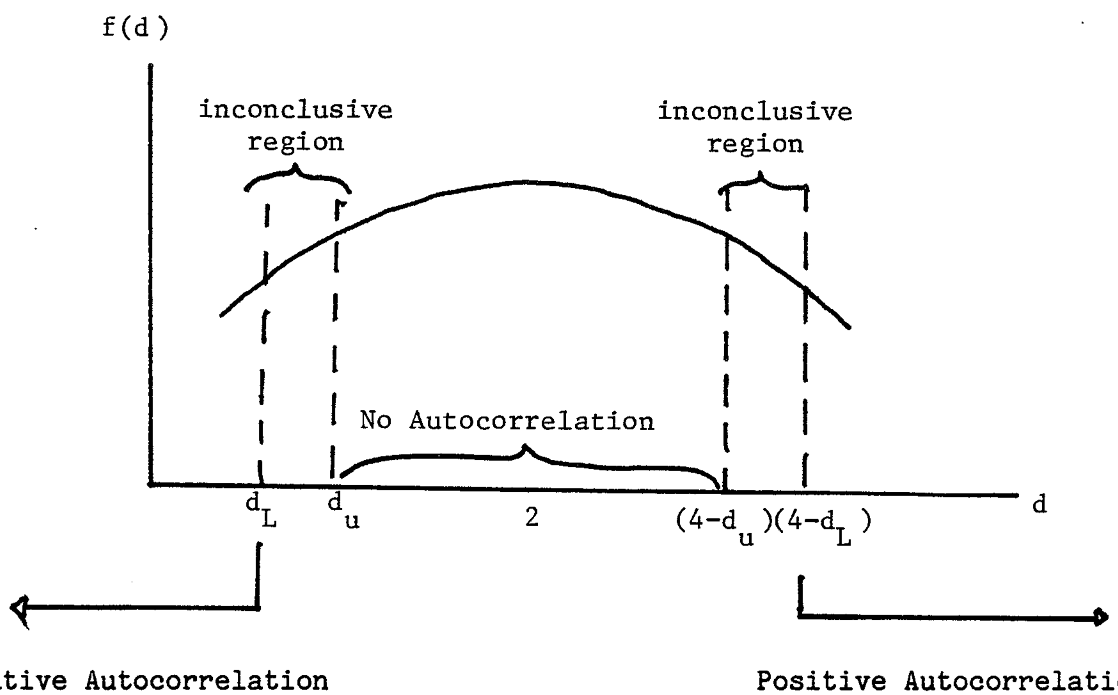

Figure C1

Critical Regions for the Durbin-Watson Test

Source: A. Koutsoyiannis, Theory of Econometrics, An Introductory Exposition of Econometric Methods, second edition (London: MacMillan Press Ltd., 1977), p. 215.

As previously mentioned, the Durbin-Watson Test is not capable of detecting autocorrelation when a lagged dependent variable is included in the set of explanatory variables. Recently, however, Durbin proposed a large sample test for autocorrelation when lagged dependent variables are present.[6] The test statistic for such cases is called the Durbin-h, and is calculated as follows:

$$h^{*} = \hat{p}\sqrt{\frac{n}{1-n\left[\text{var}\ (\alpha_2)\right]}}$$

where:

n = the number of observations

$\hat{p}$ = an estimate of first order autoregression

var ($\hat{\alpha_2}$) = the variance coefficient for the lagged dependent variable

For a large sample, the h* statistic has been shown to follow a standard normal distribution. Unlike the four comparisons which are required in the Durbin-Watson Test, the Durbin-h statistic (h*) needs only to be compared to a critical h value obtained from a standard normal table. If h* exceeds the critical-h value, we reject the null hypothesis and accept that there is autocorrelation in the equation.

The Durbin-Watson and Durbin-h Tests suffer from some serious drawbacks. In a small sample, the Durbin-h statistic has no validity. The Durbin-Watson Test remains valid within small samples, but its level of sensitivity has been questioned. Thiel and Nager,[7] and Hernshaw[8] have

---

[6] Damadar Gujarati, Basic Econometrics (New York: McGraw Hill Books, Inc., 1978), pp. 269-272.

[7] H. Thiel and A.L. Nagar, "Testing the Independence of Regressive Disturbances", Journal of the American Statistical Association, Vol. 56, 1961, pp. 793-806.

[8] R.C. Hernshaw, Jr., "Testing Single Equation Least Squares Regression Models for Autocorrelated Distrubances", Econometrica, Vol. 34, pp. 646-660.

argued that if d* falls within the inconclusive region, the null hypothesis should be rejected. In order to provide a more definitive test for autocorrelation, various functional forms of past errors will be regressed against current errors. Examples of some functional forms are shown below.

$$e_t = pe_{t-1} + v_t$$

$$e_t = pe_{t-1}^2 + v_t$$

$$e_t = p_1e_{t-1} + p_2e_{t-2} + v_t$$

$$e_t = p\sqrt{e_{t-1}} + v_t$$

If the individual estimates (p's) are found to be statistically significant and if the overall explanatory power (F-statistic) of the equation is also significant, we will reject the null hypothesis. Rejecting the null hypothesis leads us to conclude that autocorrelation is present in the form specified by the regression equation.

Given the above discussion, it is clear that the appropriate method for testing autocorrelation depends on the nature of the equation. Each of the equations included in the model will be examined using one or more of the aforementioned tests. Tables C3, C4 and C5 outline the respective results from the Durbin-Watson, Durbin-h and Residual Regression Tests.

Table C3

Durbin-Watson Test for Autocorrelation

Dependent Variable	Equation Number	n	k	d*	d_L	d_u	$4-d_L$	$4-d_u$
HECT	5.8	11	2	1.2[a]	.758	1.064	3.242	1.984
UPU	5.11	11	2	2.2[b]	.758	1.064	3.242	1.984
CPC	5.12	11	2	1.1[a]	.758	1.064	3.242	1.984
CEXPS	5.13	10	3	2.3[b]	.525	2.016	3.475	1.984
CEXPD	5.14	10	3	2.7[a]	.525	2.016	3.475	1.984

[a]The Durbin-Watson Test in inconclusive.

[b]Fail to reject the null hypothesis--conclude that there is no first order autocorrelation in the equation.

Table C4

Durbin-h Test for Autocorrelation

Dependent Variable	Equation Number	Durbin-h (h*)	h-critical (standard normal)
FERT	5.25	.96	1.645
RMACH[a]	--	2.96	1.645
PERT[b]	--	2.83	1.645
CHEM[c]	--	2.57	1.645

[a]This equation is adjusted for autocorrelation and included in the text as $RMACH^R$ (5.26).

[b]This equation is adjusted for autocorrelation and included in the text as $PERT^R$ (5.27).

[c]This equation is adjusted for autocorrelation and included in the text as $CHEM^R$ (5.28).

Table C5

Residual Regression Test for Autocorrelation

Dependent Variable	Equation Number	t-statistics				f-statistics	
		e_{t-1}	e_{t-1}^2	e_{t-2}	$\sqrt{e_{t-1}}$	calculated	critical (= .05)
HECT	5.8	1.06				1.13	4.84
			.54			0.29	4.84
		2.35[a]		3.63[a]		7.78[a]	4.10
					0.98	0.96	4.84
CPC	5.12	1.54				2.38	4.84
			0.63			0.40	4.84
		1.82[a]		1.01		1.70	4.10
					1.29	1.69	4.84
CEXPD	5.14	1.57				2.45	4.84
			0.77			0.60	4.84
		2.19[a]		1.50		2.50	4.10
					1.86[a]	3.47	4.84
CDOMD	5.16	0.16				0.26	4.84
			0.26			0.07	4.84
		0.18		0.32		0.06	4.10
					0.39	0.16	4.84
SEED	5.19	0.21				0.04	4.84
			2.27[a]			5.16[a]	4.84
		0.36		1.86[a]		1.76	4.10
					0.53	0.29	4.84

[a]Denotes statistical significance at the 5 percent level.

APPENDIX D

ESTIMATED RESULTS FOR THE INPUT COST MODEL

Table D1

Bivariate Fertilizer Model[a]

Univariate Fertilizer Model:

$d = 2,\ p = 1$

$$FERT_t = (1 + \underset{(3.54)}{.416^*}B)^{-1}(1 - 2B + B^2).a_t$$

Std. error = 14.85 $\quad {}^*X_{17} = 21.68$

Univariate Exchange Rate Model:

$d = 1,\ q = 1$

$$Ex_t = (1 + \underset{(4.67)}{.568^*}B)\ (1 - B)^{-1} \cdot b_t$$

Std. error = .015 $\quad {}^*X_{17} = 15.52$

Bivariate Fertilizer Model:

$FERT_t = f(EX_{t-1}) \quad d = 2,\ p = 1$

$$FERT_t = (1 - \underset{(1.58)}{159.55}B)(1 - B)(1 + \underset{(3.49)}{.459^*}B)^{-1}(1 - 2B + B^2)^{-1} \cdot EX_{t-1} + (1 + \underset{(3.49)}{.459^*}B)^{-1}(1 - 2B + B^2)^{-1} \cdot a_t$$

Std. error = 14.62 $\quad {}^*X_{17} = 21.62$

---

[a]Estimated coefficients are included in the equations, with the corresponding t-statistics shown in brackets. Parameters which are statistically significant at the .05 level are denoted by an asterisk. The variables are defined in Section 5.4.

Table D2

Bivariate Machinery Model[a]

<u>Univariate Machinery Model</u>:

d = 2, sd = 1, q = 1, sp = 1

$$MACH_t = (1 - \underset{(7.44)}{.772^*B} - \underset{(5.61)}{.731^*B^4})(1 - 2B + B^2)^{-1}(1 - b^4)^{-1} \cdot a_t$$

std. error = 3.47 $^*X_{16}$ = 11.06

<u>Univariate Exchange Rate Model</u>:

d = 2, q = 2

$$EX_t = (1 - \underset{(2.59)}{.340B^*} - \underset{(3.69)}{.486^*B})^{-1}(1 - 2B + B^2)^{-1} \cdot b_t$$

std. error = .016 $^*X_{16}$ = 14.35

<u>Bivariate Machinery Model</u>:

$MACH_t = f(EX_{t-4})$ d = 2, sd = 1, q = 1, sq = 1

$$MACH_t = (1 - \underset{(1.06)}{29.034^*B})(1 - B^4)^{-1} \cdot EX_{t-4} + (1 - \underset{(7.00)}{.759^*B} - \underset{(5.07)}{.693^*B^4})$$

$$(1 - 2B + B^2)^{-1}(1 - B^4)^{-1} \cdot a_t$$

std. error = 3.46 $^*X_{17}$ = 17.10

---

[a]Estimated coefficients are included in the equations, with the corresponding t-statistics shown in brackets. Parameters which are statistically significant at the .05 level are denoted by an asterisk. The variables are defined in Section 5.4.

Table D3

Bivariate Petroleum Model[a]

<u>Univariate Petroleum Model</u>:

$d = 2,\ q = 1$

$$PETR_t = (1 - \underset{(10.93)}{.861^{*}}B)(1 - 2B + B^2)^{-1}.a_t$$

std. error = 11.28 $\quad {}^{*}X_{17} = 18.88$

<u>Univariate Exchange Rate Model</u>:

$d = 1,\ p = 1$

$$EX_t = (1 - \underset{(3.35)}{.458^{*}}B)^{-1}(1 - B)^{-1}.b_t$$

std. error = .016 $\quad {}^{*}X_{17} = 20.33$

<u>Bivariate Petroleum Model</u>:

$PETR_t = f(EX_t) \quad d = 2,\ q = 1$

$$PETR_t = (1 - \underset{(1.92)}{54.78^{*}}B)(1 - B)(1 - 2B + B^2)^{-1}.EX_t + (1 - \underset{(20.25)}{1.037^{*}}B)$$

$$(1 - 2B + B^2)^{-1}.a_t$$

std. error = 11.12 $\quad {}^{*}X_{17} = 21.28$

---

[a]Estimated coefficients are included in the equations, with the corresponding t-statistics shown in brackets. Parameters which are statistically significant at the .05 level are denoted by an asterisk. The variables are defined in Section 5.4.

Table D4

Bivariate Chemical Model[a]

Univariate Chemical Model:

$d = 2,\ p = 2$

$$CHEM_t = (1 + \underset{(4.43)}{.698^*}B + \underset{(3.97)}{.639^*}B)^{-1}(1 - 2B + B^2)^{-1} \cdot a_t$$

std. error = 8.72 $\quad {}^*X_{18} = 23.18$

Univariate Exchange Rate Model:

$d = 1,\ q = 1$

$$EX_t = (1 + \underset{(2.38)}{.424^*}B)(1 - B)^{-1} \cdot b_t$$

std. error = 0.18 $\quad {}^*X_{17} = 15.09$

Bivariate Chemical Model:

$CHEM_t = f(EX_t) \quad d = 2,\ p = 2$

$$CHEM_t = (1 - \underset{(.30)}{23.077}B)(1 + \underset{(4.40)}{.708^*}B + \underset{(3.96)}{.648^*}B)^{-1}(1 - 2B + B^2)^{-1} \cdot EX_t +$$

$$(1 + \underset{(4.40)}{.708^*}B + \underset{(3.96)}{.648^*}B)^{-1}(1 - 2B + B^2)^{-1} \cdot a_t$$

std. error = 8.865 $\quad {}^*X_{17} = 16.69$

---

[a]Estimated coefficients are included in the equations, with the corresponding t-statistics shown in brackets. Parameters which are statistically significant at the .05 level are denoted by an asterisk. The variables are defined in Section 5.4.

Table D5

Fertilizer Price Regression Results[a]

Dependent Variable Y_t	Independent Variables: Intercept	Y_{t-1}	Y_{t-2}	Ex_t-Ex_{t-1}	Ex_t-Ex_{t-2}	I_t-I_{t-1}	I_t-I_{t-2}	R^2	Durbin-h
FERT	8.549 (1.68)	.966* (35.41)		43.436 (.42)		4.045* (3.33)		.98	.96
FERT	17.569* (2.51)		.828* (20.87)		25.833 (.28)		4.274* (4.19)	.96	4.77
$FERT^R$	34.872 (2.02)		.731* (10.44)		40.811 (.48)		5.224* (4.54)	.72	****
FERT	.116 (1.60)	.914* (16.99)		.069 (.12)				.86	1.29
FERT	.252* (2.41)		.813* (10.44)		.108 (.21)			.70	5.64
$FERT^R$	.916* (4.81)		.293* (2.10)		.175 (.42)			.40	****

[a]Calculated t-statistics are shown in brackets. Variables which are statistically significant at the .05 level are denoted by an asterisk. The superscript R represents equations which have been adjusted for first order autocorrelation.

Table D6

Machinery Price Regression Results[a]

Dependent Variable Y_t	Independent Variables: Intercept	Y_{t-1}	Y_{t-2}	Ex_t-Ex_{t-1}	Ex_t-Ex_{t-2}	I_t-I_{t-1}	I_t-I_{t-2}	R^2	Durbin-h
MACH	1.803 (1.13)	1.003* (100.74)		5.720 (.18)		.477 (1.40)		.99	1.77
MACH	2.918 (1.22)		.998* (61.59)		7.692 (.26)		.642* (2.14)	.99	2.96
$MACH^R$	6.254 (1.30)		1.011* (35.13)		25.697 (.78)		-.192 (.47)	.96	****
RMACH	.110 (1.66)	.890* (13.41)		.058 (.37)				.79	1.87
$RMACH^R$	.207 (2.34)	.792* (8.93)	.078 (.49)					.87	****
RMACH	.261* (2.66)		.739* (7.53)	.069 (.48)				.56	4.85
$RMACH^R$	1.361* (9.86)		-.368* (2.74)		.122 (1.17)			.85	****

[a]Calculated t-statistics are shown in brackets. Variables which are statistically significant at the .05 level are denoted by an asterisk. The superscript R represents equations which have been adjusted for first order autocorrelation.

Table D7

Petroleum Price Regression Results[a]

Dependent Variable Y_t	Intercept	Y_{t-1}	Y_{t-2}	Ex_t-Ex_{t-1}	Ex_t-Ex_{t-2}	I_t-I_{t-1}	I_t-I_{t-2}	R^2	Durbin-h
	Independent Variables								
PETR	-.7503 (1.63)	.991* (70.53)		9.899 (.12)		3.724* (4.50)		.99	3.15
$PETR^R$	-6.399* (2.84)	.995* (110.09)		-10.987 (.18)		3.712* (6.49)		.99	****
PETR	-11.892* (3.15)		.989* (62.90)		15.207 (.28)		3.635* (7.42)	.99	2.83
$PETR^R$	-9.58 (1.66)		.981* (42.19)		38.609 (.64)		3.499* (5.41)	.97	****
PETR	.024 (.58)	.986* (27.87)		.271 (.67)				.94	.84
PETR	.029* (.54)		.988* (20.67)		.241 (.73)			.90	4.52
$PETR^R$	.687* (3.94)		.413 (3.12)		.475 (1.69)			.48	****

[a]Calculated t-statistics are shown in brackets. Variables which are statistically significant at the .05 level are denoted by an asterisk. The superscript R represents equations which have been adjusted for first order autocorrelation.

Table D8

Chemical Price Regression Results[a]

Dependent Variables Y_t	Independent Variables: Intercept	Y_{t-1}	Y_{t-2}	Y_{t-3}	Y_{t-4}	Ex_{t-1}	I_t	I_t-I_{t-1}	I_t-I_{t-2}	I_t-I_{t-3}	I_t-I_{t-4}	R^2	Durbin-h
CHEM	8.807 (.08)	.626* (2.65)				3.67 (.03)	.517 (1.30)					.98	1.31
CHEM	8.765 (.90)	.971* (37.00)						1.617 (1.87)				.98	1.08
CHEM	14.515 (1.21)	.957* (29.30)							1.379* (2.18)			.97	.71
CHEM	17.102 (1.48)		.945* (29.61)							1.424* (3.17)		.97	2.25
$CHEM^R$	18.814 (1.11)		.942* (20.06)							1.361* (2.26)		.93	****
CHEM	16.147 (1.23)			.935 (25.05)							1.602* (3.87)	.96	2.57
$CHEM^R$	17.993 (.87)			.920* (15.95)							1.705* (2.84)	.90	****

[a]Calculated t-statistics are shown in brackets. Variables which are statistically significant at the .05 level are denoted by an asterisk. The superscript R represents equations which have been adjusted for first order autocorrelation.

APPENDIX E

FOCUS RESULTS

Table E1

Interest Rate Forecasts from the Focus Model

Quarter		Scenarios								
		Base	1A	1B	2A	2B	3A	3B	4A	4B
1984	I	11.167	11.167	11.167	11.167	11.167	11.167	11.167	11.167	11.167
	II	12.000	12.000	12.000	12.000	12.000	12.000	12.000	12.000	12.000
	III	12.822	12.588	13.062	12.588	13.063	13.284	12.360	11.414	14.114
	IV	13.259	12.907	13.615	12.908	13.614	13.960	12.557	12.023	14.356
1985	I	13.171	12.769	13.578	12.783	13.563	13.996	12.345	12.544	13.770
	II	13.125	12.710	13.546	12.729	13.525	14.015	12.235	12.327	13.890
	III	13.101	12.694	13.515	12.482	13.792	14.024	12.178	12.395	13.774
	IV	13.089	12.702	13.481	12.381	13.807	14.029	12.149	12.940	13.288
1986	I	12.330	11.971	12.694	11.631	13.055	13.279	11.380	12.270	12.438
	II	11.936	11.602	12.275	11.238	12.644	12.890	10.982	11.806	12.090
	III	11.732	11.423	12.047	10.839	12.639	12.688	10.776	11.768	11.751
	IV	11.627	11.341	11.918	10.671	12.597	12.584	10.669	11.674	11.629
1987	I	11.092	10.827	11.316	10.154	12.043	12.049	10.133	10.791	11.380
	II	10.841	10.567	11.066	9.919	11.724	11.772	9.855	10.683	10.959
	III	10.670	10.439	10.909	9.596	11.761	11.629	9.711	10.554	10.809
	IV	10.596	10.378	10.822	9.470	11.736	11.554	9.637	10.088	11.082

Table E2

Exchange Rate Forecasts from the Focus Model

Quarter		Scenarios								
		Base	1A	1B	2A	2B	3A	3B	4A	4B
1984	I	1.255	1.255	1.255	1.255	1.255	1.255	1.255	1.255	1.255
	II	1.293	1.293	1.293	1.293	1.293	1.293	1.293	1.293	1.293
	III	1.314	1.317	1.310	1.317	1.310	1.307	1.321	1.340	1.288
	IV	1.315	1.322	1.308	1.321	1.308	1.302	1.327	1.341	1.289
1985	I	1.307	1.317	1.297	1.317	1.297	1.284	1.328	1.333	1.281
	II	1.307	1.318	1.296	1.317	1.296	1.281	1.332	1.333	1.281
	III	1.307	1.318	1.296	1.321	1.292	1.281	1.332	1.333	1.281
	IV	1.307	1.320	1.293	1.328	1.285	1.273	1.341	1.333	1.281
1986	I	1.302	1.317	1.286	1.329	1.274	1.260	1.344	1.328	1.276
	II	1.302	1.318	1.286	1.329	1.275	1.258	1.347	1.328	1.276
	III	1.302	1.318	1.285	1.333	1.270	1.256	1.350	1.328	1.276
	IV	1.302	1.320	1.284	1.341	1.262	1.251	1.355	1.251	1.276
1987	I	1.297	1.316	1.279	1.340	1.252	1.241	1.353	1.323	1.271
	II	1.297	1.315	1.279	1.341	1.252	1.239	1.358	1.323	1.271
	III	1.297	1.315	1.279	1.346	1.247	1.238	1.359	1.323	1.271
	IV	1.297	1.315	1.279	1.353	1.239	1.235	1.362	1.323	1.271

Table E3

Inflation Forecasts from the Focus Model

Quarter		Base	1A	1B	2A	2B	3A	3B	4A	4B
		Scenarios								
1984	I	2.5390	2.5390	2.5390	2.5390	2.5390	2.5390	2.5390	2.5390	2.5390
	II	2.5660	2.5660	2.5660	2.5660	2.5660	2.5660	2.5660	2.5660	2.5660
	III	2.6455	2.6295	2.6260	2.6295	2.6260	2.6245	2.6315	2.6400	2.6155
	IV	2.6110	2.6135	2.6080	2.6135	2.6080	2.6035	2.6170	2.6240	2.5975
1985	I	2.6520	2.6575	2.6470	2.6575	2.6470	2.6395	2.6645	2.6690	2.6355
	II	2.6910	2.6980	2.6840	2.6975	2.6850	2.6745	2.7075	2.7130	2.6700
	III	2.7470	2.7545	2.7390	2.7565	2.7370	2.7270	2.7665	2.7720	2.7215
	IV	2.7210	2.7305	2.7105	2.7345	2.7060	2.6940	2.7475	2.7465	2.6950
1986	I	2.7655	2.7775	2.7525	2.7840	2.7460	2.7305	2.8005	2.7940	2.7360
	II	2.8015	2.8145	2.7875	2.8220	2.7795	2.7620	2.8415	2.8325	2.7700
	III	2.8565	2.8720	2.8415	2.8835	2.8295	2.8120	2.9025	2.8900	2.8235
	IV	2.8290	2.8460	2.8115	2.8625	2.7940	2.770	2.8820	2.8620	2.7960
1987	I	2.8985	2.9175	2.8790	2.9375	2.8575	2.8385	2.9585	2.9330	2.8630
	II	2.9395	2.9595	2.9190	2.9830	2.8935	2.8735	3.0065	2.9760	2.9025
	III	3.0005	3.0220	2.9795	3.0510	2.9480	2.9305	3.0725	3.0380	2.9635
	IV	2.9760	2.9985	2.9540	3.0340	2.9145	2.9000	3.0530	3.0115	2.9400

APPENDIX F

DESCRIPTION OF THE BASE SCENARIO

This appendix provides a detailed description of the baseline projections for the Focus-ARIMA and Focus-Regression Models. The macroeconomic variables forecasted by the Focus Model from 1984 to 1987 are depicted in Figure F1. Throughout this four-year period, the money supply (M1) is set so as to increase at a constant rate of 6 percent per year. The interest rates[1] which result from changes in the demand and supply of money are shown to increase from 11.17 percent in the first quarter of 1984 to a peak of 13.26 percent by the end of that year. Given that the money supply is increasing at a constant rate, the upward pressure on interest rates stems from an increase in the demand for money. During 1984, there was a release of pent-up consumer demand as well as a good deal of upward pressure on interest rates as a consequence of government deficit financing. The results of the Focus Model predict that the government deficit will rise to $29 billion by the end of 1985.

Returning to Figure F1, we see that interest rates are predicted to decline only slightly during 1985. However, by the first quarter of 1986 interest rates begin a protracted decline, falling to a low of 10.67 percent by the fourth quarter of 1987. Paralleling this decline in interest rates is a reduction in government deficits. The Focus model predicts that by the end of 1987 the government deficit will decline to $22 billion, down $7 billion from its 1984 level.

The exchange rate movements recorded in Figure F1 display a pattern which is similar to that of interest rates. The Cdn./U.S. exchange rate increases from 1.255 to a predicted high of 1.315 by the end of 1984.

---

[1]The interest shown in Figure F1 is the rate for chartered bank loans to prime business customers and is related to the prime interest rate by a constant percentage adjustment.

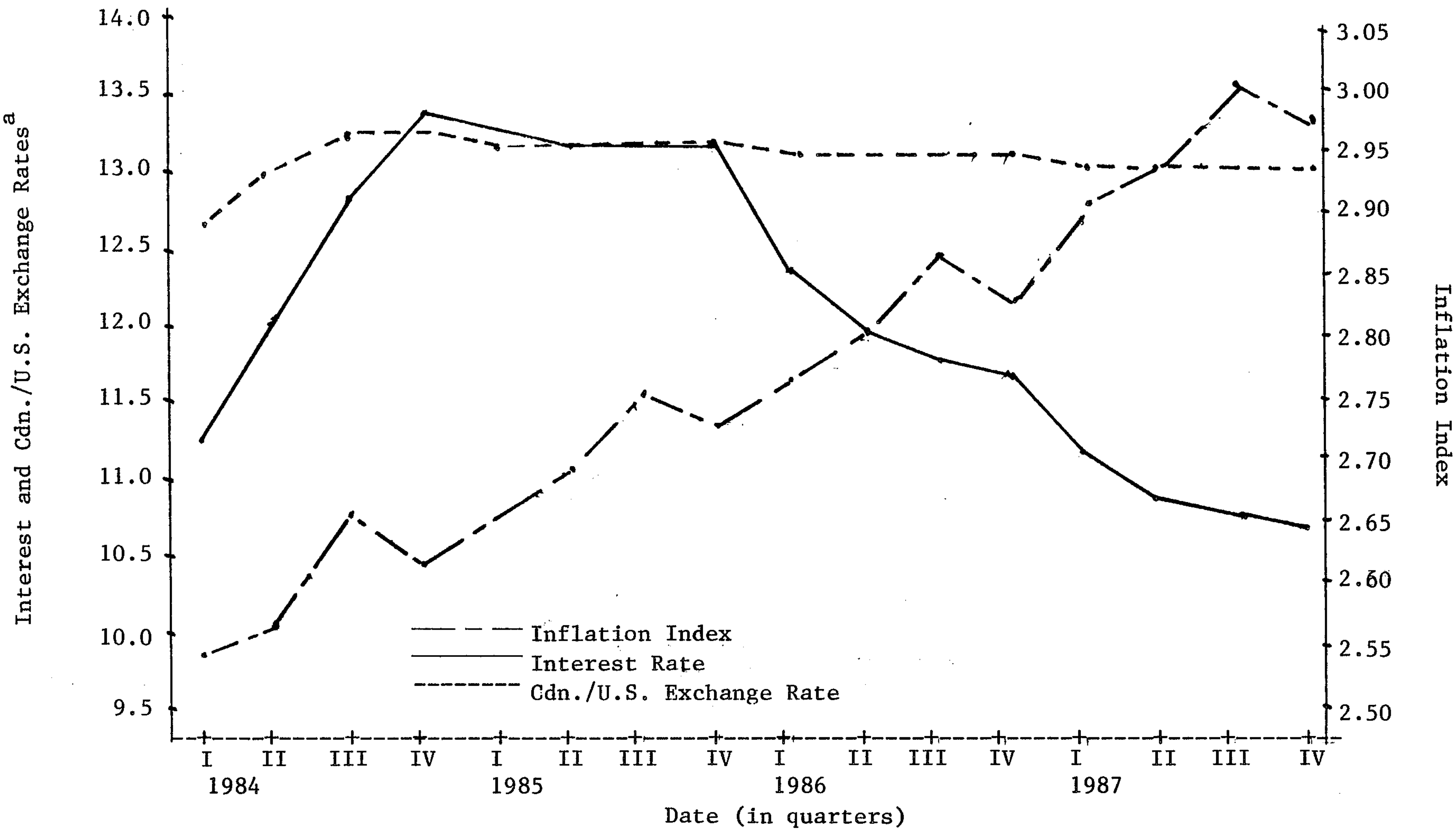

Figure F1

Focus Model Forecasts from 1984 to 1987

---

[a] In order to fit all of the series on the same graph, the Cdn./U.S. exchange rate has been multiplied by a factor of 10.

As Canadian interest rates increase, investment capital flows into Canada, increasing the demand for Canadian dollars. If this was the only consequence of higher interest rates, the Cdn./U.S. exchange rate would decline rather than increase. However, when interest rates rise, the debt payments flowing out of Canada also increase. In addition, the Focus Model predicts that during 1984 there will be an increase in consumer and investment demand, as well as concerted effort to rebuild inventory levels depleted during the recession of the early 1980's. With an increased proportion of total production going to satisfy domestic demand, the amount of Canadian product moving into the export market declines. Meanwhile, imports continue to rise since they are tied to the income level. Increased debt servicing and reductions in the balance of merchandise trade outpace the inflow of foreign capital. The end result is that the supply of Canadian dollars exceeds demand and the Cdn./U.S. exchange rate appreciates.

Beginning in the first quarter of 1985, the Cdn./U.S. exchange rate experiences a stepwise decline. The increase in Cdn./U.S. exchange rates, which was recorded during 1984, has a lagged impact on trade. It is only after a lag of three to four quarters that Canadian exports begin to react to the change in the exchange rate. This time lag is necessary in order for manufacturers to expand production and increase inventories.

The inflation index shown in Figure F1 is comprised of the price of consumer services and durables. Unlike interest and exchange rates, the inflation index follows a fairly constant trend. In the first quarter of 1984, the inflation index is at 2.539 and by the fourth quarter of 1987, the index is predicted to increase to 2.976. This is equivalent to an average annual inflation rate of 4.3 percent.

The exchange rate variable predicted by the Focus Model[2] and the exogenous variables included in Table 3 of the text are fed into the Trade Model. The simulated results for the 1984/85 to 1986/87 period are displayed in Table F1. As we move from 1983/84 to 1984/85, the first variable that should be discussed is the number of hectares seeded. The level of prices and deliveries experienced during the 1983/84 crop year are expected to result in 13.328 million hectares of wheat in 1984. Total production from this seeded area is predicted to be in the order of 26.735 million tonnes. When current production is added to the 11.212 million tonnes of wheat carried over from 1983/84, total Canadian supply stands at 37.947 million tonnes.

Compared to year earlier levels, Canadian wheat supply has increased by .936 million tonnes. This increase serves to moderate the U.S. price of wheat, which rises by only $.72 to $176.72 per tonne (as expressed in U.S. dollars). Although U.S. prices are expected to remain fairly stable, Canadian wheat prices (as expressed in Canadian dollars) are shown to rise by $15.78 for a total of $253.78 per tonne. The reason that Canadian wheat prices rise while U.S. prices remain constant is that the Cdn./U.S. exchange rate increases from 1.260 to 1.311.

Increases in the price and supply of Canadian wheat cause Canadian export levels to rise. Although the increase in price has a negative impact on demand, increases in the other variables which influence Canada's export demand, namely, the Cdn./U.S. exchange rate and the level of world wheat exports override the negative price effect. The end result is that the estimated export demand for Canadian wheat increases from 20.5

---

[2]Given that the Focus Model is quarterly and the Trade Model is annual, the Cdn./U.S. exchange rate is converted to a crop year basis.

Table F1

Trade Model Results for the Base Scenario

(Year) Crop Year	(CUEX) Cdn./U.S. Ex-Change Rate	(HECT) Hectares Seeded	(CPROD) Cdn. Wheat Production	(CSUP) Cdn. Wheat Supply	(UPU) U.S. Wheat Price	(CPC) Cdn. Wheat Price
		('000 ha)	.......('000 t).......		(U.S. $/t)	(Cdn. $/t)
1984/85	1.311	13,238	26,735	37,947	176.72	253.78
1985/86	1.305	13,823	28,254	40,115	168.04	243.01
1986/87	1.300	13,504	27,932	40,633	174.08	248.65

(Year) Crop Year	(CEXPS) Cdn. Export Supply	(CEXPD) Cdn. Export Demand	(CEXP) Cdn. Wheat Exports	(CDOMD) Cdn. Domestic Demand	(CESTK) Cdn. Ending Stocks
	..........................('000 t)..........................				
1984/85	20,662	20,768	20,715	5,372	11,861
1985/86	21,745	22,123	21,934	5,480	12,701
1986/87	21,989	22,903	22,446	5,580	12,608

to 20.768 million tonnes. Once the predictions for export demand and export supply have been averaged, the total volume of wheat moving out of Canada is estimated to be 20.715 million tonnes. After 5.372 million tonnes of domestic demand has been added to export movement the total disposition of Canadian wheat stands at 26.087 million tonnes. Finally, by subtracting total disposition (domestic plus export demand) from total Canadian wheat supply we are left with a carryover of 11.861 million tonnes.

As we progress from 1984/85 to 1985/86, the area seeded to wheat increases by .585 million hectares. This increase is the direct result of higher wheat prices and deliveries during 1984/85. When the new estimate for seeded area is multiplied by a predicted average yield of 2.044 tonnes per hectare (Table 3 in the text), Canadian wheat production reaches 28.254 million tonnes. The combination of 1984/85 carryover and current production serves to increases the total Canadian wheat supply by 2.168 million tonnes.

Despite the predicted increase in world demand for wheat (as embodied in the world population variable), the increase in Canadian wheat supply exerts a downward pressure on the U.S. price. The U.S. export price for wheat (as expressed in U.S. dollars) is estimated to be $168.04 per tonne in 1985/86, down $8.68 from its 1984/85 level. Meanwhile, the Cdn./U.S. exchange rate (as predicted by the Focus Model) falls to 1.305. The combined effect of a reduced U.S. price, and a drop in the Cdn./U.S. exchange rate pushes the Canadian domestic price of wheat down to $243.01 per tonne.

As the decline in the price of Canadian wheat works its way through the system, export supply and export demand increase to 21.745 and 22.123 million tonnes, respectively. Export demand increases due to the decline in the Canadian price of wheat and the increase in the predicted volume of world wheat exports. The Cdn./U.S. exchange rate, which represents a third variable in Canada's export demand equation, exerts a negative impact. All three of the variables included in the export supply equation contribute to increased volume, with price, production and carryover all producing a positive effect. When export supply and export demand are averaged and added to Canada's domestic demand, the total 1985/86 disposition of wheat is 27.414 million tonnes.

The final simulation year is 1986/87. Referring once again to Table F1, we see that the number of hectares seeded to wheat is predicted to fall from 13.823 million in 1985/86 to 13.504 million in 1986/87. The price reduction which occurrs during the 1985/86 crop year appears to overshadow the positive impact of increased sales. The decline in seeded area subsequently affects both production and supply. For the 1986/87 crop year, Canadian wheat production is forecast to fall to 27.932 million tonnes, while supply increases to 40.633 million tonnes. The .518 million tonne increase in supply can be derived by subtracting the .322 million tonne loss in production from the .84 million tonne increase in 1985/86 carryover.

Reduced Canadian wheat supplies and rising world population leads to a $6.04 per tonne increase in the estimated price of U.S. wheat (as expressed in U.S. dollars). The rise in the U.S. price of wheat counters the decline in the Cdn./U.S. exchange rate, with the Canadian price appreciating to $248.35 per tonne. Once again, export demand and export supply increase as average exports reach 22.903 million tonnes. Domestic demand for wheat records its third consecutive gain rising to 5.58 million tonnes. Canadian wheat stocks are predicted to decline slightly during the final simulation year, ending up at 12.608 million tonnes.

Turning from the Trade Model to the Input Price Model, the Cdn./U.S. exchange rate will once again be used as an input variable. In addition, the inflation and interest rate variables predicted by the Focus Model will be used to generate miscellaneous costs and interest expense. The simulated results for the ARIMA Input Price Model are presented in Table F2.

Given that the cost estimates for the 1984/85 crop year are assumed to be known with certainty (Table 2 in the text) they will not change from one scenario to the next. As for the 1985/86 and 1986/87 estimates, production costs will depend directly on the price of the input variables. Between 1984/85 and 1985/86, the per hectare cost of wheat production is forecast to increase by 8.2 percent for a total cost of $299.99 (Table F2). Each of the individual cost components records an increase. Fuel costs experience the greatest increase (13.3 percent), while seed costs display the lowest increase rising by less than 1 percent. Fertilizer costs increase by 9.8 percent, chemicals 2.6 percent, and miscellaneous expenses by 4.9 percent. Meanwhile, interest and machinery expenses (depreciation and investment) are predicted to increase by 6.4 and 5.8 percent, respectively.

When we compare 1985/86 to the following year, total production costs are forecast to rise by 4.3 percent. The estimated total cost of $313.00 per hectare can be divided into $21.34 for seed (up 2 percent), $78.72 for fertilizer (up 11.4 percent), $48.17 for chemicals (up 5.4 percent) and $28.44 for fuel (up 12.9 percent). Miscellaneous expense is estimated at $45.21 per hectare (up 4.1 percent), while interest and machinery expense account for $13.60 and $77.88 per hectare, respectively.

Table F2

ARIMA Input Cost Results for the Base Scenario

Crop Year	Seed	Fertilizer	Chemical	Fuel	Miscellaneous Expense
	.............(in dollars per hectare)................				
1984/85	20.90	64.35	45.70	22.25	41.40
1985/86	21.02	70.67	46.91	25.20	43.42
1986/87	21.34	78.72	48.17	28.44	45.21

Crop Year	Interest Expense	Operating Cost	Machinery Depreciation	Machinery Investment	Total Cost
	...............(in dollars per hectare).............				
1984/85	11.68	206.28	34.60	36.33	277.21
1985/86	13.60	220.82	36.60	42.57	299.99
1986/67	13.25	235.13	38.10	39.78	313.00

For both 1985/86 and 1986/87, fuel costs increase at the greatest rate, averaging 13.1 percent annually. Fertilizer is a close second, recording an average annual increase of 10.6 percent. Other cost components such as machinery depreciation, miscellaneous expense and chemicals experience an annual average increase of 4.9, 4.5 and 2.7 percent, respectively. The price of seed encompasses the lowest increase, rising at an average annual rate of 1 percent. This minimal increase is the direct result of depressed wheat prices throughout 1985/86 and 1986/87 (Table F2).

Interest related costs represent an exception in that they do not record consistent increases. From 1984/85 to 1985/86, interest and machinery investment expenses increase by 16.4 and 17.2 percent, respectively (Table F2). However, in the next simulation year a drop in the nominal interest rate (Figure 16) causes interest expense to decrease by 2.6 percent to $13.25 per hectare, while machinery investment expense drops by 6.6 percent to $39.78 per hectare.

The simulated results from the Regression version of the Input Price Model differ from that of the ARIMA Model. As shown in Table F3, the Regression Model predicts that production costs will total $296.05 in 1985/86 and $300.29 in 1986/87. When the Base Scenarios for the ARIMA and Regression Models are compared (Tables F2 and F3), we find that the 1985/86 Regression estimate for total cost is 1.3 percent ($3.94 per hectare) below its ARIMA counterpart. For 1985/86 the Regression estimate is 4.1 percent ($12.71 per hectare) lower. The greatest difference between the two modelling options is in terms of fuel and fertilizer components. Fuel costs, which were predicted to increase at an average annual rate of 13.1 percent under the ARIMA Model are limited to an

Table F3

Regression Input Cost Results for the Base Scenario

Crop Year	Seed	Fertilizer	Chemical	Fuel	Miscellaneous Expense
	....	(in dollars	per hectare)	....	....
1984/85	20.90	64.35	45.70	22.25	41.40
1985/86	21.02	69.51	46.67	23.04	43.42
1986/87	21.34	72.60	47.25	23.47	45.21

Crop Year	Interest Expense	Operating Cost	Machinery Depreciation	Machinery Investment	Total Cost
	....	(in dollars	per hectare)	....	....
1984/85	11.68	206.28	34.60	36.33	277.21
1985/86	13.37	217.03	36.54	42.49	296.05
1986/87	12.53	222.40	38.11	39.78	300.29

increase of 2.7 percent when the Regression option is in place. Fertilizer costs exhibit a smaller difference, rising at an average annual rate of 6.2 percent using the Regression Model rather than 10.6 percent as predicted by the ARIMA Model. The Regression Model's predictions for chemical costs are just slightly lower than their ARIMA counterparts. For 1986/87, the Regression Model estimates chemical costs at $47.25 per hectare, down only $.92 from the ARIMA forecast. The other cost components (miscellaneous interest and machinery) remain virtually unchanged.

The aforementioned differences in fertilizer and fuel prices can be explained by reverting back to premises on which the Regression and ARIMA Models were constructed. In the case of the Regression Model, inflation enters the estimation process as a separate regressor. When the Regression Model is used for forecasting, predicted changes in inflation (and exchange) will have a direct impact on fertilizer and fuel costs. For example, if inflation slows from 10 to 5 percent, the change will be incorporated within a lower price prediction. The same type of adjustment does not occur in the ARIMA Model. Given that the ARIMA estimates are based on past occurrences, the model assumes that past inflation rates will continue into the future. Therefore, it should be expected that the cost predictions will differ between the Regression and ARIMA Models.

The results portrayed in Tables F1, F2 and F3 can now be combined to estimate net revenue. Gross revenue (as predicted by the Trade Model) remains the same regardless of whether the ARIMA or the Regression Input Price Model is in effect. As shown in Table F4, the price of Canadian wheat is estimated to be $253.78 per tonne in 1984/85. Following this, wheat price declines to $243.01 per tonne in 1985/86 before increasing to $248.65 per tonne in 1986/87. Estimated deliveries increase throughout the simulation period, but their rate of increase varies. Wheat exports

Table F4

Simulated Net Revenue for the Base Scenario

Crop Year	Canadian Wheat Price	Estimated Deliveries	Gross Revenue	Total Cost	Net Revenue	Deflated Net Revenue
	($/t)	(t/ha)	($/ha)	($/ha)	($/ha)	($/ha)
Focus-ARIMA Option:						
84/85	253.78	1.971	500.20	277.21	222.99	222.99
85/86	243.01	1.983	481.89	299.99	181.90	173.49
86/87	248.65	2.075	515.95	313.00	202.95	185.91
Focus-Regression Option:						
84/85	253.78	1.971	500.20	277.21	222.99	222.99
85/86	243.01	1.983	481.89	296.05	185.84	177.25
86/87	248.65	2.075	515.95	300.29	215.66	197.55

are the driving force behind changes in estimated deliveries. As the price of Canadian wheat falls (1985/86) and then rises (1986/87), the total disposition of Canadian wheat (exports plus domestic demand) continues to increase. Multiplying wheat prices by estimated deliveries yields a per hectare value of gross revenue. Subtracting production costs from gross revenue leaves us with an estimate of net revenue. Deflated net revenue can then be calculated by discounting net revenue by the inflation rate which prevails in the model. As such, deflated net revenue is nothing more than net revenue expressed in constant (1984/85) dollars.[3]

The results of the Base Scenario (Table F4) predict that the price of Canadian wheat, gross revenue, net revenue, and deflated net revenue will all follow a similar pattern. Both net revenue and deflated net revenue are forecast to be $222.99 per hectare during the 1984/85 crop year. As we begin to simulate input costs, net revenue estimates for the Focus-ARIMA and Focus-Regression options diverge. In 1985/86, the Focus-ARIMA option predicts deflated net revenue to be $173.49 per hectare before increasing to $185.91 per hectare in 1986/87. Similarly, deflated net revenue for the Focus-Regression option drops to $177.25 per hectare before rebounding to its 1986/87 level of $197.55 per hectare. The divergence between the two deflated net revenue series can be accounted for by changes in deflated total costs. In the final simulation year (1986/87), deflated net revenue for the Focus-Regression option is $11.64 per hectare above the corresponding Focus-ARIMA estimate.

[3]The use of deflated net revenue becomes more important when interscenario comparisons are made in which inflation rates differ.

APPENDIX G

TRADE MODEL SIMULATIONS

Table G1

Simulated Results for the Trade Model Using Focus Forecasts[a]

Year	CUEX	HECT	CPROD	CSUP	UPU	CPC	CEXPS	CEXPD	CEXP	CDOMD	CESTK
Base Scenario:											
84/85	1.311	13238	26735	37947	176.72	253.78	20662	20768	20715	5372	11861
85/86	1.305	13823	28254	40115	186.04	243.01	21745	22123	21934	5480	12701
86/87	1.300	13504	27932	40633	174.08	248.65	21989	22903	22446	5580	12608
Scenario 1A:											
84/85	1.319	13238	26735	37947	176.72	255.50	20690	20739	20715	5368	11864
85/86	1.318	13876	28362	40226	167.03	244.71	21844	22115	21980	5474	12772
86/87	1.317	13552	28030	40802	172.67	250.65	22115	22900	22508	5573	12721
Scenario 1B:											
84/85	1.303	13238	26735	37947	176.72	252.06	20634	20797	20715	5375	11857
85/86	1.290	13770	28146	40004	169.04	240.88	21639	22138	21889	5485	12630
86/87	1.282	13445	27807	40437	175.95	246.79	21846	22899	22373	5587	12478
Scenario 2A:											
84/85	1.318	13238	26735	37947	176.72	255.29	20687	20743	20715	5369	11864
85/86	1.327	13869	28349	40212	167.16	246.79	21869	22078	21973	5471	12768
86/87	1.338	13616	28163	40930	171.51	253.90	22252	22870	22561	5566	12804
Scenario 2B:											
84/85	1.303	13238	26735	37947	176.72	252.06	20634	20797	20715	5375	11857
85/86	1.282	13770	28146	40004	169.03	239.16	21611	22167	21889	5488	12626
86/87	1.259	13392	27698	40324	176.97	242.87	21711	22943	22327	5595	12402
Scenario 3A:											
84/85	1.294	13238	26735	37947	176.72	250.12	20602	20829	20716	5378	11854
85/86	1.268	13711	28025	39878	170.16	237.38	21502	22174	21838	5493	12547
86/87	1.247	13343	27597	40144	178.59	242.06	21599	22923	22261	5600	12283
Scenario 3B:											
84/85	1.327	13238	26735	37947	176.72	257.22	20718	20711	20714	5365	11867
85/86	1.341	13929	28470	40337	166.03	248.57	21978	22071	22025	5466	12847
86/87	1.354	13666	28265	41111	169.88	255.57	23379	22875	22627	5560	12925
Scenario 4A:											
84/85	1.337	13238	26735	37947	176.72	259.37	20753	20675	20714	5362	11872
85/86	1.331	13995	28605	40476	164.78	245.05	22010	22155	22082	5470	12924
86/87	1.326	13552	28029	40953	171.31	251.11	22187	22920	22554	5570	12829
Scenario 4B:											
84/85	1.285	13238	26735	37947	176.72	248.19	20571	20861	20716	5381	11850
85/86	1.279	13651	27903	39753	171.29	240.97	21481	22091	21786	5489	12479
86/84	1.274	13459	27837	40315	177.05	246.19	21792	22886	22339	5590	12387

[a]Variables are defined in Sections 5.2.1 and 5.2.2 of the text.

APPENDIX H

INPUT COST SIMULATIONS

Table H1

Simulated Results for the ARIMA Input Price Model Using Focus Forecasts (in dollars per hectare)

Crop Year	Seed	Fertilizer	Chemical	Fuel	Miscellaneous Expense	Interest Expense	Operating Cost	Machinery Depreciation	Machinery Investment	Total Cost
Base Solution:										
84/85	20.90	64.35	45.70	22.25	41.40	11.68	206.60	34.60	36.33	277.21
85/86	21.02	70.67	46.91	25.20	43.42	13.60	220.82	36.60	42.57	299.99
85/86	21.34	78.72	48.17	28.44	45.21	13.25	235.13	38.10	39.78	313.00
Scenario 1A:										
84/85	20.90	64.35	45.70	22.25	41.40	11.68	206.28	34.60	36.33	277.21
85/86	21.06	70.67	46.91	25.21	43.53	13.18	220.56	36.60	41.03	298.19
86/87	21.41	78.72	48.17	28.46	45.42	12.89	235.07	38.11	38.49	311.67
Scenario 1B:										
84/85	20.90	64.35	45.70	22.25	41.40	11.68	206.28	34.60	36.33	277.21
85/86	20.96	70.66	46.91	25.20	43.30	14.03	221.05	36.60	44.10	301.76
86/87	21.26	78.70	48.16	28.43	44.98	13.60	235.13	38.10	41.07	314.30
Scenario 2A:										
84/85	20.90	64.35	45.70	22.25	41.40	11.68	206.28	34.60	36.33	277.21
85/86	21.16	76.67	46.91	25.21	43.53	13.21	220.68	36.60	41.10	298.39
86/87	21.62	78.74	48.17	28.45	45.53	12.50	235.01	38.11	37.12	310.24
Scenario 2B:										
84/85	20.90	64.35	45.70	22.25	41.40	11.68	206.28	34.60	36.33	277.21
85/86	20.88	70.66	46.91	25.20	43.32	14.00	220.97	36.60	44.03	301.60
86/87	21.04	78.69	48.17	28.44	44.85	13.98	235.17	38.10	42.44	315.71
Scenario 3A:										
84/85	20.90	64.35	45.70	22.25	41.40	11.68	206.28	34.60	36.33	277.21
85/86	20.84	70.64	46.91	25.20	43.16	14.49	221.24	36.60	45.82	303.66
86/87	21.03	78.66	48.17	28.43	44.56	14.23	235.08	38.10	43.40	316.57
Scenario 3B:										
84/85	20.90	64.35	45.70	22.25	41.40	11.68	206.28	34.60	36.33	277.21
85/86	21.20	70.67	46.91	25.22	43.69	12.71	220.40	36.60	39.31	296.31
86/87	21.67	78.72	48.16	28.47	45.85	12.24	235.16	38.11	36.13	309.35
Scenario 4A:										
84/85	20.90	64.35	45.70	22.25	41.40	11.68	206.28	34.60	36.33	277.21
85/86	20.98	70.71	46.91	25.21	43.77	12.80	220.38	36.60	39.64	296.62
86/87	21.30	78.80	48.18	28.47	45.71	13.14	235.59	38.10	39.28	312.97
Scenario 4B:										
84/85	20.90	64.35	45.70	22.25	41.40	11.68	206.28	34.60	36.33	277.21
85/86	21.06	70.50	46.90	25.16	43.08	14.35	221.05	36.60	45.35	303.00
86/87	21.38	78.32	48.11	28.33	44.69	13.35	234.18	38.10	40.35	312.63

Table H2

Simulated Results for the Regression Input Price Model Using Focus Forecasts
(in dollars per hectare)

Crop Year	Seed	Fertilizer	Chemical	Fuel	Miscellaneous Expense	Interest Expense	Operating Cost	Machinery Depreciation	Machinery Investment	Total Cost
Base Solution:										
84/85	20.90	64.35	45.70	22.25	41.40	11.68	206.28	34.60	36.33	277.21
85/86	21.02	69.51	46.67	23.04	43.42	13.37	217.03	36.54	42.49	296.05
86/87	21.34	72.60	47.25	23.47	45.21	12.53	222.40	38.11	39.785	300.29
Scenario 1A:										
84/84	20.90	64.35	45.70	22.25	41.40	11.68	206.28	34.60	36.33	277.21
85/86	21.06	70.22	46.81	23.21	43.53	13.02	217.85	36.65	41.08	295.57
86/87	21.41	73.71	47.51	23.22	45.42	12.25	223.52	38.30	38.68	300.51
Scenario 1B:										
84/85	20.90	64.35	45.70	22.25	41.40	11.68	206.28	34.60	36.33	277.21
85/86	20.96	68.93	46.51	22.87	43.30	13.72	216.30	36.43	43.89	296.62
86/87	21.26	71.53	46.97	23.14	44.98	12.76	220.65	37.90	40.86	299.41
Scenario 2A:										
84/85	20.90	64.35	45.70	22.25	41.40	11.68	206.28	34.60	36.33	277.21
85/86	21.16	70.16	46.80	23.20	43.53	13.04	217.89	36.65	41.15	295.69
86/87	21.62	74.38	47.67	23.94	45.53	11.98	225.13	38.44	37.45	301.00
Scenario 2B:										
84/85	20.90	64.35	45.70	22.25	41.40	11.68	206.28	34.60	36.33	277.21
85/86	20.88	69.02	46.54	22.89	43.32	13.71	216.36	36.44	43.84	296.63
86/87	21.04	70.82	46.79	22.96	44.85	13.05	219.51	37.78	42.08	299.37
Scenario 3A:										
84/85	20.90	64.35	45.70	22.25	41.40	11.68	206.28	34.60	36.33	277.21
85/86	20.84	68.04	46.32	22.65	43.16	14.09	215.10	36.26	45.39	296.75
86/87	21.03	69.41	46.44	22.57	44.56	16.24	217.16	37.51	42.72	297.39
Scenario 3B:										
84/85	20.90	64.35	45.70	22.25	41.40	11.68	206.28	34.60	36.33	277.21
85/86	21.20	71.08	47.01	23.44	43.69	12.63	219.05	36.82	39.54	295.41
86/87	21.67	75.96	48.07	24.38	45.85	11.85	227.78	38.72	36.70	303.20
Scenario 4A:										
84/85	20.90	64.35	45.70	22.25	41.40	11.68	206.68	34.60	36.33	277.21
85/86	20.98	71.48	47.13	23.55	43.77	12.76	219.67	36.88	39.94	296.48
86/87	21.30	74.97	47.87	24.15	45.71	12.64	226.63	38.54	39.74	304.91
Scenario 4B:										
84/85	20.90	64.35	45.70	22.25	41.40	11.68	206.28	34.60	36.33	277.21
85/86	21.06	67.74	46.22	22.55	43.08	13.94	214.58	36.22	44.88	295.68
86/87	21.38	70.31	46.61	22.77	44.69	12.44	218.22	37.67	39.89	295.78

APPENDIX I

ESTIMATED ELASTICITIES

Table I1

Trade Model Elasticities[a]

Dependent Variable	Equation Number	Independent Variables												
		CPC	CPC_{t-1}	UPU	CUEX	CSUP	CPROD	$CESTK_{t-1}$	DEL_{t-1}	$CDOMD_{t-1}$	CEXPS	WEXP	CPOP	WPOP
<u>Simultaneous</u> <u>Trade</u> <u>Model</u>:														
5.1	CEXPS	.20					.81	.39						
5.2	CEXPD	-.43			.28							1.13		
5.3	CPC			.93	1.15						.07			
<u>Recursive</u> <u>Trade</u> <u>Model</u>:														
	HECT		.48						.31					
5.11	UPU					-1.86								3.45
5.12	CPC			.92	1.30									
5.13	CEXPS	.20					.80					1.11		
5.14	CEXPD	-.43			.29									
5.16	CDOMO		-.07							.56			.78	

[a]The elasticities included in this table are expressed at the mean level.

Table I2

Input Price Model Elasticities[a]

Dependent Variable	Equation Number	Independent Variables										
		CPC	$SEED_{t-1}$	$FERT_{t-1}$	$RMACH_{t-1}$	PETR	$CHEM_{t-4}$	EX_t-EX_{t-1}	EX_t-EX_{t-2}	I_t-I_{t-1}	I_t-I_{t-2}	I_t-I_{t-4}
SEED	5.20	.41	.48									
FERT	5.25			.948				.001		.062		
$RMACH^R$	5.26				.792			.001				
$PETR^R$	5.27					.924			.002		.118	
$CHEM^R$	5.28						.766					.127

[a]The elasticities included in this table are expressed at the mean level.