THE UNIVERSITY OF ALBERTA

Macroeconomic Effects on Canadian Agriculture

by

Kelly Anne Buck

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE

OF Master of Science

IN

Agricultural Economics

Department of Rural Economy

EDMONTON, ALBERTA

Spring, 1989

ISBN 0-315-52789-7

THE UNIVERSITY OF ALBERTA

RELEASE FORM

NAME OF AUTHOR Kelly Anne Bluck

TITLE OF THESIS Macroeconomic Effects on Canadian Agriculture

DEGREE FOR WHICH THESIS WAS PRESENTED Master of Science

YEAR THIS DEGREE GRANTED Spring, 1989

(SIGNED) ....

PERMANENT ADDRESS:

....

....

....

DATED 19

THE UNIVERSITY OF ALBERTA

FACULTY OF GRADUATE STUDIES AND RESEARCH

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research, for acceptance, a thesis entitled Macroeconomic Effects on Canadian Agriculture submitted by Kelly Anne Bluck in partial fulfilment of the requirements for the degree of Master of Science in Agricultural Economics.

....

Supervisor

....

....

Date..

Abstract

The purpose of the research was to investigate the relationships between domestic and foreign macroeconomic policy variables and Canadian agricultural export and price levels.

The vector autoregression (VAR) technique was used to estimate three econometric models, including two unrestricted models and a model using Bayesian priors. The research focused on the effects of the U.S./Canadian exchange rate, the CPI, the U.S. money supply and interest rate, and the Canadian money supply and interest rate on the Canadian Farm Price Index and an aggregate value of Canadian agricultural exports. The relative strengths of the relationships between variables were determined using the forecast error decompositions and impulse response functions of the VAR model.

The results suggest that events in agriculture explain more of the instability in agricultural prices and exports than do changes in the macroeconomy. The macroeconomic variables in the model with the most relative importance to agricultural prices and exports are the U.S. and Canadian interest rates, both of which exhibited a negative effect on the agricultural variables. The exchange rate demonstrated little influence. The effect of the U.S. money supply on the interest rates and the exchange rate suggest an indirect influence on Canadian agriculture.

Dedication

For Edith M. Reid,

who would have wanted a copy.

Acknowledgements

In the course of my research I have incurred debts to a number of individuals. I owe a debt of gratitude to my advisor, Dr. Wiktor Adamowicz, as his inspiration, advice and general support proved invaluable in the completion of this research. Whatever merit this thesis possesses is due in part to Vic's influence.

I also owe a debt of thanks to my examining committee, Dr. Paul Boothe, Dr. [illegible]ele Veeman, and Dr. Terry Veeman, for their constructive criticism of this study and their pertinent questions and advice.

I owe Jim Copeland and fellow student Di[illegible] [illegible] or their help with com[illegible]ter problems and especially for recognizing that manuals are useless when 'one kno[illegible] one doeth'. I also owe Judy Boucher for having all the answers to my textform problems and other students for taking the time to demonstrate shortcuts.

I would like to thank Barb Johnson for supplying the newspaper and both Barb and Hildegard Zeidler for their help in the library. I also need to thank Wendy Williamson and Holly Horvath in the front office for their attention to details of which I was blissfully unaware until after the fact.

I appreciate the atmosphere created by other graduate students and am especially grateful to my office mates, Alison, Bruce, Clarita, the Marks, and Bruce's ruler, for their camaraderie and for simply being there. I owe a special debt of gratitude to Ann, a kindred spirit who understood.

I want to also acknowledge my family, especially my parents, whose support was the most critical of all. I am grateful.

Table of Contents

List of Tables

List of Figures

I. Introduction

A. Purpose of the Study

As the Canadian agricultural sector becomes more integrated with the rest of the Canadian economy and the international commodity and financial markets, the agricultural sector becomes more sensitive to the macroeconomic policy decisions of both domestic and foreign governments. Perceptions of the causes of price and income instability in agriculture have extended from microeconomic level causes such as market imperfections and shocks from the natural environment, to a more macroeconomic approach. Levels of government subsidies and supports program attest to the continued importance of microlevel concerns. However, monetary fluctuations and changes in the international commodity and financial markets are perceived as having a substantial influence on the performance of the Canadian agricultural sector. Changes in exchange rates can affect the value of agricultural products in world commodity markets by causing demand shifts and price changes. Interest rates, through economic linkages with exchange rates, money supplies and government expenditures, can also affect agricultural prices and exports. As the Canadian economy becomes further integrated into a global economic structure, more emphasis needs to be placed on understanding the economic relationships that are important causes of price and export instability in Canadian agriculture. Discussions of agricultural trade liberalization between countries may have to include consideration of the role of monetary and fiscal policies of countries as well as their agricultural subsidies, tariffs, and other support programs. The growing significance of the linkages between the international macroeconomy and Canadian agriculture emphasizes the need for increased awareness and more thorough understanding of the relationships.

Canadian agriculture depends heavily on exports. The degree of integration of Canadian agriculture in world commodity markets is very high.[1] The value of exports corresponds to about fifty percent of total farm gate receipts. At the same time, agricultural imports are valued at roughly thirty percent of total farm gate receipts, indicating the degree

[1]Garth H. Coffin, "The Internationalization of Canadian Agriculture," *Canadian Journal of Agricultural Economics*, vol. 35, 1987, pp. 692.

to which Canadian agricultural products compete in the international markets.[2]

Due to the importance of export trade to Canadian agriculture, Canada's competitive position in world markets must be maintained in the face of growing agricultural trade protectionism sentiment at an international level. Exchange rates are considered crucial for the maintenance of a competitive position in international agricultural commodity markets.[3] As Canada's currency strengthens relative to other trading nations' currencies, Canadian products become less competitive and foreign demand for Canadian products decreases. Further, the relative price of competing imports put downward pressure on the domestic prices of Canadian goods.

The currency of most concern for Canada is the American dollar. At the present, the American dollar is the most important price in the world economy and affects the competitive postion of other trading countries relative to the United States, a major player in agricultural commodity markets.[4] As well as affecting Canada's competitive position abroad, the Canada/U.S. exchange rate affects agricultural exports to the United States. Given that the U.S. domestic market absorbs the largest share of total Canadian agricultural exports (approximately thirty-seven percent), the American dollar acquires even further significance. Further, the U.S. accounts for fifty-seven percent of Canadian agricultural imports.[5]

The true influence of exchange rates on Canadian agriculture is uncertain. Estimation of the effects is compounded by the extreme volatility experienced by different currencies since most governments switched from fixed to flexible exchange rates in the early seventies. Figure 1.1 shows the monthly fluctuations in the Canada/U.S. exchange rate since 1960. The monthly changes in agricultural export values illustrated in Figure 1.2 demonstrate that fluctuations in agricultural trade are not closely correlated with exchange rate changes.

---

[2]Agriculture Canada, Handbook of Selected Agricultural Statistics, Ottawa, Canada, 1986. Percentages are an average of 1982-1985.

[3]George L. Brinkman, "The Competitive Position of Canadian Agriculture," *Canadian Journal of Agricultural Economics*, vol. 35, 1987, pp. 273.

[4]Otmar Emminger, "The International Role of the Dollar," *Economic Review*, Federal Reserve Bank of Kansas, Sept./Oct., 1985, p. 17-24.

[5]Agriculture Canada, *Canada's Trade in Agricultural Products 1985, 1986, 1987.*, Ottawa, Canada, July, 1988.

However, the Canadian farm price index in Figure 1.3 suggests that farm prices decline as the Canada/U.S. exchange rate increases.

Since attention was first directed towards the integration of agricultural trade, the role of the exchange rate has received much emphasis in economic trade models.[6] The exchange rate, however, does not operate independent of other macroeconomic variables. At different times, various countries, Canada included, have managed the value of their currencies by restricting or expanding money supplies, or by altering interest rates.[7] High interest rates alone have severely strained the financial situation of farmers due to the capital-intensive nature of Canadian agriculture. The link between interest rates and the exchange rate may provide a further influence on Canadian agriculture.

The need to understand the effects of macroeconomic policies at a domestic level is highlighted when consideration is given to the fact that instruments used in the Canadian monetary policy work through the financial markets. The monetary goal of a stable inflation rate, for example, may unintentionally be negatively affecting the agricultural industry through a restricted money supply and subsequent higher interest rates. Control of the inflation rate has been a major goal of the Bank of Canada. The correlation between the Canadian currency and demand deposits (M1) and the nominal Consumer Price Index is illustrated in Figures 1.4 and 1.5. The U. S. monetary policy is often perceived to indirectly affect Canadian agriculture through U. S. interest rate influence on Canadian monetary variables. The Canadian interest rate tends to follow fluctuations in the U.S. interest rate as demonstrated in Figure 1.6. The influences of Canadian monetary goals are perceived to have large impacts in Canadian agriculture but, as of yet, there does not exist a clear understanding the linkages involved, nor the strength of the influence.

[6]For the most part, the emphasis on exchange rate is the result of a pioneering article by Edward Schuh, "The Exchange Rate and U.S. Agriculture," *American Journal of Agricultural Economics*, vol. 56, 1974, pp. 1-13.

[7]Good analyses of Canadian monetary policy are provided by Thomas J. Courchene, *Abandoning Monetary Targets: An Evaluation*, Toronto: C.D. Howe Institute, 1983; Peter Howitt, *Monetary Policy in Transition: A Study of Bank of Canada Policy 1982-1985*. Toronto: C.D. Howe Institute Policy Study No. 1, 1986; John E. Floyd, *Focus on the Canadian Dollar*, Vancouver: The Fraser Institute, 1985.

The purpose of the study is to review the current state of understanding of the relationships between macroeconomic variables and agricultural prices and exports and provide some empirical evidence as to the relative strengths of the relationships. If the macroeconomic causes of price and export instability are more clearly understood, policies can be directed toward reducing the instability rather than subsidizing the victims of instability.

B. Objectives of the Study

The central objective of the research is to analyze the effects of changes in major domestic and international macroeconomic variables on Canadian agricultural prices and exports.

The specific objectives undertaken by the study are:

1. To develop an econometric model suited to determining the relationships between the macroeconomy and agriculture.
2. To examine the relative importance of national versus international policy shocks.

C. Outline of the Study

The study will proceed as follows. Chapter Two surveys the empirical studies on the influences of macroeconomic variables on agricultural prices and exports. The chapter highlights some of the advances made but also emphasizes the need for more research given the conflicting views of the importance of different variables in empirical studies. Chapter Three outlines the Vector Autoregression econometric technique, the mod chosen as the most appropriate procedure for achieving the objectives defined in the initial stages of the research. As well, the third chapter lists the data series chosen. The model estimation, results and implications of the results are described in Chapter Four. Chapter Five presents the conclusions, limitations of the study, and possible avenues for further research.

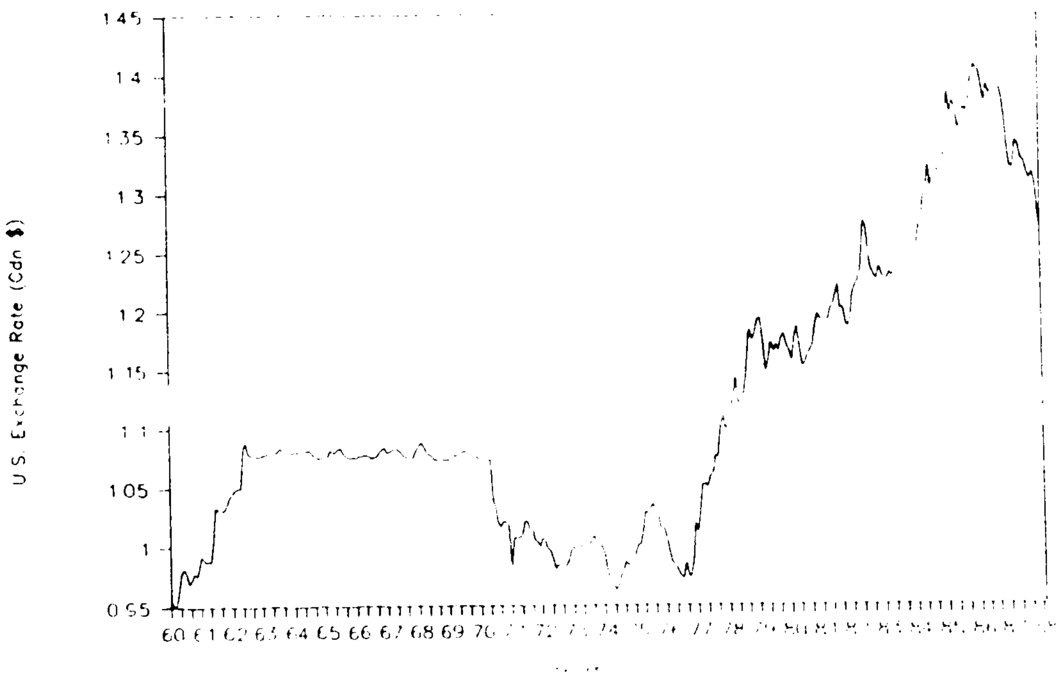


Figure I.1 U.S. Spot Rate in Canadian Dollars. Source: CANSIM-Statistics Canada.

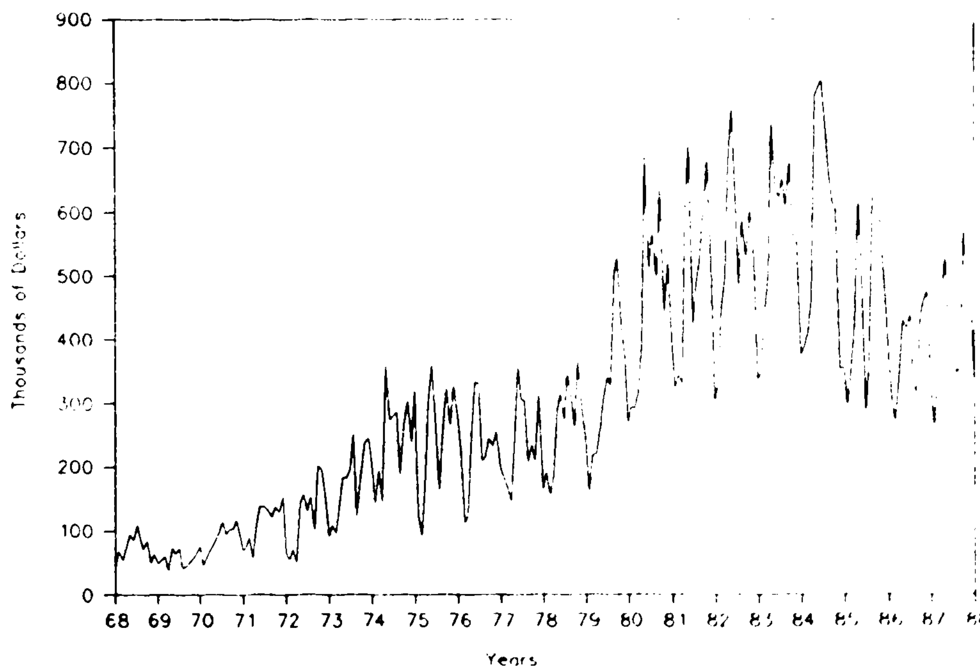


Figure I.2 Value of Canadian Agricultural Exports.

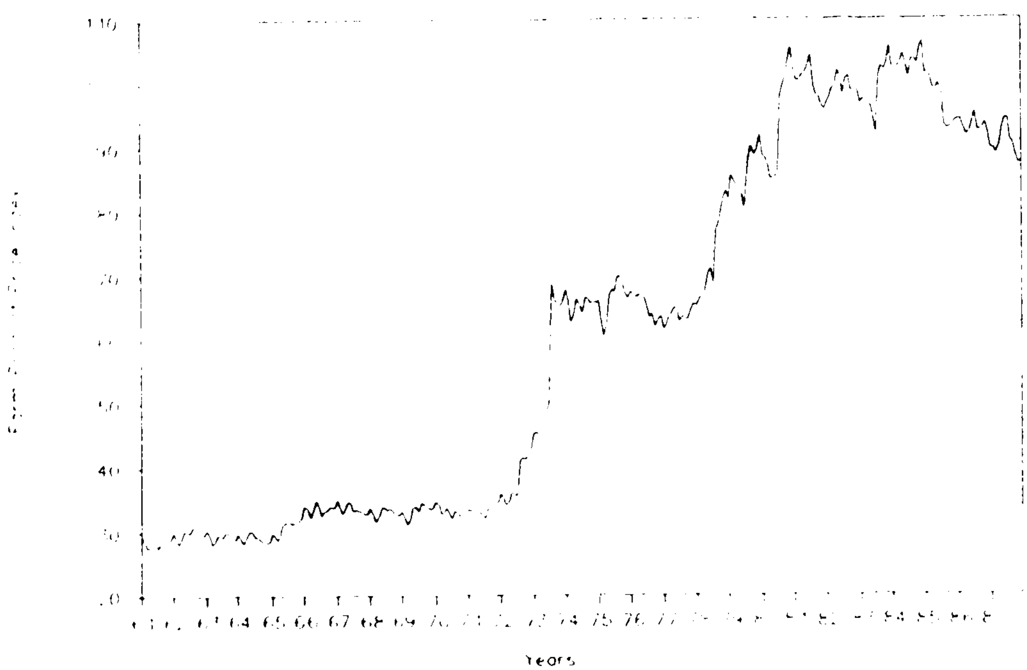


Figure 1.3 Farm Product Price Index (1981=100). Source: Statistics Canada.

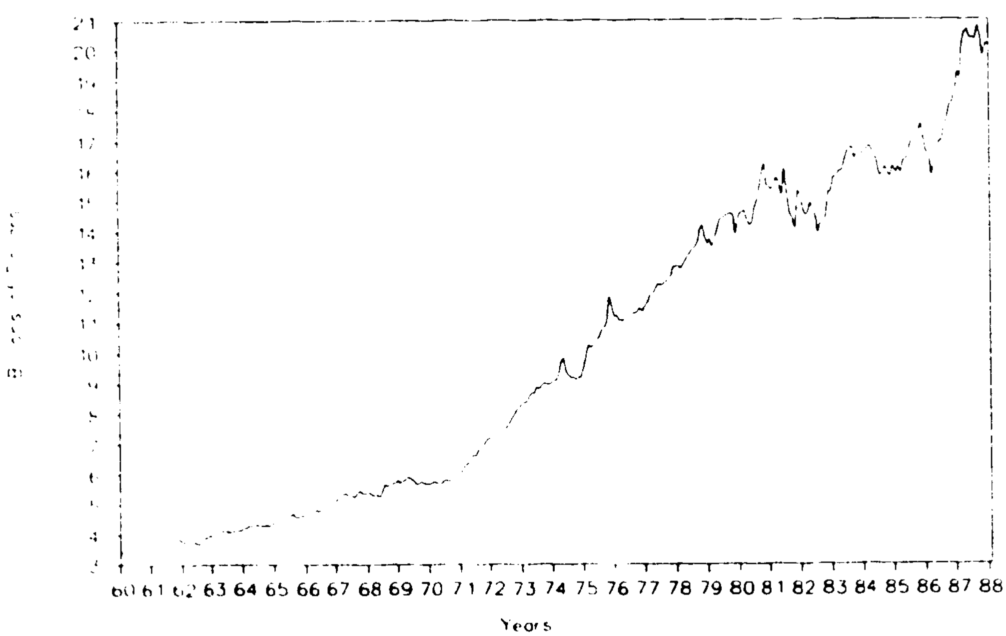


Figure 1.4 Canadian Currency and Demand Deposits. Source: CANSIM-Statistics Canada.

Figure 1.5 Consumer Price Index for Canada (1981 = 100). Source: CANSIM-Statistics Canada.

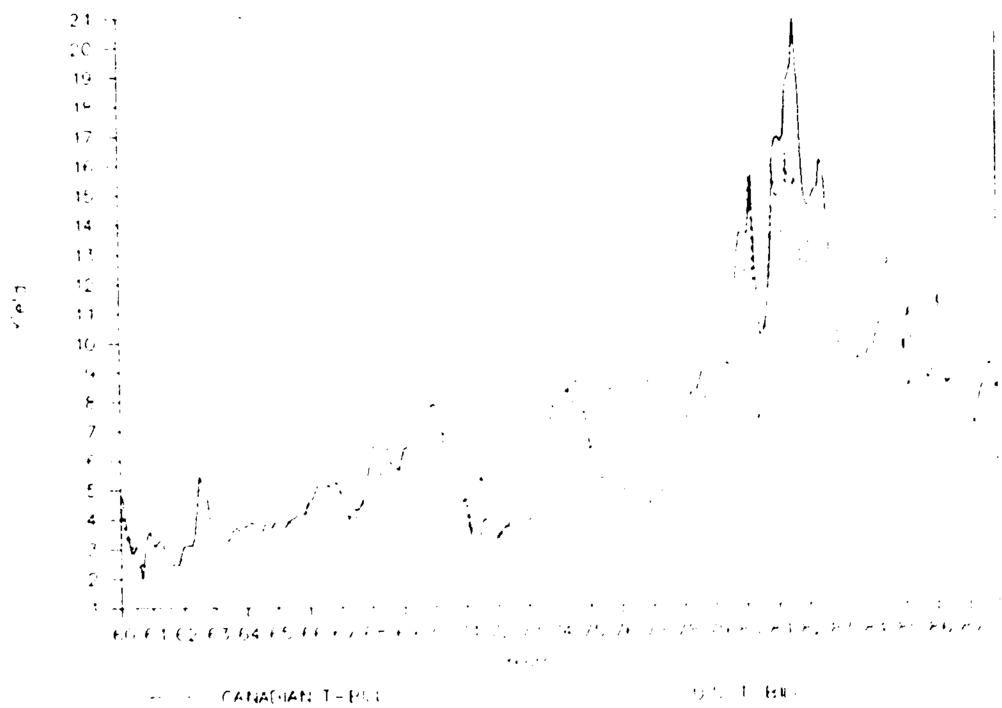


Figure 1.6 Canadian and U.S. 91-Day Treasury Bills. Source: CANSIM-Statistics Canada.

II. Theoretical Framework

A. Introduction

The Canadian agricultural sector is sensitive to world markets and foreign and domestic macroeconomic policy. Canadian agricultural prices and exports are influenced by macroeconomic variables such as exchange rates, interest rates, and the money supply. Some of the instability in the agricultural sector may be a product of macroeconomic policies developed to achieve goals not considered directly related to the agricultural sector. There appears to be a lack of consensus, however, about the nature or significance of macroeconomic linkages to the agricultural sector. The present state of macroeconomic theory is such that several different, and sometimes conflicting theoretical approaches are considered acceptable for formulating conceptual frameworks. A natural first step should be to identify regularities in macroeconomic and agricultural data that can be used in support of economic models. Given the importance of the agricultural industry to Canada, such analysis should contribute to a better understanding of the effects of Canadian, United States and world macroeconomic policy variables on Canadian agricultural prices and exports.

Disagreement arises over how important the effects of movements in certain macroeconomic variables are to agricultural prices and exports if account is taken of buffering influences of other factors. Given the controversy, it is surprising that little empirical work has been published in Canada on macroeconomic linkages to agriculture. Brinkman, in an article describing Canadian agriculture's competitive position in world markets and Freshwater, in a paper relating similarities and differences in the financial condition of farmers in the United States and Canada to government policies, both agree that one of the most important variables affecting Canadian agriculture at the trade level is the exchange rate.[1] However, Freshwater takes the view that a decline in the Canadian dollar will protect

[1]George L. Brinkman, "The Competitive Position of Canadian Agriculture," in *Canadian Journal of Agricultural Economics*, vol. 35, 1987, pp. 263-288, and David Freshwater, "Farm Finance and the Public Sector: A Macroeconomic Perspective," *Canadian Journal of Agricultural Economics*, vol. 35, 1987, pp. 709-733.

Canadian farmers from other influences such as rising interest rates given that world commodity prices are in United States dollars and Canadian domestic production expenses are in Canadian dollars. Brinkman, on the other hand, while agreeing that a decline in the dollar will improve Canadian competitiveness in world markets, stresses that costs of production will increase because prices of inputs such as fertilizer and petroleum products are set internationally. Neither paper gives an indication as to how significant are the effects of changes in the exchange rate.

Despite a lack of agreement on the effects of macroeconomic variables on agriculture, both articles recognize the role exchange rates, and to a lesser extent, interest rates and growth in the money supply, play in explaining events in Canadian agriculture. Brinkman suggests that macroeconomic policies may be at least as important as commodity policies in affecting agriculture. Freshwater's paper goes further in that it also pays attention to indirect effects that changes in United States macroeconomic policy have on Canadian agriculture through American influences on Canadian macroeconomic variables. In an earlier article, Anderson and Gellner noted that the world capital market, and its effect on interest and exchange rates, has yet to be considered an important economic variable in regards to Canadian agricultural trade.[9] Realization of the necessity of including domestic and foreign macroeconomic policy variables in studies modelling effects on Canadian agricultural prices and exports exist, but, as of yet, few empirical studies appear to have incorporated them.

Even though empirical work from the United States on macroeconomic impacts on U.S. agriculture is far more substantial than Canadian publications on Canadian agriculture, the U.S. literature indicates that American agricultural economists also have yet to reach an agreement on how each macroeconomic variable is involved in agricultural prices and exports. Most of the studies either focus on direct monetary and fiscal policy effects on agriculture or on indirect macroeconomic effects through variables such as the exchange rate, interest rate, and inflation process. Gradually, however, the dividing line is becoming less focused as more agricultural economists search for causal linkages between monetary policy, exchange and

[9]W.J. Anderson and J.A Gellner, "Canadian Agricultural Policy in the Export Sector," *Canadian Journal of Agricultural Economics*, vol. 32, 1984, pp. 170-185.

interest rates, and agricultural prices and exports.

The purpose of the following chapter is to review some of the existing literature on macroeconomics and agriculture in an effort to decide which macroeconomic variables are considered the most significant in linkages with Canadian agriculture. The standard Mundell/Fleming macroeconomic model modified to explicitly include the agricultural sector is presented as a convenient method of discussing the theoretical linkages between macroeconomic variables and agricultural prices and exports. In order to provide a logical direction to the review, the macroeconomic connections to agriculture will be divided into three groups: first, the effects of fiscal policy on agriculture; second, the effects of monetary policy, in this case, money supply, interest rates and subsequently exchange rates, on agricultural prices and exports; and finally, the effects of international policy in terms of other nations' macroeconomic policy effects on Canadian agricultural prices and exports.

B. Macroeconomic Linkages to Agriculture

Conceptual Framework

A modification of the Mundell/Fleming macroeconomic model provides the opportunity to demonstrate possible macroeconomic influences on agriculture in a small open economy.[10] The following model is divided into two sectors: a non-agricultural sector and an agricultural sector. To simplify the model, the sectors are assumed to be separable.

$$Y^n = C(Y^n) + I^n(r) + G^n + (X^n \cdot \frac{EP^{xn}}{P^d}) - \frac{EP^{mn}}{P^d} \cdot M^n(Y^{dn}, \frac{EP^{mn}}{P^d}) \qquad (2.1)$$

$$Y^a = C(Y^a) + I^a(r) + G^a + (X^a \cdot \frac{EP^{xa}}{P^d}) - \frac{EP^{ma}}{P^d} \cdot M^a(Y^{da}, \frac{EP^{ma}}{P^d}) \qquad (2.2)$$

$$I(r) = I^n(r) + I^a(r) \qquad (2.3)$$

[10] The Mundell/Fleming model was adapted from William Scarth, *Macroeconomics: An Introduction to Advanced Methods*, Toronto: Harcourt Brace Jovanovich, 1988, p. 133.

$$Y = Y^n + Y^a \tag{2.4}$$

$$Y^d = \frac{(P^d Y)}{P} \tag{2.5}$$

$$P = \gamma P^d + (1-\gamma)EP^m \tag{2.6}$$

$$P^m = \theta(P^{mn}, P^{ma}) \tag{2.7}$$

$$P \cdot L(Y, r) = D + R \tag{2.8}$$

$$R^{\bullet} = P^d[X^n(\frac{EP^{xn}}{P^d}) + X^a(\frac{EP^{xa}}{P^d}) - \frac{EP^{mn}}{P^d} \cdot M^n(Y^{dn}, \frac{EP^{mn}}{P^d})$$

$$- \frac{EP^{ma}}{P^d} \cdot M^a(Y^{da}, \frac{EP^{ma}}{P^d})] + K(r - r^f - \frac{E^{\bullet}}{E}) \tag{2.9}$$

where the superscripts denote the following: n denotes the non-agricultural sector, a denotes the agricultural sector, d denotes a domestic variable, f denotes a foreign variable, m denotes imports, and x denotes exports. Equations 2.1 and 2.2 are standard IS functions for the non agriculture and agriculture sectors, respectively. Y is the total supply of goods in the economy and is a function of the total spending by households, firms, and government, and the amount exported less the amount spent on imports. Units of import i (where i represents one of the sectors) are converted to domestic currency units by multiplying the exchange rate, E (domestic currency price of one unit of foreign currency), the world price, P^{mi}, and imports, M. Division by the domestic price, P^d, will put imports into domestic physical units.

Equation 2.3 and 2.4 describe total investment and total output as the sum of investment and output supply in both sectors. The income effects of exchange rate changes are captured in equation 2.5 and 2.6. The real value of domestic income is found by dividing the nominal value of production, P^dY, by the average price of all goods consumed by domestic agents, P. The average price index, as defined by equation 2.6, weights the value of domestic and imported goods. Assuming no savings, the average propensity to consume domestic goods is specified by γ and the average propensity to spend on imported goods is given by $1-\gamma$. The exchange rate in equation 2.6 allows a decrease in the val[illegible] domestic dollar to directly raise the price level. The world price for imports is a funct[illegible] he non-agricultural and agricultural world price as defined in equation 2.7.

Equation 2.8 depicts the money market equilbrium or the LM function. The money supply is defined as the assets of the central bank in the form of government bonds, D, and foreign exchange reserves, R. Money demand is a function of the price level, transaction demand for money, L(Y), and the asset demand for money, L(r). Money supply and money demand increase in the same proportion. As the exchange rate is considered flexible in this model, D and R are exogenous.

The foreign exchange market is introduced in equation 2.9. The change in foreign reserve holdings (balance of payments), R•, is divided into the current account (trade account) balance and the capital account (asset transaction account) balance. The current account balance, or net exports, allows for the direct influence of the exchange rate. Exports are defines as a function of the exchange rate and imports as a function of the exchange rate and domestic output. If the domestic currency depreciates, exports will increase and imports will decline, assuming people everywhere substitute cheap goods for expensive goods. The direct influence of interest rates on the balance of payments and the exchange rate is felt through the capital account, $K(r - r^f - \frac{E^\bullet}{E})$, where K is the net capital inflow, r^f is the foreign yield on bonds, and $\frac{E^\bullet}{E}$, is the percentage change in the exchange rate which captures any speculative gain from changes in different currencies. As r^f increases relative to the domestic interest rate, large capital outflows will cause the domestic dollar to depreciate.

Much of the value of a structural model is the ability to determine the effects of changes in economic variables through evaluation of their multipliers. In order to avoid too much complexity, the model is simplified by eliminating the non-agricultural sector. Several other simplifying assumptions are made. The IS function for agriculture is considered to be independent of prices by assuming that the Laursen/Metzler effect can be ignored. Note however, that by making these assumptions, the average propensity to consume, γ, must be unity and thus domestic agricultural output must equal total agricultural output, implying that imports do not exist.[11] The speculative gain from exchange rate changes ($\frac{E^{\bullet}}{E}$ in equation 2.9), is also disregarded. The model now becomes:

$$Y^a = C(Y^a) + I^a(r) + G^a + (X^a \cdot (E) - E \cdot M^a(Y^a, E) \qquad (2.2a)$$

$$L_y(Y^a, r) = D + R \qquad (2.8a)$$

$$R^{\bullet} = X^a \cdot (E) - E \cdot (Y^a, E) + K(r - r^f) \qquad (2.9a)$$

To calculate the multipliers, the total differentials of each equation must be derived and arranged so that the endogenous variables are on the left hand side and the exogenous variables are on the right hand side:

$$(1 - C^a_y\ E \cdot M^a_y)dY^a\ I^a_r dr + (X^a_e - E \cdot M^a_e)dE = dG \qquad (2.10)$$

$$L_y dY^a + L_r dr = dD + dR \qquad (2.11)$$

$$(E \cdot M^a_y)dY^a - K_r dr - (X^a_e - E \cdot M^a_e)dE = -dR^{\bullet} - K_r dr^f \qquad (2.12)$$

Each partial derivative represents the slope of a function. Together, the partial derivatives define the structure of the economic system. As examples, the marginal propensity to consume, C_y, is assumed to always be a positive fraction less than one, and the partial derivative, I_r, is negative due to the downward sloping demand relationship between investment and interest rates. The multipliers can be derived using either algebraic substitution or matrix notation.

The simplified model will be used to derive examples of multipliers affecting the agricultural sector. The following sections will discuss fiscal and monetary policy with respect

[11]See W. Scarth, *op. cit.*, p. 126, for the underlying justifcations of these assumptions.

to a small open economy as specified in the above model and the results of other studies.

Effects of Fiscal Policy

Conventional macroeconomic theory indicates that agricultural output and prices are directly influenced by changes in fiscal policy and indirectly influenced by fiscal policy through interactions between fiscal policies and interest and exchange rates. The net impact of government expenditure on agricultural output can be evaluated through the derivation of the fiscal multiplier, $\frac{dY^a}{dG}$. Using matrix notation, the denominator for the fiscal multiplier is the determinant of the structural matrix composed of the partial derivatives from the endogenous variables (on left hand side of equations 2.10 to 2.12). The numerator is derived from the structural matrix when column dY^a is replaced by the dG column of the exogenous variable matrix.

The fiscal multipler in a flexible exchange rate becomes:

$$\frac{dY^a}{dG} = \frac{L_r}{L_r(1-C_y) + I_r L_y - K_r L_y}$$

From the fiscal multiplier represented in the Mundell/Fleming model, a government expenditure increase will have little to no effect on agricultural output if there is perfect capital mobility between countries. The fiscal pressure on interest rates will be buffered by capital inflows. As K_r increases, $\frac{dY^a}{dG}$ approaches zero. However, if the supply side effects of exchange rates are considered by relaxing the assumption that the average propensity to consume is equal to unity and instead is less than unity, the fiscal multiplier will have a positive effect on agricultural output. By relaxing this assumption, equation 2.6 is included in the simplified model and exchange rate changes are allowed to affect prices. Therefore, increasing fiscal expenditure will cause upward pressure on the domestic interest rate, as before, but this will in turn raise the domestic dollar. While agricultural exports will be less favourably received in world markets, imports will be less expensive and prices lower.

Domestic agricultural output (IS curve) will increase because money supply increases (LM shifts right) due to to the price change. The price change, however, means lower prices for competing domestic agricultural output.

There has been little investigation of the sensitivity of agricultural prices and exports to government expenditures. Lamm, in a U.S. two sector dynamic model designed to determine macroeconomic linkages to agriculture, found that increased nominal government expenditure has a negative effect on nominal and real agricultural income and agricultural output.[12] Lamm suggested that U.S. agricultural price support policies as a component of total government expenditure, may actually decrease agricultural incomes. However, if agricultural income and output are considered to be equivalent, it can be argued that the effect of government expenditure should be negative as many U.S. support policies are designed to reduce agricultural output.

The standard open economy results are supported by a general equilibrium simulation analysis of U.S. monetary and fiscal policy impacts on the U.S. agricultural industry from 1970 to 1984.[13] This study found that U.S. government spending without compensating tax revenue was found to raise interest rates, hence increasing the U.S. dollar and dampening demand for U.S. agricultural exports. Due to the momentum of previously high U.S. deficits, simulation of reduced government spending with a constant money supply (and therefore reduced interest and exchange rates) only slowed the decline in agricultural exports. Although lessened by high levels of world commodity stocks, agricultural prices increased in the world commodity markets. The study suggests that the fiscal behavior of the U.S. government has a significant effect on the international demand for U.S. agricultural products.

---

[12]R. McFall Lamm, "The Role of Agriculture in the Macroeconomy: A Sectoral Analysis," *Applied Economics*, vol. 12, 1980, pp. 19-35.
[13]T. Barclay and L. Tweeten, "Macroeconomic Policy Impacts on the United States Agriculture: A Simulation Analysis," *Agricultural Economics*, vol. 1, 1988, pp. 291-307.

Effect of Monetary Policy

The instruments of monetary policy are those macroeconomic variables primarily determined within domestic or international monetary markets: typically money aggregates, or interest rates, or exchange rates.[14] Changes in the endogenous variables of output, the domestic interest rate, prices and the exchange rate, can affect the economy through a number of channels. At a given Y, changes in the price level will change the demand for money in equation 2.8 and the level of output in equation 2.5. To restore equilibrium in the money market, the interest rate will move opposite the direction of the price level movement. Interest rate changes influence investment and subsequently aggregate demand. Foreign macroeconomic shocks can affect domestic monetary variables through the exchange rate and the foreign interest rate in equation 2.9. The possible consequences of monetary policy prescriptions on agricultural prices and exports depend on linkages of macroeconomic variables to the agricultural sector and also the effects of macroeconomic variables on the factors affecting the demand for agricultural products.

The effects of money supply changes can be evaluated through the monetary policy multiplier $\frac{dY^a}{dD}$, where D is the monetary assets held by the central bank. Using the same procedure as used to derive the fiscal policy multiplier, the monetary policy multplier becomes:

$$\frac{dY^a}{dD} = \frac{I_r - K_r}{L_r(1-C_y) + I_rL_y - K_rL_y}$$

As the money supply is expanded, interest rates will decline and agricultural output will increase. If prices were included in the model, the interest rate decline would raise the aggregate demand and therefore raise prices. The price increase would affect aggregate supply and cause the real money balance effect to be undermined, therefore causing the LM curve to shift backwards and lessen the positive effect of the money supply increase on agricultural

[14] Robert Chambers, "Interrelationships Between Monetary Instruments and Agricultural Commodity Trade," *American Journal of Agricultural Economics*, vol. 63, p. 934.

output. In essence, the money supply expansion will have the same result as a depreciation in the domestic currency.

Much of the work on macroeconomic linkages to agriculture has been mainly concerned with the role of exchange rates on agricultural prices and exports. Theoretically, in a flexible exchange rate regime, with sufficient substitutability in agricultural import and export demand, a depreciation of the domestic currency will increase the export demand for agricultural products as determined by import demand elasticities, thus putting upward pressure on agricultural prices both in international and domestic markets. (This discussion is based on the trade balance portion of equation 2.9, as previously described.) The condition for sufficient substitutability (Marshall-Lerner Elasticity Condition) is met as long as the sum of the export demand elasticity (elasticity of exports with respect to relative prices) and the import demand elasticity is greater than unity.[15] Most of [illegible]'s agricultural exports are sold into competitive markets thus meeting the requirem[illegible]ficient substitutability for the agricultural trade balance. However, should a depreciat[illegible]ne dollar also cause domestic inflation, the Marshall-Lerner condition will not be sufficient to ensure an improvement in the trade balance.

Schuh first brought the attention of agricultural economists to these issues in a pioneering article in which he argued that the over-valuation of the U.S. dollar in the 1950s at its fixed rate played an important role in the decline of U.S. agricultural prices and profoundly influenced the rate of technical change in the industry.[16] Since Schuh's article, much analysis has been done on the impact of exchange rate movements on agriculture. Not all studies have been supportive of Schuh's conclusions, however. Kost's partial equilibrium analysis concludes that more research directed to effects of exchange rate changes on specific agricultural commodity prices and quantity would show that the impact of devaluations of the dollar would not be all that significant to agricultural trade.[17] Kost argues that although a

---

[15]W. Scarth, *op. cit.*, p. 130.

[16]G. Edward Schuh, "The Exchange Rate and U.S. Agriculture," ***American Journal of Agricultural Economics***, vol. 56, 1974, pp. 1-13.

[17]William Kost, "Effects of an Exchange Rate Change on Agricultural Trade," ***Agricultural Economics Research***, vol. 28, 1976, pp. 99-106.

devaluation of the domestic dollar raises both foreign demand and price for domestic agricultural goods, the quantity exported is controlled by the import and export demand elasticities. Kost assumes that export and import demand elasticities are low and as a result, movements in the exchange rate will change price more than quantity exported. If other policies such as stockpiling are involved, the impact of exchange rate fluctuations on agricultural prices will be smaller.[18]

Chambers and Just suggest that the standard two-country excess supply and demand model may be unnecessarily restrictive.[19] The excess demand equations, for example, can only be estimated if the assumption of zero cross-price elasticities between the traded agriculture goods and all other goods with flexible prices holds. Chambers and Just propose that rather than treating the exchange rate as a means of adjusting prices, as the classical two-sector models tend to do, the exchange rates should be incorporated directly into the excess supply and demand equations in order to distinguish the different effects arising from the exchange rate and price fluctuations.

Chambers and Just provide evidence to support their assertion in a econometric model consisting of fifteen equations which explain disappearances, inventories, exports and production for U.S. wheat, corn, and soybeans.[20] The results suggest that exchange rate changes significantly alter the levels of agricultural exports at the expense of domestic use. Barclay and Tweeten found similar results of the exchange rate on agricultural exports in another econometric model.[21]

---

[18]Maury E. Bredahl and Paul Gallagher, "Comment on "Effects of an Exchange Rate Change on Agricultural Trade," *Agricultural Economics Research*, vol. 29, 1977, pp. 45-48, examined conclusions made by Kost and by estimating the net elasticities of excess supply and demand curves without allowing domestic supply and demand curves to change with exchange rate changes, found that the quantity of goods traded due to fluctuations in the exchange rate may be quite large.

[19]R.Chambers and Richard E. Just, "A Critique of Exchange Rate Treatment in Agricultural Trade Models," *American Journal of Agricultural Economics*, vol. 61, 1979, pp. 249-257.

[20]Chambers and Just, "Effects of Exchange Rate Changes on U.S. Agriculture: A Dynamic Analysis," *American Journal of Agricultural Economics*, vol. 63, pp. 32-46.

[21]Tom Barclay and Luther Tweeten, *op. cit.*, p. 296.

Since the first empirical estimates of exchange rate impacts on agriculture were published, the major trading nations have moved from fixed to floating exchange rates. Agricultural economists, such as Chambers, now argue that too much emphasis has been placed on finding magnitudes of exchange rate adjustment on agricultural prices and exports, and not enough attention has been given to the variables determining floating exchange rate levels.[22] However, a problem arises in finding a common basis on which to start modeling exchange rate determination as a wide range of theoretical explanations exist. The issue becomes a question of which model type best explains exchange rate movements and what improvements can be made to improve the explanatory power of empirical models of the exchange rate.

Even leading models of exchange rate determination such as monetary models, monetary models with sticky prices, and portfolio balance models are not supported satisfactorily by empirical evidence.[23] Monetary models consider the exchange rate serves solely to equate prices of all goods in different currencies in order to achieve purchasing price parity. The exchange rate will follow a random walk if exogenous shocks follow a random process or the money demand is interest inelastic. In other words, changes in the money supply will cause equal changes in the exchange rate. However, in the sticky-price model of Dornbusch, changes in the money supply will lead, in the short term, to a larger change in the exchange rate relative to a change in the money supply, otherwise known as overshooting of the exchange rate.[24] Backus, however, finds no evidence of overshooting of exchange rates in his regressions using Dornbusch's sticky price model. Portfolio balance models also suggest declines in the exchange rate for increases in the money supply but instead of affecting exchange rate through prices, the demand for assets is directly affected by the exchange rate

[22]R. Chambers, "Interrelationships Between Monetary Instruments and Agricultural Commodity Trade," *American Journal of Agricultural Economics*, vol. 63, 1981, p. 935.
[23]David Backus, "Empirical Models of the Exchange Rate: Separating the Wheat from the Chaff," *Canadian Journal of Economics*, vol. 17, 1984, pp. 824-846.
[24]Rudiger Dornbusch, "Expectations and Exchange Rate Dynamics," *Journal of Political Economy*, vol. 84, 1976, pp. 1161-1176.

through the valuation of assets in foreign currencies.[25]

According to the small open economy model, restricting the money supply will increase the interest rate thus driving up the exchange rate which in turn will decrease the quantity of agricultural products exported. In a U.S. study, Batten and Belongia found no significant relationship between money supply growth and the real dollar value. The real exchange rate, however, was found to have a significant, negative effect on U.S. agricultural exports.[26]

Another issue raised with respect to money supply changes, exchange rate movements and the effect on agricultural prices and exports is the question of whether there is a distinction between the short and long run in whether prices are flexible or sticky. Denbaly and Williams examine the linkages between money supply changes and U.S. exports and prices of feedgrains.[27] In this model, linkages were dependent on two factors: the responsiveness of the exchange rate to money supply changes and the responsiveness of prices and exports to exchange rate changes. The conclusion drawn was that only a weak link was evident in the former and little reaction in the long run was demonstrated by the latter due to high price elasticity of U.S. agricultural export supplies and the protectioni   easures of other countries.

The possibility of direct linkages between the money supply and agricultural prices and exports is gaining increasing attention in the literature, placing further stress on the issue of the neutrality of money. The agricultural industry is possibly more sensitive to changes in monetary and fiscal policy due to the "flex-price" nature of agricultural products as compared to the "fixed" prices of most non-agricultural commodities. As a result of flex and fixed price behavior, changes in the money supply may cause agricultural prices to overshoot their long

---

[25]Backus, *op. cit.*, p. 833.
[26]Dallas Batten and Michael Belongia, "Monetary Policy, Real Exchange Rates, and U.S. Agricultural Exports," ***American Journal of Agricultural Economics***, vol. 68, 1986, pp. 423-427.
[27]M.S. Mark Denbaly and Gary W. Williams, "U.S. Money Supply and the Exchange Rate: Long Run Effects on the World Feed Grain Market," ***American Journal of Agricultural Economics***, vol. 10, 1988, pp. 49-62.

run value. In the perspective of the rational expectations school, however, a decline in the nominal money supply should cause the same decrease in the level of prices. However, because some non-agricultural prices are fixed in the short term, a fall in the nominal money supply will also mean a decrease in the real money supply and a rise in interest rates. Changes in the money supply may therefore cause agricultural commodity prices to overshoot their long run equilibrium value.[28]

The assumption of fixed prices for non-agricultural commodities and flexible prices for agricultural commodities is still controversial. Chambers found evidence of the non-neutrality of money in the short run in a model linking the financial and agricultural sectors. A preliminary empirical analysis showed agricultural prices to fall relative to non-agricultural prices in the short-run.[29] Bessler, however, using Granger-type causality techniques on Brazilian data, found no difference in the adjustment rates of agricultural and non-agricultural prices to changes in the money supply if the monetarist assumption that money supply shocks cause price changes is used in the ordering of the vector autoregression (VAR) model.[30] A different ordering, placing money supply after prices in the causal progression, results in weak support for the hypothesis of relative price changes.

Other monetary policy instruments, such as interest rates, have not been given as much attention in the literature as have the money supply and exchange rates. Frankel applied the Dornbusch overshooting model as developed for exchange rates to agricultural prices.[31] Declines in agricultural prices from 1980 to 1984 were found to be a result of rising interest rates, which in turn were created by a decline in the nominal and therefore real money supply. Given the capital-intensive nature of agriculture and current levels of debt to asset ratios, interest rate movements can have significant effects on agricultural costs and therefore can

---

[28]Jeffrey A. Frankel, "Commodity Prices and Money: Lessons from International Finance," *American Journal of Agricultural Economics*, vol. 66, 1984, pp. 560-566.
[29]R. Chambers, "Agricultural and Financial Market Interdependence in the Short Run," *American Journal of Agricultural Economics*, vol. 66, 1984, pp. 12-24.
[30]David J. Bessler, "Relative Prices and Money: A Vector Autoregression on Brazilian Data," *American Journal of Agricultural Economics*, vol. 66, 1984, pp. 25-30.
[31]J. Frankel, "Expectations and Commodity Price Dynamics: The Overshooting Model," *American Journal of Agricultural Economics*, vol. 68, 1986, pp. 344-348.

affect the levels of both storable and non-storable commodity (for example, breeding livestock) stocks. An increase in interest rates will cause supply-induced price declines as commodity stock levels are decreased. Both movements in the interest rate and changes in stock levels can produce changes in the value of the dollar which in turn creates pressure on grain prices given the export dependent nature of the agricultural sector.[32] Frankel's work demonstrates the need to recognize that although the U.S. and Canadian agricultural sectors are operating in an increasingly open economy and the need for emphasis to be placed on the effects of exchange rates, macroeconomic variables such as interest rates, important in both closed and open economies, must also be included.

Currently, new econometric techniques such as vector autoregressive models can be used to investigate linkages between macroeconomic variables and agricultural prices and exports while placing few restrictions on the model.[33] Orden used three- and six-variable vector autoregressive models to investigate empirical relationships between the money supply, the interest rate, exchange rate, general price level and agricultural exports and prices.[34] From the results, Orden was able to isolate linkages between the exchange rate, interest rate, and agricultural prices and exports as being particularily significant. However, as Orden points out, depending on whether one considers interest rates and exchange rates as independent of monetary policy or whether they can be controlled by government authorities will, in the former case, result in monetary policy being interpreted as having little significance on agricultural prices and exports or, in the case of the latter, having a substantial impact.

Given the present state of macroeconomics, much more empirical work will have to be completed before a concensus on the conceptual framework will be found. Literature from the

[32]Gordon C. Rausser, "Macroeconomics and United States Agricultural Policy" in *U.S. Agricultural Policy: The 1985 Farm Legislation*, Bruce L. Gardner, editor. Washington D.C.: American Enterprise Institute for Public Policy Research, 1985, p. 211.

[33]J. Taylor, *The Impacts of Monetary Macroeconomic Policy on Canadian Agricultural Prices*, Unpublished M. Sc. thesis, University of Saskatchewan, 1987.

[34]David Orden, "Money and Agriculture: The Dynamics of Money-Financial Market-Agricultural Trade Linkages," *Agricultural Economics Research*, vol. 38, 1986, pp. 14-28, and "Agriculture, Trade, and Macroeconomics: The U.S. Case," *Journal of Policy Modeling*, vol. 8, 1986, pp. 27-51.

United States suggests that the domestic money supply, exchange rates, interest rates, and the general price level will have significant impacts on agricultural prices and exports. From a Canadian standpoint, changes in United States macroeconomic policy may be as significant as domestic policy. The importance of world markets to Canadian agriculture requires that empirical evidence of causal linkages between macroeconomic variables and agricultural prices and exports be estimated for use in monetary and fiscal policy decision-making.

Effects of International Policy

To a large extent, research into the effects of the exchange rate as discussed in the previous section could be considered a result of events in international commodity and financial markets. Focusing on the impact of exchange rate movements has meant a shift from closed economy models to consideration of agriculture in the context of an open economy. However, although exchange rates are recognized as important influences on agricultural prices and exports, little research has been completed on linking the underlying macroeconomic policies of foreign governments to changes in agricultural trade.

In the standard open economy model with a flexible exchange rate, exogenous foreign macroeconomic policies can affect the Canadian agricultural prices and exports through foreign policy effects on foreign price levels and therefore foreign imports and exchange rates; and through effects of changes in foreign interest rates. Any foreign macroeconomic change that increases demand of Canadian agricultural products will cause the exchange rate to appreciate due to increasing demand for Canadian currency. The rising dollar dampens the volume of agricultural exports and may cause a decline in the domestic price for agricultural goods. On the other hand, a positive shock to the foreign interest rate will [illegible]crease the value of the Canadian dollar as a result of capital outflows (capital account po[illegible] equation 2.9). The foreign interest rate multiplier of the simplified model is:

$$\frac{dY^a}{dr^f} = \frac{L_r K_r}{L_r(1-C_y) + I_r L_y - K_r I_y}$$

An increase in the foreign interest rate will stimulate the domestic agricultural sector as the economy experiences a capital outflow and the domestic dollar falls in value. The depreciating exchange rate adds to the competitiveness of agricultural exports. This combination puts a positive pressure on the price level, causing a decrease in the real money balance and an increase in the domestic interest rate. The effects of a rise in the foreign interest rate are therefore buffered by the exchange rate.

The dominant role of the U.S. dollar in international capital markets prevents other countries from achieving independence from U.S. monetary policy. For example, suppose that the Canadian monetary authorities target the Canadian monetary growth rate to achieve particular policy objectives on the basis of expected foreign demand for Canadian currency. If the U.S. increases the U.S. money supply, and the change causes a decrease in the value of the U.S. dollar, demand will increase for other currencies (including Canadian). As a result, Canadian money supply will be more restrictive than the Canadian monetary authorities initially estimated.[35] A study by Bordo and Choudhri supported this conclusion by finding evidence of the influence of the U.S. monetary growth on Canadian monetary growth and, further, a link between the monetary-induced portion of the U.S. inflation and Canadian inflation.[36] While monetary authorities have control over their own money supply, the dominant role of the U.S. dollar in international markets prevents individual governments from following a path of monetary independence. Kuszczak and Murray used VAR analysis to evaluate the transmission of macroeconomic influences among the industrialized countries of Canada, France, Germany, Italy, Japan, United Kingdom, and the United States, with particular attention to interactions between the Canadian and United States economies.[37] The results supported the conclusion that foreign variables had a statistically significant impact on the Canadian economy as well as lending support to the authors' hypothesis that Canada's

[35]Rausser, *op. cit.*, p. 223.
[36]Micheal Bordo and Ehsan Choudhri, "The Link Between Money and Prices in an Open Economy: The Canadian Evidence from 1971 to 1980," *Federal Reserve Board of Saint Louis Review*, vol. 64, 1982, pp. 13-23.
[37]John Kuszczak and John D. Murray, *A VAR Analysis of Economic Interdependence: Canada, the United States, and The Rest of the World*. Bank of Canada Technical Report No. 46, March, 1987.

relationship with the United States is one of dependence.

Other studies provide evidence that foreign macroeconomic variables, other than the U.S. variables, are important in assessing the impacts of the international macroeconomy on agricultural exports. Penson and Babula modelled the effects of Japanese monetary policy on U.S. agricultural exports.[31] The conclusions indicate that domestic macroeconomic variables affecting the demand for foreign imports are of significance. Expansionary monetary policy in a foreign country can increase the demand for another country's exports through higher incomes and domestic inflationary pressures.

C. Conclusion

If any consensus can be reached from the existing literature and empirical work on the strength and effects of macroeconomic linkages on a country's agricultural sector, it is that a large amount of research is required in the area. Realization that macroeconomic variables directly and indirectly affect agricultural prices and exports has not produced a firm understanding as to how significant the macroeconomic linkages are to the agricultural industry. Such an understanding is necessary in order to appreciate the effects that government monetary and fiscal policies may have on the agricultural sector, both in the short and long term. Government policies aimed at achieving goals considered totally unrelated to the agricultural industry may prove to have undesirable impacts on agricultural prices and exports. Attention must be paid not only to domestic macroeconomic influences on agricultural prices and exports but also to the role played by international financial and commodity markets.

For the purposes of this study, identifying the effects of the macroeconomy on agricultural prices and exports, the above model and existing literature provides a valuable means of narrowing the scope for analysis. Exchange rates appear to be a major factor in explaining changes in both agricultural exports and prices. Domestic money supply and

[31]John B. Penson and Ronald A. Babula, "Japanese Monetary Policies and Agricultural Exports," *The Journal of Agricultural Economics Research*, vol. 40, no. 1, Winter, 1988, pp. 11-18.

domestic and foreign interest rates as important influences on the exchange rate will need to be included. The direct effect of these variables on agriculture will also be of interest. The dominating presence of U.S. monetary policy in international capital markets suggests that the U. S. money supply and interest rate may be the most important foreign macroeconomic variables to consider. Although fiscal policy can be important to agriculture, especially in the form of agricultural subsidies, it will not be included due to its apparently less direct importance when compared to other variables.

The following chapter will present the advantages and limitations of the vector autoregression technique as well as the data series chosen for modelling purposes.

III. Empirical Framework

A. Introduction

The objective of this study is to develop an econometric model to analyze the effects of changes in domestic and international macroeconomic variables on Canadian agricultural prices and export quantities. Given the dissimilar, and often conflicting, conclusions of different models, it is desirable to avoid as many restrictions as possible. Vector autoregression techniques (VAR) are a natural first step in identifying relationships between macroeconomic variables as a means of clarifying issues without reliance on overly restrictive economic theory. VAR models identify the interactions among variables by lagging each variable on itself and all other variables in the model. The VAR technique therefore can avoid the exogeneity and functional form restrictions imposed by more structural models.[39] Theoretical considerations must be given, nevertheless, to other strong assumptions required by VAR models such as ordering of variables and lag lengths.

Vector autoregressions estimate the dynamics of an economic system through two techniques. Impulse response functions, also known as moving-average measures, can demonstrate the effects of an unit shock of one variable on that variable's time path and the time paths of all other variables in the model. Decomposition of forecast error variance can help to understand causal relationships and also make inferences as to the relative strength of relationships at various lag lengths.[40] Techniques of VAR estimation and restrictions of which one should be aware are discussed in the following section.

---

[39]Girard W. Bradshaw and David Orden, "Time Series Models for Exchange Rate and Agricultural Price Forecasts," proceedings of a seminar sponsored by Southern Regional Project S-180, "An Economic Economic Analysis of Risk Management Strategy for Agricultural Production Firms," Savannah, Georgia, March 20-23, 1988.
[40]D. Bessler, "An Analysis of Dynamic Economic Relationships: An Application to the U.S. Hog Market," *Canadian Journal of Agricultural Economics*, vol. 32, 1984, p. 111.

B. Techniques of VAR Estimation

Introduction

A VAR model is created by estimating a set of regression equations in which the current value of each variable is a function of the lagged values of all variables.

In vector notation, the time series model underlying the vector autoregressive model can be represented as:

$$\sum_{k=0}^{\infty} Y_{t-k}\beta(k) = \sum_{k=0}^{\infty} v_{t-k} \qquad (1)$$

where Y_t is a 1 x n vector of endogenous variables; $\beta(k)$ is a n x n matrix of estimated coefficients on the lagged values of the endogenous variables; v_{t-k} is a 1 x n vector of error terms assumed independent (no serial correlation between v_t and v_s when t is not equal to s) and normally distributed with a mean of zero. It is assumed that v_{t-k} equals zero for all k greater than zero. A more complex VAR model can be created with the addition of a constant and dummy variables to capture unknown deterministic trends.

Every variable is included in all the equations of other variables and, unlike structural models, no variable is considered prior to modeling to be exogenous.[41] The basic estimating equation (as shown below), is of the form:

$$Y_t = \sum_{k=1}^{\infty} D(k)\, Y_{t-k} + u_t \qquad (1')$$

where D(k) is $-\beta(k)\beta(0)^{-1}$ and u_t is $v_t\beta(0)^{-1}$. Therefore, because the right hand side regressors are the same for all equations, ordinary least squares (OLS) will produce efficient estimates.

Stationarity of Time Series

A crucial assumption in the estimation of VAR equations is that the data represents a covariance stationary process.[42] Without stationarity in the time series, it is unjustified to

---

[41] This section is adapted from a number of sources, primarily D. Bessler, *op. cit.* and David Orden, "Money and Agriculture: The Dynamics of Money-Financial Market-Agricultural Trade Linkages," *Agricultural Economics Research*, vol. 38, 1986. Issues raised by other studies will be referenced accordingly.

[42] G. Judge *et. al.*, *Introduction to the Theory and Practice of Econometrics*, New

assume the stable probability laws necessary for VAR modelling. The essence of vector autoregressions is the information gained from the analysis of the error terms. Stationary data satisfies the conditions required to decompose the time series into two parts, a stochastic (random) portion and a portion completely predictable from past values of the series.[43] Nonstationarity in a VAR model time series can cause the forecast errors to be biased. Further, because the covariance between time series is not independent of time in nonstationary data, the decomposition of errors may be misleading.[44] It is generally unrealistic to assume the stationarity of data time series. As a result, it may be necessary to transform the data in order to remove trend and seasonal components that would violate the covariance stationarity assumption.

There are a number of ways to test for stationarity in economic time series data. Direct observation of the autocorrelation coefficient plots can produce quick conclusions as to the existence of nonstationarity. If the data series is stationary, one would expect the autocorrelation plots to either taper off quickly after one lag, thus representing a MA function, or to tail off in an exponential, sinusoidal, or geometric fashion with a larger number of nonzero values as demonstrated by AR and ARMA functions. A slow decrease in the values of the autocorrelations indicate the current period's dependence on past periods and therefore, the nonstationarity inherent in the data series. Differencing a non - stationary data series one or several times should produce stationarity whereby the autocorrelation plots demonstrate one of the patterns described previously.[45]

---

[42](cont'd) York: John Wiley and Sons, 1982, p. 226. A covariance stationary process is a process in which the time series, x_t, has a constant mean, finite variances and covariances, and covariance independent of time.

[43]VAR modeling was developed from Wold's Decomposition Theorem (proved by Herman Wold in 1938) which shows that a stationary time series can be decomposed into two parts, one random, and one completely predictable. For a detailed description see Nerlove, Grether, and Carvalho, *Analysis of Economic Time Series: A Synthesis*, New York: Academic Press, 1977, pp. 29-36.

[44]J. Robertson and D. Orden, "Cointegration and Long-Run Monetary Neutrality: A Vector Error-Correction Model of Money and Price Dynamics in New Zealand," paper presented at the AAEA Meetings, Knoxville, Tennessee, Aug. 1-3, 1988, p. 3-4.

[45]Douglas Montgomery and Lynwood Johnson, *Forecasting and Time Series Analysis*, New York: McGraw-Hill Book Company, 1976, pp.208-209.

A more sophisticated approach to test for stationarity in a data series is to use a Dicky-Fuller test statistic.[46] However, estimation of coefficients for testing will produce coefficients with the minimum residual variance. The resulting distribution of the Dickey-Fuller test can conclude that the data is stationary when in fact the data series is nonstationary. The concept of cointegration has been advanced as a reason for such data transformation problems.[47] A time series that may individually be nonstationary, could prove to share a common random trend with one or more time series which are therefore cointegrated.

In economic time series, it should not be surprising to find evidence of cointegration between variables. For example, if the hypothesis of long-run neutrality of money is valid, then it is only natural that economic variables linked to money in the long run equilibrium will exhibit a tendency to maintain a consistent, proportional relationship over time. Engle and Yoo demonstrated in a simulation study comparing unrestricted VAR models with a VAR model imposing a cointegration restriction, that, if cointegration is present, a VAR model in differences is potentially misspecified and a VAR model in levels, although not misspecified, will possibly underestimate the parameters.[48] Concerns about cointegration, while valid, were not considered crucial for the data analysis in this study. Nevertheless, testing the data for cointegration is an area for further research.

Determination of Lag Length

After having selected a set of variables, and, if necessary, transforming the variables, the second step in VAR modeling is to determine the lag lengths of the equations. Proper selection of the lag length is essential for an appropriate finite approximation of an infinite VAR series. Several methods are used to establish lag lengths. The simplest approach is to

---

[46] Wayne Fuller, *Introduction to Statistical Time Series*, New York: John Wiley and Sons, 1976. See Table 8.5.2, p. 373.

[47] See R. F. Engle and C. W. J. Granger, "Co-integration and Error Correction: Representation, Estimation and Testing," *Econometrica*, vol. 55, no. 2, 1987, pp. 251-276.

[48] R. F. Engle and B. S. Yoo, "Forecasting and Testing in Co-integrated Systems," *Journal of Econometrics*, vol. 35, 1987, pp. 143-159.

define the lag lengths on the basis of economic intuition. A second method is Sim's approach of comparing models of different lag lengths using the asymptotic Chi-squared statistic:

$$(T-c)[\log \det\Sigma_1 - \log \det\Sigma_2]$$

where Σ_1 and Σ_2 are the covariance matrices of the respective models, T is the number of observations, and c is a multiplier correction (number of parameters in each unrestricted VAR equation). Such an approach finds the most suitable aggregate lag length but can result in incorrect lag lengths for some series. The advantage of the technique lies in the limits placed on the amount of estimation required. A third, more complex, approach is Akaike's suggestion to choose the model that maximizes the $\log(L_q - K_q)$, where L_q is the likelihood function maximized with respect to the parameters estimated; K_q represents parameters to estimate. A variation of the Akaike approach is the Schwarz test that suggests maximizing log $L_q - K_q \log n/2$, where n is the number of observations. The Schwarz criterion tends to favour shorter lag lengths.[49]

Impulse Response Functions and Forecast Error Decompositions

The autoregressive parameters estimated by OLS in equation (1) represent the expected evolution of the economy by explaining how each variable evolves through time. Shocks that cause deviations from the expected evolution are measured by the error terms of the autoregressive equation. However, shocks that have a direct impact on one variable may have an indirect impact on other variables through interactions between variables. Interpretation of the autoregressive parameters becomes very complex given the difficulty in separating the direct and indirect effects of a specific shock on the past evolution of the economy. Evaluations ·eractions between variables is therefore accomplished through the use of impulse response functions (moving averages) which examine the effects of the error terms on further evolutions of the variables in the model.

Separation of the effects of unexpected shocks from the expected evolution of the economy requires transformation of the estimated autoregressive equations in order to

[49]See T. A. Sanni, "Vector Autoregression on Nigerian Money and Agricultural Aggregates," *Canadian Journal of Agricultural Economics*, vol. 34, 1986, p.73.

produce the moving-average representations of the VAR model. Moving-averages, or impulse response functions, are calculated through a sequence of substitutions in which lagged values of the right hand side variables are replaced by their own variable's autoregressive equation. In order to convert the autoregressive process to a moving average, consider again equation (1):

$$\sum_{k=0}^{\infty} Y_{t-k}\,\beta(k) = \sum_{k=0}^{\infty} v_{t-k} \tag{1}$$

The covariance matrix of v(t), Ω, is assumed to be diagonal(no serial correlation), therefore restricting the error terms (shocks) to a single equation. The assumption of no serial correlation restricts the ordering of variables in the model. Orthogonalization of the error terms is discussed in the following section. Given that the shocks are assumed to influence their respective equations at a single moment in time, equation (1) can be rewritten as:

$$Y_t\beta(0) = -\sum_{k=1}^{\infty} Y_{t-k}\,\beta(k) + v_t \tag{2}$$

Multiplying (2) by the inverse of $\beta(0)$ produces:

$$Y_t = -\sum_{k=1}^{\infty} Y_{t-k}\,\beta(k)\beta(0)^{-1} + v_t\beta(0)^{-1} \tag{3}$$

Substituting D(k) for $-\beta(k)\beta(0)^{-1}$ and u_t for $v_t\beta(0)^{-1}$ yields the standard vector autoregressive representation of equation (1):

$$Y_t = \sum_{k=1}^{\infty} D(k)\,Y_{t-k} + u_t \tag{3a}$$

Ordinary Least Squares estimation will provide efficient estimates because each equation has identical right hand regressors.

The error term u_t, becomes the prediction error in Y for one period in the future. The covariance of u_t is:

$$\Sigma = E[\beta(0)^{-1}v_t v_t^T\beta(0)^{-1}]$$

where $v_t v_t^T$ is the variance of v_t, Ω. Therefore,

$$\Sigma = E[\beta(0)^{-1}\,\Omega\,\beta(0)^{-1}].$$

Inverting equation (3a) will yield the moving average representation of the autoregressive equations:

$$Y_t = \sum_{k=1}^{\infty} A(k)u_{t-s} \tag{4}$$

where $\sum_{k=1}^{\infty} A(k) = \sum_{k=1}^{\infty} D(k)^{-1}$.

If A(0) can be normalized as the identity matrix (I) then the non-orthogonalized moving average coefficients of equation (4) will describe the resulting effect of a unit shock to one variable on the time paths of each variable (as all other shocks are set to zero). The innovation process, u_t, of the impulse response functions therefore indicates both current and future impacts of a single shock on all variables, assuming that no future shocks occur and all variables evolve naturally following reaction to the shock.[50]

The decomposition of forecast error variance, also derived from computation of the moving-average coefficients, gives the relative strengths of interactions between variables. Given that the shocks are random and all additional shocks have been restricted so as to have no impact on the model, the variance of the forecast errors can be estimated from the standard error terms of the autoregressive equations. Portions of the variances in shocks of each variable are attributed to innovations (shocks) in each variable. If, for example, most of the variance in a variable's error term is due to innovations in another variable, it can be

[50]The computation of impulse response functions can be more easily understood through the use of a two variable example, x_t and z_t, where x_t and z_t are equal to two lags of past values of both variables. The VAR system is represented as:

$$x_t = a_0 + f(x_{t-1}, z_{t-1}) + g(x_{t-2}, z_{t-2}) + e_t \quad (a)$$

$$z_t = a_1 + f(x_{t-1}, z_{t-1}) + g(x_{t-2} \quad) + g_t \quad (b)$$

and $[x_t \; z_t]' = Y_t$ as given in equation (1, from the above text.

Instead of identification of simultaneous equations in the structural sense, VAR places zero restrictions on the covariance matrix. The moving average process is calculated from the autoregressive equations through an iterative procedure:

$$x_t = d_{11}x_{t-1} + d_{12}z_{t-1} + e_t \quad (c)$$

$$z_t = d_{21}x_{t-1} + d_{22}z_{t-1} + g_t \quad (d)$$

Rewrite (c) into (c1) by shifting the series by one (same procedure for (d)):

$$x_{t-1} = d_{11}x_{t-2} + d_{12}z_{t-1} + e_{t-1} \quad (c1)$$

Substitute (c1) into (c):

$$x_t = d_{11}(d_{11}x_{t-2} + d_{12}z_{t-1} + e_{t-1}) + d_{12}(d_{21}x_{t-2} + d_{22}z_{t-2} + g_{t-2}) + e_t \quad (c2)$$

The iterative procedure is continued until the regressions have been turned into a moving-average process:

$$x_t = e_t + a_{11}e_{t-1} + \ldots + a_{1k}e_{t-k} + a_{21}g_{t-1} + \ldots + a_{2k}g_{t-k} \quad (c3)$$

As an example of interpretation, a shock to z_{t-1} will be the error term g_{t-1} and the effect of the shock on x_t is equal to a_{21}.

concluded that innovations in the latter variable have a dominant effect on the fo: er.

Orthogonalization of Error Terms

Estimating both the impulse response functions and the decomposition of forecast error variance can become complicated if errors associated with specific variables are contemporaneously correlated, resulting in misleading conclusions as to effects of unit shocks to one variable. Separating the desired error terms, v_t from the $\beta(0)^{-1}$ term in the covariance of the prediction error term, u_t, requires the individual estimation of $\beta(0)^{-1}$. The error term, v_t, can be found given that $u_t = \beta(0)^{-1}v_t$, therefore equation (4) yields:

$$Y_t = \Sigma v_t \beta(0)^{-1} A(k).$$

Orthogonal ordering, which chooses a particular order of variable, can be used to address this problem. The standard approach is to use Choleski decomposition to remove any portion of a shock to each variable that is explained by contemporaneous shocks to variables previously estimated, thus imposing a recursive causality on variables in the model. Although $\beta(0)^{-1}$ is unknown, the variance/covariance matrix, Σ, can be estimated. Choleski's decomposition transforms Σ in order to set $\Sigma = \beta(0)^{-T} \beta(0)^{-1}$ such that the estimated $\beta(0)^{-T}$ forms an unique lower triangular matrix. Each ordering of the variables results in a different factorization, thereby allowing the sensitivity of the results to be compared by switching the order of the variables in the model and recomputing the variance decomposition and impulse response functions.[51] The initial criteria for the ordering of the variables usually rests with a structural economic interpretation, where the variable explaining the most variation in other variables should be placed first.

The use of VAR models to define dynamic linkages between macroeconomic variables is still controversial. Critics maintain that the shocks defined by the process of estimation and orthogonal transformation of the error terms cannot have a well-defined economic

[51]See D. Bessler, "Relative Prices and Money: A Vector Autoregression on Brazilian Data," *American Journal of Agricultural Economics*, vol. 66, 1984, for a more technical explanation of an orthogonalizing transformation using the standard method of Choleski decomposition to produce a Wold causal chain.

interpretation. In a mathematical example, Angeloni demonstrates that the standard approach of ordering variables to ensure that the residuals are orthogonal and therefore not serially correlated, requires the assumption that the underlying model is strictly recursive. If economic theory does not support the assumption of recursive ordering of variables within the model, the economic analysis of the model results are suspect. Even if the robustness of the model is tested by changing the ordering of the variables in the model, it is not possible to claim the impulse response functions are valid.[52]

Orthogonalization of a VAR model does not necessarily have to be performed using the Choleski decomposition approach. Newer studies have demonstrated a method of orthogonalization through model estimation.[53] Bernanke obtained the serially uncorrelated residuals from estimation of the standard VAR model, and then avoided conventional orthogonalization procedures by equating theoretical population moments with sample moments of the residuals (method of moments). Having defined all parameters of an identified system, the numerical estimates are defined through two stages. Non-zero parameters are found for the residuals (serially uncorrelated structural disturbances) and the model's variables by setting all elements of the symmetric matrix on the right hand side below the diagonal equal to zero. Given the parameter estimates, the non-zero values of the variance/covariance matrix can be taken from the right hand side of the method of moments equation. Although the assumption of a diagonal variance/covariance matrix is still necessary, the *a priori* assumption of a strictly recursive model is avoided.

Calculation of the Moments of the Impulse Response Functions

The estimation of impulse response functions from a single population is not particularily useful without an indication of significance levels. As a result, it is necessary to draw parameter values from the distribution space defined by the parameter space of the

[52]Ignazio Angeloni, "The Dynamic Behavior of Business Loans and the Prime Rate: A Comment," *Journal of Banking and Finance*, vol. 9, 1985, pp. 577-580.
[53]Ben S. Bernanke, *Alternative Explanations of the Money-Income Correlation*, Working Paper #1842, National Bureau of Economic Research, Cambridge MA., February, 1986.

impulse response functions in order to determine confidence intervals. While several methods exist, the Monte Carlo technique based on the Bayesian inference theory appears to be one of the most computationally efficient in problems with large dimension requirements. Using the procedure outlined by Kloek and van Dijk, the Monte Carlo technique can derive the standard deviations and means of the posterior moments of the VAR impulse response functions.[54] Any impulse which is two standard deviations away from zero is considered to be significantly different from zero.

Use of Bayesian Prior in Estimation

While VAR modeling has an intuitive appeal in that little emphasis must be placed on *a priori* economic restrictions, the forecasting results from VAR modeling have not been completely satisfactory. Part of the problem in VAR modeling is the large number of parameters in unrestricted VAR estimation. Possible overparameterization in VAR models may cause the resulting variances to be too large to produce accurate forecasts. Purely random fluctuations (outliers in the data) may obscure the systematic variation that the modeller wishes to capture.[55] Work by Tiao and Box in unrestricted VAR models attempted to improve variances by excluding variables with insignificant coefficients from each equation.[56] Unfortunately, deleting coefficients that on their own may be insignificant ignores the possible statistical importance of the coefficients as a group. Bayesian prior estimation as an alternative technique, is a technical procedure which applies prior distribution weights to the VAR parameters, thus decreasing the variances without actually having to delete coefficients.

The actual designation of prior distributions to estimated parameters can be quite difficult. Individual specification of each prior distribution may prove too time consuming in large models, as well as require an incredible amount of knowledge of the data series involved.

---

[54] T. Kloek and H. K. van Dijk, "Bayesian Estimates of Equation System Parameters: An Application of Integration by Monte Carlo," *Econometrica*, vol. 46, no. 1, January, 1978, pp. 1-19.

[55] Personal communication with C. Sims, November, 1988.

[56] G. C. Tiao and G. E. P. Box, "Modeling Multiple Time Series with Applications," *Journal of American Statistical Association*, vol. 76, 1981, pp. 802-816.

Bessler and Kling have applied system wide Bayesian priors of both a symmetric and general form on U.S. hog price data. [57] Using the procedure outlined by Bessler and Kling, each dependent variable is allowed to follow a random walk process by setting the prior mean of the first lag of the dependent variable to one; prior means on all other lags and variables are set equal to zero. Estimation of the distributions of the prior means requires the specification of weighted standard deviations which are adjusted for rates of decay. In this manner, distributions of the Bayesian priors determine the rate at which past lags approach their mean values. [58]

Other applications of Bayesian priors are difficult to find in the literature. Given the potential value of the priors in allowing the relaxation of restrictions as to parameter values, more opportunities for the application of this technique are to be expected.

Summary

Although VAR models are supported for their ability to analyze data without placing *a priori* restrictions on the data, the technique of VAR estimation is not without restrictions that must be understood. The ordering of variables within a model, for example, places a severe recursive restriction on the model preventing error terms of variables lower in the ordering from influencing higher placed variables. Care must therefore be exercised in the selection of model ordering. Despite problems that have yet to be resolved, VAR estimation procedure is a useful technique in many situations. Given the controversy as to the true relationship between macroeconomic variables and Canadian agricultural prices and exports, it would appear that VAR modeling is a useful first step in defining relationships between variables.

[57]D. Bessler and J. Kling, "Forecasting Vector Autoregressions with Bayesian Priors," *American Journal of Agricultural Economics*, vol. 68, 1986, pp. 144-151.
[58]Steve Ford, *A Beginner's Guide to Vector Autoregression*, University of Minnesota: Department of Agricultural and Applied Economics, Staff Paper P86-28, Sept. 1986.

C. Data

An analysis of the effects of changes in domestic and international macroeconomic variables on Canadian agricultural prices and exports requires a specific data base. In order to capture short term as well as long term fluctuations, the data set is comprised of monthly data from 1971 to 1987. Variables in the model and their acronyms are:

1. Canadian currency and demand deposits excluding the Canadian dollar float (cheques and other items in transit) in billions of dollars (CDNM1). Source: Cansim-Statistics Canada.
2. United States Money Stock (M1), seasonally adjusted, in billions of U. S. dollars (USM1). Source: Cansim-Statistics Canada.
3. Canadian Consumer Price Index (1981=100) as a measure of the general price level (CPI). Source: Cansim-Statistics Canada.
4. Interest rate on Canadian 91-Day Treasury Bills (TBI). Source: Cansim-Statistics Canada.
5. Interest rate on United States 91-Day Treasury Bills (TBUS). Source: Cansim-Statistics Canada.
6. Farm Product Price Index (formerly the Index of Farm Product Prices; 1981=100) (FPI). Source: Statistics Canada, Cat. No. 62-003. The index is based on prices for fifty farm products making up ninety percent of total farm cash income.
7. Value of Canadian agricultural exports (AGEX). Finding monthly data on Canadian agricultural exports proved difficult given that Statistics Canada only publishes combined groupings of manufactured agricultural products and primary agricultural products on a monthly basis. Using several Cansim series, a proxy for total value of Canadian agricultural exports was calculated by totaling the monthly exports of wheat, barley, oilseeds, other cereal grains, and live animals. Annual records from *Canada's Trade in Agricultural Products* (1968-1986) indicates that this particular combination accounts for between 54 to 74 percent of total Canadian agricultural exports, including processed agricultural products, in any given year.

8. The United States spot exchange rate in Canadian dollars (US/CDN). Source: Cansim-Statistics Canada.

9. The Canadian dollar index against G-10 currencies (1971=100) (G10). Source: Cansim-Statistics Canada.

The data are not deflated in this study. Concern has been raised as to whether deflating data for econometric modeling actually eliminates inflation effects as the procedure is meant to accomplish, or whether deflating data may be biasing estimated coefficients.[59] Orden recognized the possible distortions in results due to moving the analysis from directly observable nominal data to a deflated data series. As a result, Orden estimated two models of money, financial markets and agriculture: one using deflated data and one using nominal values. The major conclusions drawn from the studies were supported by the results of both models. Furthermore, as Orden points out, the real effects of specific shocks from a model using nominal values can be calculated "by subtracting the simultaneous effects of various shocks on the price level from their effects on other nominal variables."[60]

D. Conclusion

The purpose of this study is to examine the influences of domestic and international macroeconomic variables on Canadian agricultural prices and export quantities. The Vector Autoregressive technique was chosen to model the effects of macroeconomic variables because of the technique's advantage over structural models in avoiding restrictive assumptions. As a time series representation, the VAR technique can identify relationships between variables as a means of clarifying issues without reliance on overly restrictive economic theory. The data series for the VAR model was selected on the basis of economic reasoning and consideration of past research. The following section outlines the model estimation, results, and implications.

---

[59]Robert Thompson, "On the Power of Macroeconomic Linkages to Explain Events in U. S. Agriculture: Discussion," *American Journal of Agricultural Economics*, vol. 63, 1981.

[60]David Orden, *op. cit.*, and "Agriculture, Trade, and Macroeconomics: The U.S. Case," *Journal of Policy Modeling*, vol. 8, 1986.

IV. Model Estimation, Results, and Implications

A. Introduction

This chapter describes the data transformation and the estimation of several VAR models. Two unrestricted VAR models are estimated in order to test the significance of the influence of the different exchange rates. The unrestricted VAR models are also used as controls for the estimation of a restricted VAR model using Bayesian priors.

The results of the model estimation are also presented in this chapter. However, only the impulse response functions and forecast error decompositions for the agricultural variables are recorded; the results for the macroeconomic variables are found in the appendix. Implications and a summary conclude the chapter.

B. Data Transformation

Transformation of the data were required in order to ensure that the data represented a covariance stationary stochastic process. The data was examined for nonstationary through direct observation of the autocorrelation coefficients.[61] The autocorrelations are assumed to be normally distributed with a mean of zero and a variance of 1/N, where N is the number of observations. A ninety-five per cent confidence interval ($\pm 2/\sqrt{N}$) was estimated. Any autocorrelation plot a distance of $2/\sqrt{N}$ away from zero is accepted as significantly different from zero.[62] The data series is accepted as stationary if the autocorrelation plots do not exhibit a significant slowly declining pattern. A data series is also considered stationary if the only significant plots exhibit a cyclical or seasonal pattern.

The autocorrelation coefficients were first plotted for the level values of each variable. Every series exhibited nonstationarity in levels data. The farm price autocorrelation plots

---

[61] The Dickey-Fuller test statistic (W. Fuller, *op. cit.*, p. 373) was also used to test for nonstationary data. Some of the results of the D-F tests conflicted with the conclusions drawn from direct observation and were contrary to what was expected from the data. Concerns about problems in the D-F tests due to drifting in economic data series lead to the decision to accept the conclusions of direct observation.

[62] George Judge, *et. al.*, *op. cit.*, pp. 671-680.

given as an example in Figure IV.1 and IV.2 show how the nonstationarity indicated by the slow decline in the autocorrelation values was eliminated by taking the first differences of the data. Taking the natural logarithms of the data in both levels and differences did not result in stationarity. Using direct observation, the interest rates, exchange rates, the Canadian money supply, and the farm price index could be considered stationary after the data series were first differenced. The United States money supply, the agricultural exports and consumer price index required second differencing. Seasonal dummies, a constant, and trend variable were added to account for any remaining trend in the data.

C. Model 1 Estimation: U.S./Canadian Exchange Rate Model

An eight variable model was chosen initially, consisting of the U.S./Canadian exchange rate, the U.S. and Canadian Treasury Bill rates, the United States and Canadian money supplies, the Canadian agricultural exports and both the consumer and farm price indices.

The appropriate lag lengths for the VAR models were chosen on the basis of Sim's likelihood ratio test. Table IV.1 presents the test results. A lag length of half a year was chosen as the initial starting point based on previous studies and a prior belief that six months should be an adequate explanatory time period. A system wide lag length of six months was tested against a lag length of five months. The null hypothesis, five lag lengths is equivalent to six lag lengths, was rejected at a ninety-five per cent level of significance. A six lag model was tested against a model of seven lags. The null hypothesis was again rejected. A seven lag system was then tested against a model of eight lags. At a ninety-five per cent confidence level, seven lags were selected as the proper lag length for the eight variable model. The summary statistics for the final eight variable model are reported in Table IV.2. The significance level in the last column of Table IV.2 represents the significance of the Ljung-Box Q test for serial correlation. Through the use of the Q test, the agricultural export equation is considered to have problems of autocorrelation.

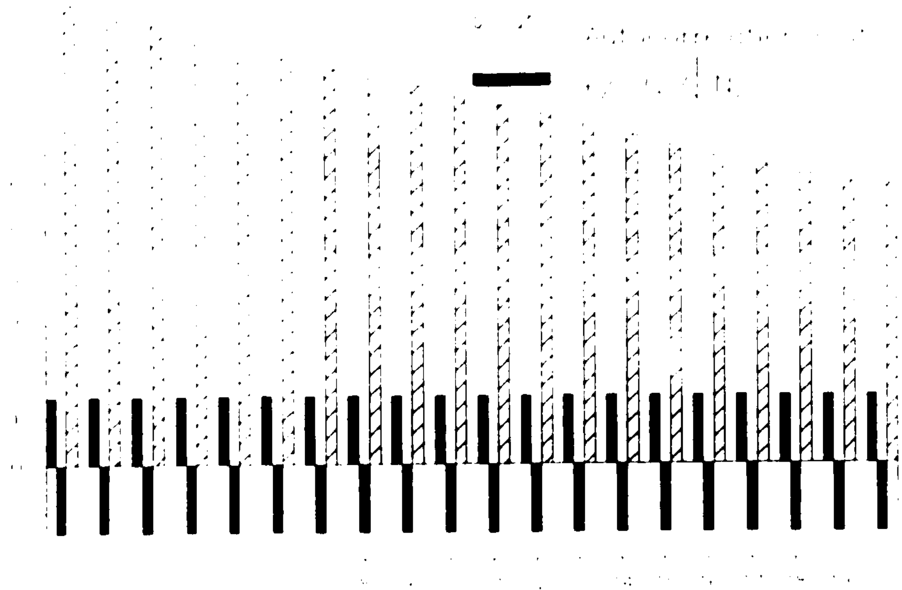


Figure IV.1: Farm Price Autocorrelation Plots in Levels Data.

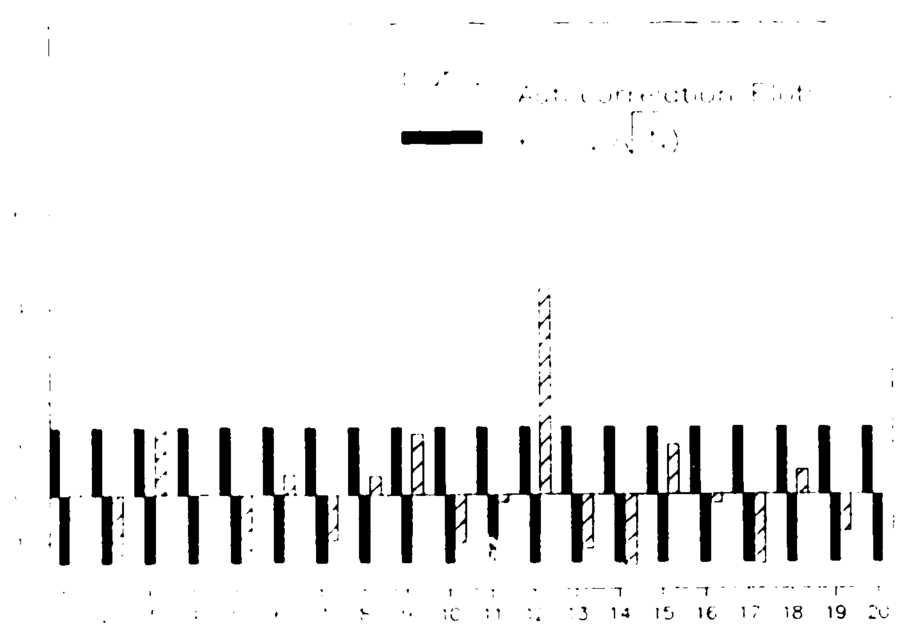


Figure IV.2: Farm Price Autocorrelation Plots After First Differencing.

Table IV.1: Model 1 Tests for Lag Length

Lags	Chi-Square	Significance Level	Decision*
6 vs 5	(64) = 125.42	.0000	reject 5
7 vs 6	(64) = 87.936	.0253	reject 6
8 vs 7	(64) = 71.464	.2438	accept 7

* = 95 per cent confidence level
( ) represent degrees of freedom restriction

Table IV.2: Model 1 Summary Statistics

Equation	R^2	R^{2A}	D-W	SSR	SSE	Q(39)	Sig Level
USM1	.662	.415	2.055	731.91	2.430	24.159	.970
CDNM1	.587		1.926	7.6432	.2483	27.549	.915
US/CDN	.425	[illegible]	2.036	.01400	.0106	34.913	.657
TBUS	.534	[illegible]	2.024	54.887	.6653	28.914	.881
TBI	.663	[illegible]	1.979	27.645	.4722	33.133	.734
CPI	.702		2.004	9.0710	.2705	33.372	.724
AGEX	.786	.6[illegible]	2.078	.83E+12	81847.0	60.519	.015
FPI	.476	.188	2.006	625.12	2.245	40.574	.401

Each equation in the model was tested for the significance of the coefficients on the lagged variables. Table IV.3 reports the significance levels of the following null hypothesis; the coefficients of the lagged variables are not significantly different from zero. According to the model results, at a ninety-five per cent significance level, there is only minor evidence that the macroeconomic variables affect agricultural prices and exports, but appreciable evidence that macroeconomic variables influence other macroeconomic variables. No variables exhibited lagged values significantly different from zero in the farm price equation. Lagged values of exports are considered significant in the agricultural export equation. Interactions of macroeconomic variables with other macroeconomic variables appear to be more complicated. Lagged values of the U.S. money supply, the Canadian money supply, and the U.S. interest rate are significant in the U.S. money supply equation. The FPI is also significant in the U.S. money supply equation; an unexpected result which may be due to spurious behavior on the part of the FPI data series. The Canadian money supply is also influenced by the lagged values of the U.S. money supply and the American interest rate as expected of a small open economy. Only lagged values of the U.S. interest rate are significant in the exchange rate equation and the U.S. interest rate equation. The Canadian interest rate, on the other hand, tests significant for lagged values of both money supplies, the American interest rate, and the FPI and agricultural exports. The CPI is considered exogenous, as only lagged values of the CPI are significant in the CPI equation.

To avoid problems resulting from contemporaneous correlations betw[illegible]n error terms, the variables are ordered on the basis of the causality implications [illegible] statistics and economic reasoning, whereby the most exogenous variables are placed firs[illegible] Other models have been ordered to allow specific variables to have as much influence on other variables as possible. Orden, for example, placed the money supply first to give this variable the maximum chance to affect the agricultural variables.[63] The initial eight variable model is arranged as follows: the United States money supply, the Canadian money supply, U.S. interest rate, U.S./Canadian exchange rate, Canadian interest rate, CPI, Canadian agricultural exports and farm price index. The placing of exports before farm prices may be questioned. Clearly, the price of commodities will in part determine the level of export demand; on the other hand, trade in agricultural products is an influence on the domestic agricultural prices, thus creating a bi-directional situation. Exports are ordered first based on the belief that in short time frames prices will adjust quicker to quantity changes than export quantities will adjust to price changes. Comparisons of forecast error decompositions with different arrangements of the variables indicated little sensitivity to changes in the ordering.

The ordering of variables is not considered to be a severely restrictive assumption in the model estimation. The data series consists of time periods short enough to suggest that the recursivity imposed on the model should not be a problem. There is, however, some evidence

[63] Orden, *op. cit.*, 1986, p. 19

Table IV.3: Model 1 Significance of Lags

Dependent Variable	Lagged Variables: USM1	CDNM1	US/CDN	TBUS	TBI	CPI	AGEX	FPI
USM1	0.0* ([illegible]1.61)	.0313* (2.293)	.8105 (.5299)	.0298* (2.314)	.9204 (.3661)	.9623 (.2759)	.7717 (.5[illegible]3)	.03025* (2.308)
CDNM1	.0099* (2.790)	.0825 (1.856)	.3921 (1.062)	.0245* (2.399)	.0002* (4.342)	.0693 (1.936)	.8375 (.4939)	.4421 (.9894)
US/CDN	.0617 (1.99)	.9167 (.3727)	.3923 (1.062)	.0188* (2.514)	.5998 (.7866)	.6397 (.7385)	.1444 (1.590)	.1426 (1.596)
TBUS	.0204* (2.479)	.0[illegible]09* (2.298)	.9046 (.3936)	.1443 (1.59)	.8926 (.4133)	.9890 (.1802)	.7178 (.6451)	.0764 (1.89)
TBI	.0054* (3.045)	.0115* (2.73)	.1538 (1.559)	.0001* (4.651)	.2069 (1.41)	.7070 (.6581)	.0456* (2.125)	.0363* (2.227)
CPI	.6566 (.7183)	.4392 (.9936)	.7037 (.6620)	.0512 (2.074)	.2570 (1.298)	0.0* (18.21)	.130 (1.642)	.6087 (.7758)
AGEX	.1055 (1.741)	.3181 (1.182)	.1923 (1.448)	.5895 (.7991)	.0866 (1.833)	.9461 (.3150)	0.0* (25.142)	.0732 (1.911)
FPI	.3828 (1.076)	.5797 (.8111)	.4748 (.9448)	.1203 (1.678)	.1340 (1.626)	.9941 (.1464)	.1119 (1.713)	.7156 (.6478)

* = do not accept H_0: lags are not significantly different from zero.
Table reports the F statistics in brackets.

of contemporaneous correlations in the data. The upper triangle of Table 4.4 reports the correlation between the residuals of the different variables. The correlation between the United States and Canadian interest rates is high. The assumption of a recursive model means that simultaneous effects of the interest rates on the agricultural variables cannot be identified. However, because changing the variable ordering does not change the forecast error decompositions, the correlation is not considered to be a cause of concern

Variance Decomposition

Tables IV.5 and IV.6 report the decomposition of variances for agricultural exports and farm prices over twenty-four months. The forecast error decompositions separate the variances of the forecasts into the portions explained by each variable.

Agricultural exports appear to be almost exogenous in the model as approximately ninety-one percent of the forecast variance in the first month is attributed to the exports. The percentage declines slowly and is still large two years later. At the end of the twenty-four month period, the Canadian and U.S. interest rates are the second and third largest explanatory variables, contributing thirteen and eight percent respectively to the variation in exports.

A similar situation exists for the FPI. Almost all of the variance in farm prices is explained by itself in the first period. By the end of the two years, the U.S. interest rate explains ten percent of the shock to FPI and the Canadian interest rate contributes ten percent of the variation.

The large percentage of forecast variance explaining exports and farm prices suggest little interaction between the agricultural sector and the macroeconomy. Other studies using U.S. data, however, have typically found more of a relationship between financial variables and the agricultural economy.[44] Orden found that fifty-six percent of the forecast error variance for the U.S. exports was explained by U.S. agricultural exports one quarter ahead, compared to seventy-five percent in the Canadian model. By the end of three years, close to sixty percent of the forecast error variance in agricultural exports in Orden's model was attributed to the U.S. interest rate and trade weighted exchange rate. The percentage of variance attributed to agricultural exports declined more slowly in the Canadian model. Chambers also found more of a correlation between the interest rate and the commodity markets. Comparison of the U. S. and Canadian models, however, must acknowledge differing market structures and shares of world trade in each country. Nevertheless, although there was more of a relationship between exports and macroeconomics in the U.S. models, the

[44] Chambers, *op. cit.* 1981; Orden, *op. cit.*, 1986.

forecast error decompositions for farm prices were similar in both Orden's U.S. VAR model and the Canadian model.

The forecast errors presented in the forecast error decomposition tables are also of interest. The standard errors are expected to increase as the time period is lengthened. Nevertheless, if the data series is stationary, the standard errors should approach an upper bound.[65] The standard errors of both agricultural exports and farm prices appear to be approaching an upper bound, thus suggesting that the assumption of stationary data is valid in this model.

Impulse Response Functions

The means and variances of the impulse response functions were calculated for twenty-four future periods of the impulse response functions using the aforementioned Monte Carlo technique. One hundred draws from the autoregressive parameters of the VAR model were made.

The impulse response functions presented in Figure IV.3 to IV.6 indicate some interesting economic dynamics. Each graph demonstrates the effect of a one standard deviation shock to one variable on another variable, and the ninety-five per cent confidence interval around the shock path. The middle line of each graph is the path of means of the impulse response functions. The lines on either side of the means give the boundaries of the two standard deviation confidence interval. If any impulse response function and its confidence interval deviates above or below zero, then the impulse response function is considered significantly different from zero.

The effects of one month shocks to the money supply variables appear to have negligible impacts on agricultural variables. A shock to either the U.S. or Canadian money supply has no significant effect on FPI or agricultural export values as the impulse response functions and confidence intervals (in Figure IV.3) do not deviate significantly from zero. The lack of response of FPI to shocks in the Canadian money supply is similar to the results

[65]Sims, *op. cit.,* 1980, p. 25

Table IV.4: Model 1 Covariance/Correlation Matrix

Variable	USM1	CDNM1	TBUS	US/CDN	TBI	CPI	AGEX	FPI
USM1	3.792	.2321	-.0567	-.0606	-.1957	.0908	.1101	.0268
CDNM1	.0700	.0396	.0296	.0348	.0473	.0152	-.0935	-.0273
TBUS	-.0589	.0031	.2844	.2091	.5697	.0122	.1284	.0967
US/CDN	-.0010	.0001	.0009	.0001	.4403	-.0212	.1121	.1519
TBI	-.1443	.0036	.1150	.0014	.1432	-.0231	.2003	.0889
CPI	.0384	.0007	.0014	-.00004	-.0019	.0470	.0877	.1687
AGEX	14069	-1220.8	4490.8	62.64	4974.1	1247.3	4.3E+9	.0847
FPI	.0938	-.0098	.0928	.0023	.0605	.0658	9996.1	3.239

Table IV.5: Model 1 Decomposition of Variance on AGEX

Step	Std Error	USM1	CDNM1	TBUS	US/CDN	TBI	CPI	AGEX	FPI
1	65604.7	1.21	1.50	1.97	.97	2.84	.62	90.88	.00
2	105319.	.52	1.58	5.34	.53	7.82	1.42	80.97	1.82
3	109230.	.70	1.51	5.73	.50	11.88	1.65	75.84	2.19
4	1100[illegible]8.	.69	1.72	5.72	.68	12.02	1.66	74.74	2.76
5	1114[illegible].	.74	1.72	6.23	.85	11.80	1.78	73.33	3.55
6	113427.	.88	1.68	6.14	1.47	11.41	1.72	71.64	5.06
7	114889.	1.10	2.57	6.37	1.73	11.44	1.69	69.96	5.14
8	1182[illegible]5.	2.62	3.02	7.04	1.67	11.71	1.69	67.11	5.14
9	120271.	3.03	2.95	6.8[illegible]	1.66	12.64	1.87	66.01	5.02
10	121488.	3.02	2.93	6.71	1.64	12.96	2.[illegible]2	65.70	4.92
11	122096.	2.99	2.90	6.77	1.66	13.08	2.12	65.57	4.91
12	122303.	3.18	2.92	6.75	1.66	13.04	2.16	65.36	4.93
13	122958.	3.59	2.90	6.68	1.71	13.23	2.20	64.74	4.94
14	123600.	3.70	2.88	6.91	1.74	13.09	2.23	64.23	5.22
15	124354.	3.68	2.88	7.37	1.73	13.14	2.20	63.57	5.43
16	124545.	3.68	2.94	7.43	1.72	13.18	2.22	63.38	5.45
17	124622.	3.73	2.94	7.42	1.73	13.20	2.22	63.31	5.45
18	124690.	3.73	2.94	7.41	1.73	13.19	2.31	63.24	5.45
19	124756.	3.74	2.96	7.41	1.73	13.18	2.34	63.19	5.45
20	124832.	3.74	3.05	7.41	1.73	13.17	2.34	63.12	5.44
21	124965.	3.78	3.08	7.45	1.77	13.15	2.34	62.99	5.44
22	125087.	3.82	3.07	7.55	1.77	13.14	2.35	62.89	5.43
23	125142.	3.82	3.07	7.57	1.77	13.14	2.36	62.85	5.43
24	125153.	3.82	3.07	7.57	1.77	13.14	2.36	62.84	5.43

Table IV.6: Model 1 Decomposition of Variance on FPI

Step	Std Error	USM1	CDNM1	TBUS	US/CDN	TBI	CPI	AGEX	FPI
1	1.79972	.07	.12	1.00	1.91	.00	2.81	.15	93.94
2	1.85525	.22	.21	1.04	3.18	3.29	2.70	.58	88.78
3	1.90290	1.45	.22	3.00	3.03	4.62	2.57	.69	84.42
4	1.98480	1.90	.34	6.65	3.13	5.82	2.50	1.72	77.94
5	2.01232	2.34	.52	7.79	3.12	5.73	2.90	1.68	75.92
6	2.04894	2.78	.65	8.55	3.32	5.72	2.80	1.69	74.50
7	2.09937	3.88	.62	8.88	3.47	6.53	3.06	2.58	70.98
8	2.11770	4.19	.64	8.73	3.65	6.60	3.06	3.19	69.94
9	2.13545	4.36	.85	9.13	3.61	6.51	3.01	3.73	68.79
10	2.14028	4.58	.92	9.11	3.60	6.49	3.11	3.72	68.49
11	2.15100	4.74	.91	9.22	3.96	6.51	3.14	3.72	67.80
12	2.15452	4.76	.92	9.21	4.07	6.49	3.20	3.76	67.59
13	2.16394	4.98	.95	9.38	4.13	6.48	3.19	3.83	67.06
14	2.17374	5.30	.99	9.56	4.17	6.43	3.28	3.80	66.46
15	2.17891	5.28	.99	9.56	4.15	6.43	3.28	3.98	66.33
16	2.18170	5.37	.98	9.54	4.16	6.44	3.27	4.05	66.18
17	2.18334	5.38	1.01	9.53	4.16	6.46	3.28	4.09	66.08
18	2.18617	5.39	1.04	9.53	4.17	6.46	3.27	4.14	65.10
19	2.18750	5.39	1.04	9.53	4.17	6.52	3.28	4.14	65.92
20	2.19051	5.47	1.04	9.55	4.16	6.51	3.28	4.16	65.83
21	2.19438	5.67	1.06	9.54	4.16	6.54	3.27	4.15	65.61
22	2.19573	5.68	1.08	9.56	4.15	6.53	3.28	4.15	65.57
23	2.19726	5.69	1.10	9.59	4.15	6.53	3.27	4.18	65.49
24	2.19885	5.77	1.11	9.59	4.14	6.52	3.28	4.20	65.40

of VAR models using U.S. data.[66] Nevertheless, holding to the quantity theory of money, one would typically expect an increase in the domestic money supply to fuel inflationary pressures as the demand for money decreases and demand for commodities is stimulated. In response to a greater expected rate of future inflation, therefore, both the CPI and, as a component of the Canadian prices, the FPI, are expected to rise following a shock to the Canadian money supply. The results of the impulse response, however, also indicate no significant response

[66] Orden, *op. cit.* found increasing the nominal U.S. money supply had only small effects on exports and relative farm prices. Using Granger causality tests, Barnett, Bessler, and Thompson (1986) found no causality running from M_1 to farm prices. Saunders (1988), however, found evidence of a bi-causality between M_1 and farm prices.

from the CPI due to a Canadian monetary shock. Any interpretation of the responses to monetary shocks must be couched in terms of data limitations. Because the model is estimated in nominal data, explanations must consider the effects of nominal versus real influences of each variable. In the absence of money illusion, nominal changes in the money supply will not affect the level of prices.

The direct influence of the U.S. money supply causes more of a fluctuation (although not significant) in both the CPI and farm prices than does domestic monetary changes. The pattern exhibited by both price levels could be a result of deviations in the "law of one price," lending support to Bordo and Choudhri's conclusion that the Canadian inflation rate, of which FPI is one component, is explained by only the long term rate of Canadian monetary growth and the U.S. monetary-induced inflation rate.[67] The law of one price argues that prices in Canada, adjusted by the exchange rate, are equal to U.S. prices. U.S. inflation as a result of U.S. monetary growth possibly directly influences Canadian inflation. However, the lack of a signi[illegible] [illegible]nt positive correlation between the U.S. [illegible]ney supply and CPI prevents a strong conclusion in support of this theory.

The exchange rate and interest rates demonstrate more dynamic effects on the agricultural variables. An increase in the U.S. dollar relative to the Canadian dollar increases the value of Canadian exports to near significant levels one period after the shock before rapidly stabilizing. In other words, a strong U.S. dollar does not improve the attractiveness of Canadian agricultural exports in this model to any significant degree. Part of the explanation for this result can be found in the effects of the exchange rate on the Canadian FPI. A shock to the U.S./Canadian exchange rate increases farm prices to near significant levels in the first two periods after the shock thus making exports more expensive. In fact, a significant decline in export values is felt in the second month following a one standard deviation shock to farm prices.

---

[67] M. D. Bordo and E. Ch[illegible] "The Link Between Money and Prices in an Open Economy: The Canadian Evi[illegible] [illegible]rom 1971 to 1980," *Federal Reserve Bank of Saint Louis Review*, vol. 64, [illegible] Aug.-Sept., pp. 13-23.

Although farm prices show a two month near significant response to a change in the exchange rate, the lack of a strong response by the agricultural exports is surprising.[68] Further, the CPI response to the exchange rate shock is completely insignificant. In the monetary and asset market approach to modelling of macroeconomic linkages to agriculture, the exchange rate is often the only linkage specified between foreign macroeconomic and the domestic agricultural sector.[69] The minor reaction of Canadian agricultural exports and prices to the U.S./Canadian exchange rate is possibly the result of management of the Canadian/U.S. exchange rate by the Canadian monetary authorities. International agricultural commodity contracts may also be a factor. Another explanation is the possibility of the modelling of an inappropriate exchange rate. A trade-weighted exchange rate may be a more appropriate data series. The issue of a nominal versus real exchange rate also needs to be considered. The nominal exchange rate used in this study represents the price of U.S. dollars in Canadian dollars. According to economic trade theory, quantities of goods traded between countries are determined by the relative price of domestic goods in terms of foreign goods, or, in other words, the real exchange rate.[70]

The effect of the U.S. interest rate on Canadian export values and farm prices contradicts the assumption made within some models that the exchange rate provides the only link between foreign macroeconomic policies and the domestic agricultural sector. A shock to the U.S. interest rate causes an initial increase in the export values followed, in the second month by a significant decline. By the third month, the response of the exports has stabilized at insignificant levels. The FPI responds to a U.S. interest rate shock by rising to nearly significant levels in the first three months, followed by an immediate, and significant drop in price in month four.

---

[68] Placing the U.S./Canadian exchange rate before the U.S. interest rate in the ordering causes the exchange rate to have slightly more of an influence on the FPI, but no change in the effect on exports.

[69] See Chambers, *op. cit.*, 1981.

[70] See John Dutton and Thomas Grennes, "Alternative Measures of Effective Exchange Rates for Agricultural Trade," ***European Review of Agricultural Economics***, vol. 14, 1987, pp. 427-442, for a discussion on the discrepancies in results due to the use of differing exchange rates.

The factors causing a farm price increase following a shock to the U.S. interest rate are not certain. It is generally acknowledged that the Canadian interest rate tends to follow the pattern (albeit at a higher level) set by the U.S. interest rate. The results of this model support this assertion.[71] A shock to the U.S. interest rate causes a two month significant increase in the Canadian interest rate but an increasing Canadian interest rate has the opposite effect of the U.S. interest rate on farm prices. Increasing the domestic interest rate causes the FPI to significantly decline in the second month followed by near significant negative levels for months three and four. The CPI is unaffected by changes in either interest rate. The fact that the U.S. interest rate has the opposite effect on farm prices than that of the domestic interest rate and no effect on the CPI suggests a dynamic influence of the U.S. interest rate on farm prices that is separate from the mechanism causing changes in FPI as a result of shocks to the domestic interest rate. The U.S. interest rate, as a foreign variable, may be affecting the foreign demand for Canadian agriculture while changes in the domestic interest rate influence the domestic supply of agricultural products.

The influence of the nominal domestic interest rate on farm prices may be caused by the transformation of the nominal interest rate shock into a real shock. In this model, an increase in the nominal money supply causes a significant rise in the nominal interest rate for three months (see appendix). Because the CPI does not significantly increase following a money supply increase, the nominal interest rate can be interpreted as an increase in the real interest rate. In order to restore the equilibrium between holding bonds and storable commodities, farm prices must decline as demonstrated in the response of the FPI to a shock in the interest rate.

The effect of the Canadian interest rate on export values follows the pattern set by that of the U.S. interest rate, although at more significant levels. An increase in the Canadian interest rate causes the export values to bounce in the first three months; an increase in the first month is followed by a decrease and a subsequent increase before stabilizing in period

[71]Evidence of a direct link between the U.S. interest rate and the Canadian interest rate is also provided by Kuszczak and Murray, *op. cit.*, and P. M. Boothe *et. al.*, *International Asset Substitutability: Theory and Evidence for Canada*, Ottawa: Bank of Canada, 1985.

four. If the exports are determined by declining farm prices as a result of the interest rate increase, then it would be expected that exports would remain at significantly high levels due to price declines. The response, however, of Canadian agricultural exports to interest rate changes is also determined by other factors. Rising interest rates will increase the opportunity cost of storing agricultural commodities, therefore creating pressure for increasing exports. The significant decrease in exports in month two may be a result of a shortage of quantities available for export due to the depletion of stored stocks following the interest rate shock. The subsequent increase in exports suggests a time delay in restocking.

A shock to the general inflation level results in a near significant increase in the FPI, but appears to have little influence on any of the other variables in the model.[72] An increase in farm prices did decrease export values at a level significantly less than zero in the second month. Exports, on the other hand, have no significant impact on the FPI. An increase in export values causes exports to drop to a significant level in the second month, further suggesting that a depletion in the stock levels may be an important determinant in levels of exports. A shock to the FPI on itself, quickly stabilized in the second period.

Examination of the effects of exports and farm prices on the macroeconomy is interesting. While it is expected that the agricultural sector has very minor effects on macroeconomic variables, an increase in the FPI causes a three month significant rise in the U.S. interest rate and a four month significant increase in the Canadian interest rate. The statistical correlation between the FPI and macroeconomic variables cannot be readily identified through economic theory. A cautionary note must therefore be placed on the results of the model. As a component of the CPI, the farm price could be expected to be an influence on the CPI and, in fact, does cause an almost significant increase in the second month. The increase in the CPI following the farm price shock could be used to support the hypothesis that consumers' expectations of the effects of food price shocks on the rest of inflation have a tendency to magnify effects on the general inflation rate. Other empirical results, however,

[72]Orden, *op. cit.* 1986, p. 23, found that a shock to the price level has a strong negative effect on agricultural prices.

do not support this hypothesis.[13] Export values had very little influence on the rest of the model.

[13]Rausser, *op. cit.*, p. 216

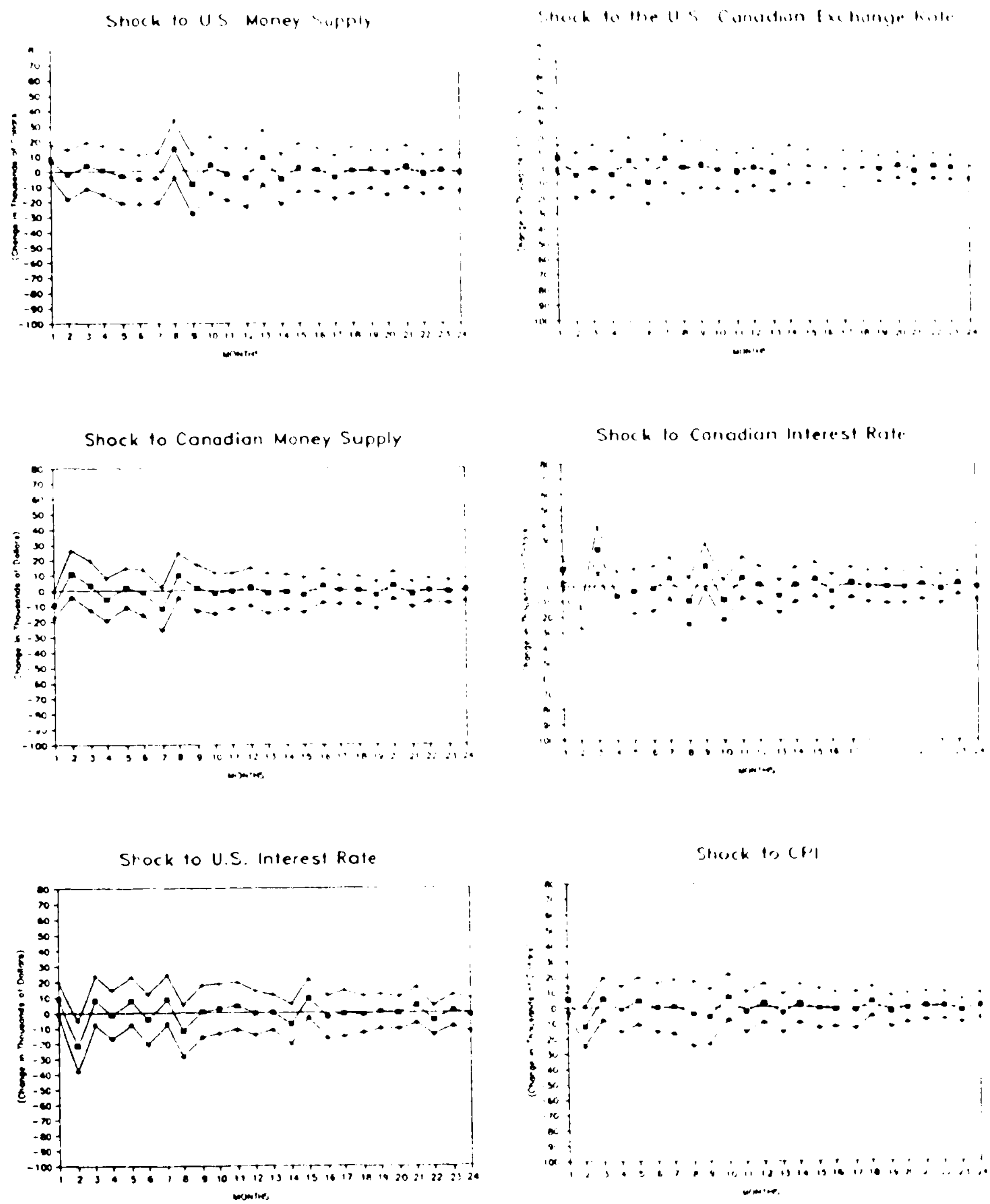
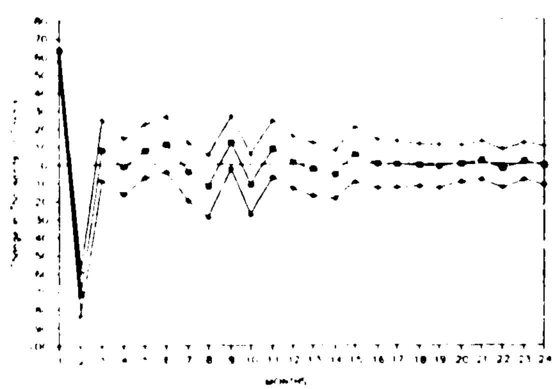


Figure IV.3 Response of Agricultural Exports to Shocks in Macroeconomic Variables.

Shock to Agricultural Exports



Shock to FPI

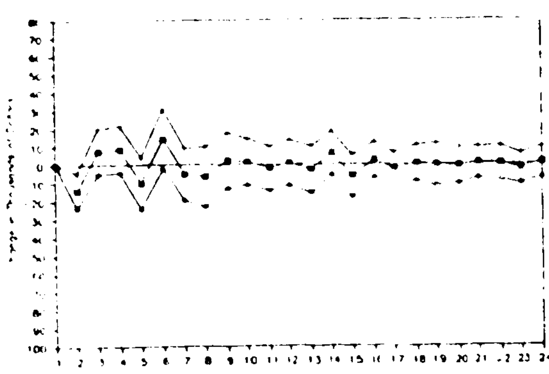


Figure IV.4 Response of Agricultural Exports to Shocks in Agricultural Variables.

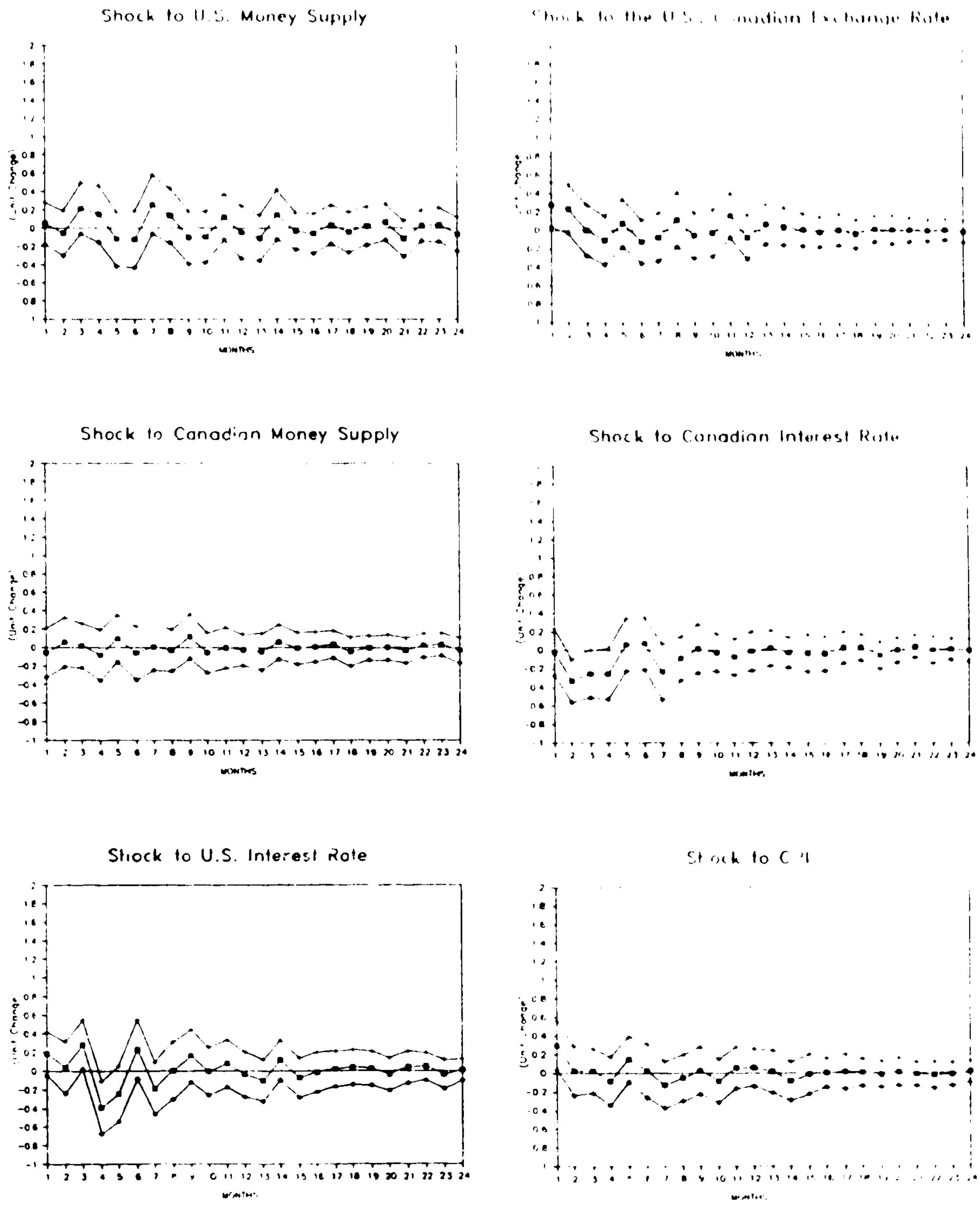
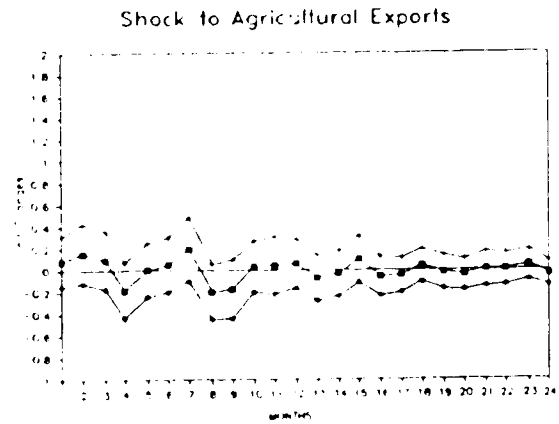


Figure IV.5 Response of Agricultural Prices to Shocks in Macroeconomic Variables.



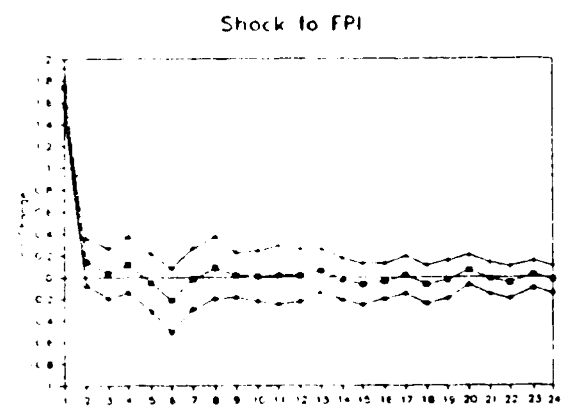


Figure IV.6 Response of Agricultural Prices to Shocks in Agricultural Variables.

D. Model 2 Estimation: G10 Exchange Index Model

The lack of response of farm prices and exports to the exchange rate was surprising. Speculation as to problems created by the exclusion of foreign agricultural demand variables in the model resulted in an eight variable model estimated to consider the effects of the replacement of the U.S./Canadian exchange rate with a more international exchange rate.[74] The G10 exchange rate index is used as the more universal exchange rate.

The test results, variance decompositions and impulse response functions are presented in appendix C. The tests for the appropriate lag length followed the same procedure as outlined for the first model. At a ninety five percent confidence level, 7 lags were selected as the proper lag length for the eight variable model. The test conclusions for the significance of the coefficients on the lagged variables are similar for both models. With the inclusion of the G10 exchange index, the lagged values of the Canadian money supply are significant in the Canadian money supply equation. The agricultural exports are not considered significant in the Canadian interest rate equation, although they are significant in the previous model. As expected, the G10 exchange index is exogenous, being determined only by lagged values of itself.

As a result of the test for the significance of the lagged variables, the G10 exchange index is ordered first in the model as it is considered determined by factors not included in the model estimation. The remaining variables are ordered as in the last model: U.S. money supply, Canadian money supply, the U.S. interest rate, the Canadian interest rate, CPI, agricultural exports, and FPI.

Variance Decomposition

There is virtually no change between the forecast error decompositions in the previous model and the model including the G10 exchange index. At the end of the twenty-four month period, the G10 exchange index accounts for 1.3 per cent of the variance in the agricultural

[74] The possibility that the interest rates are masking the direct influence of a shock to the exchange rate was explored by removal of the interest rates from the model. The impulse responses of both agricultural exports and prices remained unchanged.

export shock compared to 1.8 per cent attributed to the U.S./Canadian exchange rate in the previous model. Similarily, both exchange rates are attributed with explaining approximately four per cent of the variance in a shock to FPI. Likewise, all other variables remained at approximately the same levels of explanatory power in each model.

Impulse Response Functions

There was no striking change in the impulse response functions when compared to the previous model. The G10 exchange rate has no significant effect on agricultural exports. According to the results of the models, exchange rates do not have much of an influence on the competitiveness of Canadian agricultural exports. Normally, exchange rates are expected to be a important factor in determining the level of export values. The possibility arises that a shock of one standard deviation for a period of one month is too small to have an significant effect on agricultural exports. One possibility to consider is the effects of long term contracts for agricultural products. If the volatility of the exchange rates are as much of a factor as are believed, trade agreements may be taking currency values into consideration.

The G10 exchange index demonstrates the same relationship with agricultural prices as the U.S./Canadian exchange rate. Following an increase in the G10 exchange index, the FPI decreases significantly in the second month.

F. Bayesian Estimation of the U.S./Canadian Exchange Rate Model

The behavior of the farm price variable in the U.S. money supply and Canadian interest rate equation raises concerns of overparameterization of the variables. Further, the removal of variables from the model and the changing of lag lengths caused the significance of the coefficients to vary in a number of equations. The lack of robustness in the two unrestricted models is possibly the result of outliers in the data series creating random fluctuations which obscure the systematic variation the VAR moving averages are trying to [illegible]. Because of the large number of variables in the model, it was decided to attempt to test the robustness of the model by using Bayesian priors.[75] The restricted Bayesian VAR is compared to the unrestricted models. Only the eight variable model containing the U.S./Canadian exchange rate is modelled as the G10 exchange rate is not considered to add any explanatory power to the model.

Model 3 Estimation

The Bayesian model was estimated using the same ordering and lag length as the initial unrestricted model. The Bayesian priors are estimated such that the data series will follow a random walk pattern about a uncertain, deterministic drift as suggested by Litterman.[76] Therefore, the mean of the prior on the first lag of the dependent variable in each equation is set equal to one; the mean values of the priors on all other lags are restricted to zero. As well, the tightness information on the standard deviations of the lagged coefficients is provided. Only strong determinants will therefore enter an equation as significant.

A number of different priors and distribution specifications were applied to the model. Litterman's results suggested that a tightness parameter of between .1 and .2 is reasonable for a model of the size in this study. Experimentation indicated that a relatively loose tightness parameter of .2 provided the best results. The symmetric prior with weights on the lagged coefficients of the independent variables estimated at half the weight of the dependent lags, proved adequate. More restrictive priors that applied a weak economic structure allowing variables considered important in explaining all variables in the model to have larger weights relative to the other, less important variables, caused problems of serial correlation.[77]

[75]Decision made after personal communication with C. Sims, November, 1988.
[76]Bessler and Kling, 1986, p. 145. See also Robert B. Litterman, "Forecasting With Bayesian Vector Autoregressions - Five Years of Experience," *Journal of Business and Economic Statistics*, January, 1986, vol. 4, pp. 25-38.
[77]The Circle-Star prior (see RATS manual) provides a weak economic specification to the model estimation. Restricting the agricultural variables to weights of .5 and the macroeconomic variables (other than the dependent variable) to weights of .7 to .9 gave similar results to the symmetric prior reported in the analysis.

Table IV.7 provides the summary statistics for the Bayesian prior estimation and Table IV.8 gives the results of the tests for significance of the lagged coefficients. As expected, the significance of the lagged coefficients changed from the results of the unrestricted model. The agricultural export equation still demonstrates an autocorrelation problem. Many of the variables demonstrated the random walk pattern suggested by the specification of the Bayesian priors. Lagged values of the U.S. money supply and the Canadian money supply are significant in the U.S. money supply equation. The lagged values of the U.S. money supply and Canadian interest rate are significant in the Canadian money supply equation, but the lags of Canadian money supply are not significant. The U.S. interest rate, the U.S. Canadian exchange rate, the Canadian interest rate, the CPI, and the agricultural exports, are determined only by the values of their own lags. The FPI equation did not contain any significant lagged coefficients.

Variance Decompositions

Tables IV.10 and IV.11 report the decompositions for agricultural exports and prices over twenty-four months. Both agricultural variables provided more of the variance in their own forecast error decompositions than in the unrestricted VAR model. By the end of the twenty-four month period, agricultural exports contributes eighty per cent of its own variance compared to sixty-three per cent of the variance in the unrestricted model. The explanatory power of the U.S. and Canadian interest rates is reduced to approximately six and five per cent respectively. Eighty-six per cent of the variance in the FPI at the end of the twenty-four month estimation period is explained by the FPI compared with sixty-five per cent in the unrestricted model. The explanatory power provided by each of the other variables is less than four per cent.

Table IV.7: Model 3 Summary Statistics

Equation	R^2	R^{2A}	D-W	SSR	SSE	Q(39)	Sig Level
USM1	.5184	.4863	2.61	932.9	2.277	48.18	.1488
CDNM1	.4674	.4319	2.30	9.847	.2339	45.64	.2156
TBUS	.4648	.4291	2.19	63.18	.5920	36.74	.5736
US/CDN	.3365	.2923	2.19	.016	.0095	46.48	.1914
TBI	.5688	.5400	2.18	35.38	.4433	31.88	.7837
CPI	.6228	.5976	2.50	11.47	.2524	40.16	.4185
AGEX	.6924	.6719	2.56	1.E+12	81364.	85.10	.00003
FPI	.4117	.3725	2.25	701.6	1.974	41.78	.3510

Table IV.8: Model 3 Significance of Lags

Lagged Variables

Dependent Variable	USM1	CDNM1	TBUS	US/CDN	TBI	CPI	AGEX	FPI
USM1	.0000*	.0490*	.1988	.9454	.9856	.6615	.9778	.0610
	(6.532)	(2.069)	(1.422)	(.3174)	(.1977)	(.7125)	(.2296)	(1.973)
CDNM1	.0055*	.1135	.1379	.2335	.0305*	.1647	.5294	.8187
	(2.985)	(1.692)	(1.600)	(1.341)	(2.273)	(1.515)	(.8725)	(.5200)
TBUS	.0944	.1043	.0000*	.9020	.8961	.9948	.9703	.1242
	(1.777)	(1.731)	(7.196)	(.3990)	(.4087)	(.1412)	(.254)	(1.650)
US/CDN	.2323	.8782	.1782	.00[illegible] *	.8851	.4450	.3723	.5473
	(1.343)	(.4367)	(1.477)	(3.[illegible]	(.4264)	(.9831)	(1.089)	(.8501)
TBI	.1283	.0537	.0183*	.5025	.0000*	.7957	.0802	.0959
	(1.634)	(2.029)	(2.489)	(.9067)	(6.522)	(.5498)	(1.851)	(1.769)
CPI	.7320	.8381	.6304	.9388	.9485	.0000*	.1401	.9437
	(.6284)	(.4940)	(.7495)	(.3316)	(.3107)	(12.21)	(1.593)	(.3213)
AGEX	.7475	.8778	.8524	.9763	.3299	.8587	.0000*	.2915
	(.6097)	(.4372)	(.4743)	(.2347)	(1.157)	(.4654)	(17.93)	(1.22)
FPI	.6878	.9367	.3171	.8019	.6074	.9983	.3821	.1026
	(.6813)	(.3359)	(1.179)	(.5419)	(.777)	(.0996)	(1.074)	(1.739)

* = do not accept H_0: lags are not significantly different fro[illegible] ro.

Table reports the F statistics in brackets.

Table IV.9: Model 3 Covariance/Correlation Matrix

Variable	USM1	CDNM1	TBUS	US/CDN	TBI	CPI	AGEX	FPI
USM1	4.834	.1751	-.1207	-.0841	-.2584	.0580	.0879	-.0060
CDNM1	.0869	.0510	.0343	.0298	.0271	.0028	-.0905	.0188
TBUS	-.1518	.0044	.3268	.1725	.5300	.0313	.1492	.0771
US/CDN	-.0017	.0001	.0009	.0001	.3939	-.0507	.0654	.0830
TBI	-.2433	.0026	.1297	.0015	.1833	-.0357	.1893	.0847
CPI	.0311	.0002	.0044	-.0001	-.0037	.0594	.1143	.1558
AGEX	15181	-1605.	6704.	46.99	6369.	2189.	6.E+10	.0653
FPI	-.0252	.0080	.0841	.0014	.0691	.0724	9777.3	3.635

Table IV.10: Model 3 Decomposition of Variance on AGEX.

Step	Std Error	USM1	CDNM1	TBUS	US/CDN	TBI	CPI	AGEX	FPI
1	78576.3	.7722	1.156	2.802	.2656	2.481	1.210	91.31	.0000
2	98208.6	.8340	1.313	4.403	.3472	4.000	2.307	85.83	.9530
3	98788.4	.8947	1.322	4.446	.3442	4.297	2.756	84.85	1.086
4	99208.0	.8907	1.325	4.433	.3586	4.261	2.950	84.39	1.386
5	99482.7	.9216	1.318	4.524	.4127	4.287	3.033	83.93	1.569
6	100132.	.9785	1.310	4.483	.6382	4.232	3.006	83.46	1.885
7	100980.	1.260	1.744	4.817	.6706	4.368	3.003	82.27	1.863
8	103160.	2.025	1.802	5.535	.6426	4.522	2.895	80.56	2.010
9	103734.	2.120	1.788	5.503	.6528	4.625	2.958	80.34	2.003
10	103886.	2.124	1.784	5.487	.6564	4.639	2.958	80.35	1.999
11	103995.	2.120	1.780	5.520	.6577	4.638	2.960	80.31	2.006
12	104040.	2.160	1.784	5.529	.6576	4.644	2.959	80.25	2.004
13	104118.	2.238	1.792	5.528	.6689	4.651	2.960	80.15	2.001
14	104210.	2.234	1.789	5.559	.6760	4.644	2.955	80.09	2.042
15	104325.	2.245	1.806	5.612	.6753	4.644	2.951	80.00	2.059
16	104346.	2.244	1.809	5.616	.6775	4.653	2.954	79.98	2.059
17	104355.	2.244	1.809	5.615	.6776	4.658	2.954	79.98	2.059
18	104360.	2.246	1.809	5.617	.6781	4.657	2.955	79.97	2.059
19	104364.	2.251	1.809	5.618	.6783	4.657	2.954	79.96	2.059
20	104367.	2.252	1.809	5.620	.6785	4.657	2.957	79.96	2.059
21	104372.	2.252	1.809	5.624	.6791	4.657	2.957	79.95	2.059
22	104378.	2.254	1.810	5.629	.6790	4.657	2.958	79.95	2.059
23	104380.	2.254	1.810	5.629	.6791	4.657	2.958	79.95	2.059
24	104381.	2.254	1.810	5.629	.6792	4.657	2.958	79.95	2.059

Table IV.11: Model 3 Decomposition of Variance on FPI.

Step	Std Error	USM1	CDNM1	TBUS	US/CDN	TBI	CPI	AGEX	FPI
1	1.90668	.0036	.0405	.5764	.4978	.0895	2.518	.0948	96.17
2	1.95174	.1007	.1559	.7329	.9273	.1635	2.473	.1562	95.28
3	1.96491	.3101	.1993	1.344	.9253	.4121	2.446	.3428	94.01
4	2.00369	1.066	.1930	2.752	1.184	1.204	2.363	.5350	90.70
5	2.01652	1.291	.2538	3.453	1.228	1.201	2.391	.6259	89.55
6	2.03425	1.674	.2527	3.662	1.271	1.218	2.358	.6964	88.86
7	2.05610	2.097	.2505	3.697	1.524	1.401	2.308	1.722	86.99
8	2.06261	2.280	.2532	3.692	1.612	1.457	2.422	1.771	86.50
9	2.06569	2.284	.2560	3.779	1.649	1.453	2.460	1.826	86.29
10	2.06665	2.313	.2694	3.778	1.649	1.459	2.471	1.841	86.21
11	2.06899	2.337	.2690	3.874	1.707	1.461	2.474	1.847	86.02
12	2.06971	2.336	.2717	3.872	1.708	1.461	2.490	1.881	85.97
13	2.07147	2.403	.2748	3.870	1.721	1.465	2.508	1.879	85.87
14	2.07253	2.451	.2816	3.868	1.724	1.470	2.514	1.898	85.79
15	2.07302	2.451	.2837	3.869	1.726	1.473	2.516	1.913	85.76
16	2.07327	2.455	.2847	3.875	1.726	1.477	2.515	1.918	85.74
17	2.07341	2.458	.2898	3.876	1.726	1.476	2.515	1.919	85.73
18	2.07373	2.466	.2943	3.875	1.726	1.478	2.515	1.927	85.71
19	2.07379	2.466	.2948	3.876	1.726	1.479	2.515	1.927	85.71
20	2.07399	2.475	.2952	3.876	1.727	1.479	2.515	1.928	85.70
21	2.07417	2.486	.2968	3.877	1.727	1.480	2.514	1.928	85.68
22	2.07420	2.486	.2970	3.878	1.727	1.480	2.515	1.929	85.68
23	2.07425	2.489	.2972	3.878	1.727	1.480	2.514	1.930	85.68
24	2.07430	2.492	.2975	3.878	1.727	1.480	2.514	1.930	85.67

Impulse Response Functions

The impulse response functions of the Bayesian model demonstrated the same pattern as the impulse response functions of the unrestricted model. Due to computer limitations, the standard errors could not be estimated. However, the graphs of the impulse response functions in Figures IV.7 to IV.10 are scaled the same as the impulse response functions of the unrestricted VAR in order to allow for direct comparison.

The response of agricultural exports to a shock in the Canadian interest rate differs from the unrestricted VAR in that the exports demonstrate less of a decline in the second month in the Bayesian model. As well, a[illegible]tural exports decreased less in the Bayesian model following a shock to agricultural exports. The response of the FPI to the Canadian interest rate also changes from the unrestricted model. Instead of a decrease following the interest rate shock, the FPI increases. However, the levels of response in the first month of either model appear insignificant. The response of the FPI to a shock in the U.S./Canadian exchange rate is stronger in the unrestricted model in the first month but the same for the rest of the response path.

The lack of major changes in the impulse response functions suggests a certain robustness in the models. The economic relationships suggested by the time series are not dampened by imposing Bayesian priors on the model.

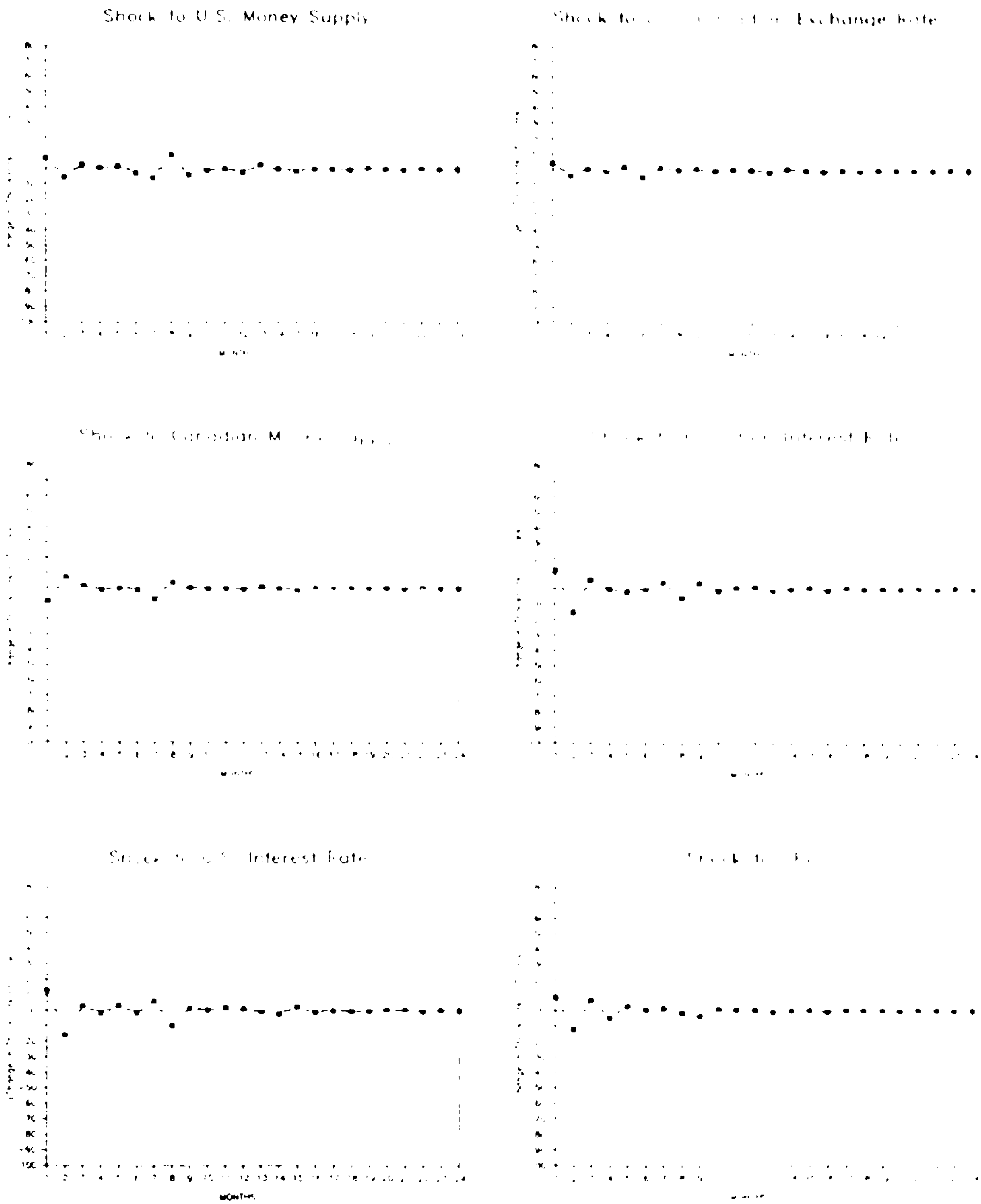
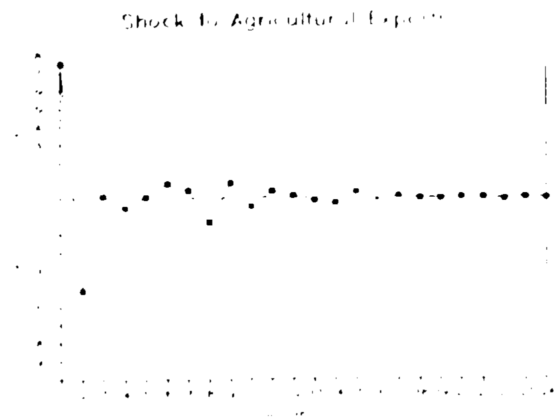


Figure IV.7 Response of Agricultural Exports to Shocks in Macroeconomic Variables.



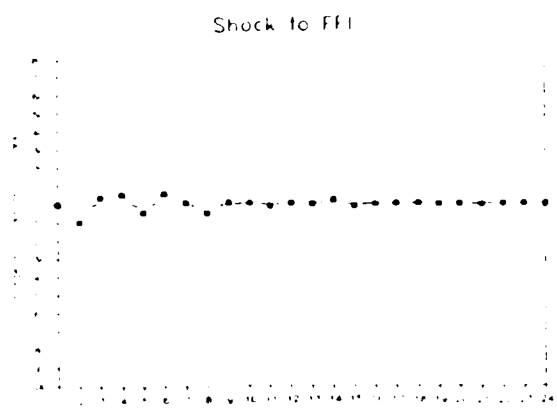


Figure IV.8 Response of Agricultural Exports to Shocks in Agricultural Variables.

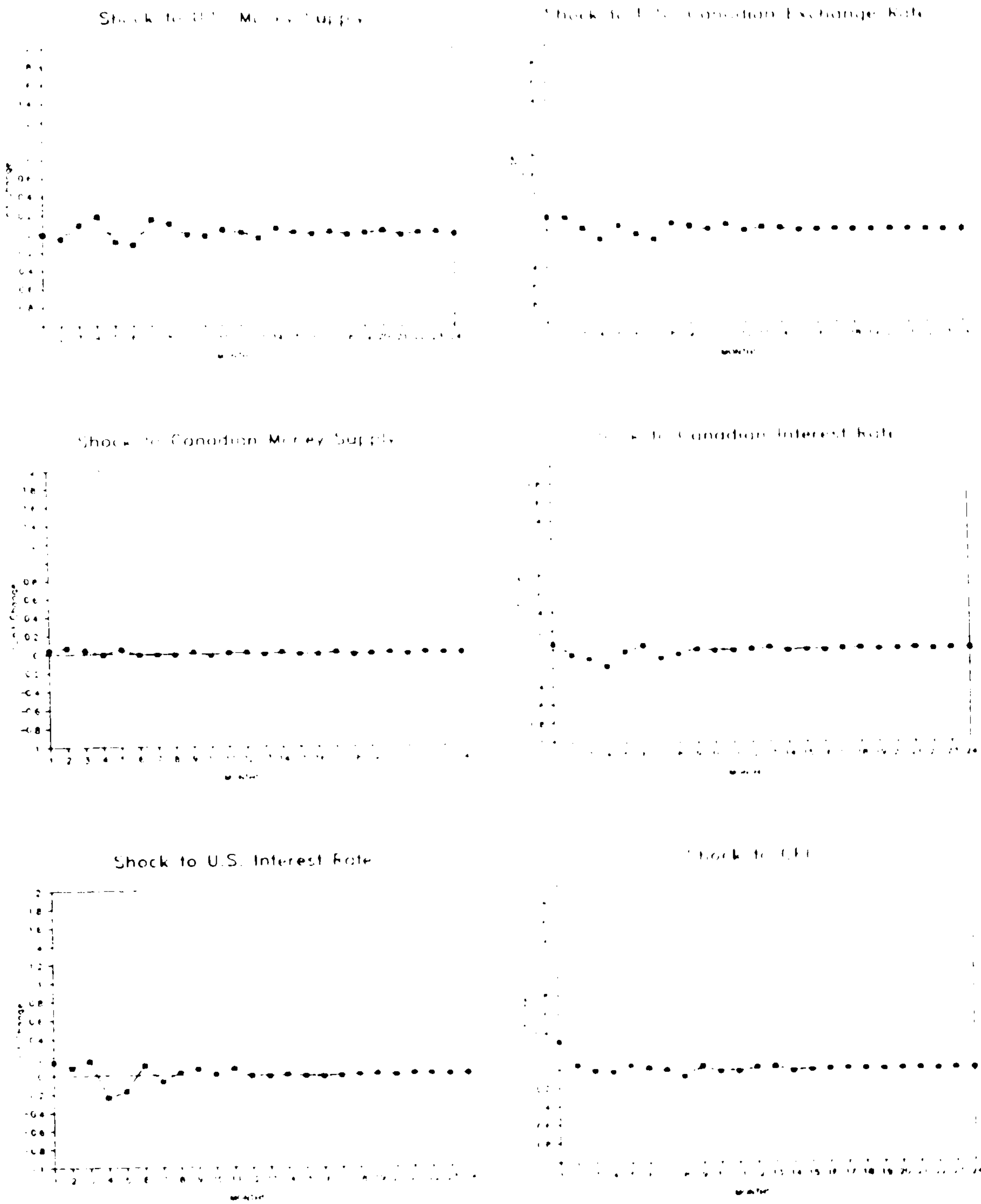


Figure IV.9 Response of Agricultural Prices to Shocks in Macroeconomic Variables.

Figure IV.10 Response of Agricultural Prices to Shocks in Agricultural Variables.

F. Implications of the Results

The VAR models estimated and reported in the study capture some interesting relationships in the economic data. Stress must be placed on the fact that although the responses of the agricultural variables are observed in terms of 'significant' and 'near significant,' one standard deviation shocks in a time period of one month should not be expected to cause extremely strong responses for long periods of time. The linkages observed between the macroeconomic and agricultural variables have some important implications for the present perceptions of the interactions of the different economic relationships.

Of particular interest is the very weak response of the agricultural exports to the exchange rates compared to the response of the exports to the interest rates. Exchange rates may not be as important a determining factor in agricultural trade as is believed. A high American dollar relative to the Canadian dollar has only a slight positive effect on Canadian agricultural exports. On the other hand, the response of exports to the domestic interest rate is relatively dramatic. The perception that interest rates only affect agricultural trade indirectly through the exchange rate may have to be revised. The direct impact of interest rates, possibly as a result of storage costs, on agricultural exports requires more attention.

The use of the money supply as a tool of monetary policy appears not to have any direct effects on either agricultural prices or exports. However, the significant decrease in interest rates as a direct result of an increase in the money supply suggests that the indirect influence of money supply changes on agriculture may be quite substantial. High interest rates are already considered detrimental in a capital intensive industry such as agriculture; the fact that the interest rate decreases both agricultural prices and exports more than either the money supply or the exchange rate, lends support to demands for lower interest rates.

The general price level does not appear to be an important influence on agricultural output prices. Farm prices may increase slightly due to a shock in the price level but not enough to have the inflation rate be considered a major influence. Additional research to compare the effect of the general inflation rate on both agricultural input and output prices may provide evidence of a cost-price squeeze. The results of this study suggest that more attention must be placed on the effects that policy initiatives to combat inflation have on the agricultural sector. If, for example, the monetary authorities use the interest rate to restrict the money supply and therefore inflation, agriculture will be negatively affected.

The relationship between agricultural exports and prices also has interesting implications. Even though Canadian agriculture depends heavily on exports, farm prices are not significantly affected by increases in exports, supporting the conclusion that prices for agricultural exports are set internationally. While having no apparent influence on agricultural exports, the significance of the exchange rate as a determinant of the FPI adds further support to the argument that some domestic farm prices are set in world commodity markets.

The influence of American macroeconomic variables on Canadian agriculture directly and indirectly through influences on domestic macroeconomic variables contains very strong implications. Restrictive U.S. monetary policy in the form of shocks in the interest rate cause a dramatic increase in both the U.S./Canadian exchange rate and the Canadian interest rate. The subsequent effects on agricultural prices and exports are substantial. Shocks to the U.S. money supply do not have significant direct effects on Canadian agriculture. The indirect effects of U.S. money supply changes on Canadian agriculture through domestic monetary variables and the U.S. interest rate may be quite important. The interactions of the U.S. monetary variables with Canadian variables suggest that some important macroeconomic effects on Canadian agricultural prices and exports are beyond the control of the Canadian monetary authorities and will have to be addressed through international negotiations.

G. Summary

The intent of the empirical work presented in this chapter was to examine the economic relationships between both domestic and international macroeconomic variables and Canadian agricultural prices and exports. A number of interesting results were presented and implications of the results were highlighted. Conclusions and limitations of the empirical work will be presented in the final chapter.

V. Conclusion

A. Review of the Research Objectives

The purpose of the study was to provide empirical evidence of causal relationships between macroeconomic variables and Canadian agricultural prices and exports, as well as the relative strengths of the relationships. The integration of the agricultural industry with both the rest of the economy and the international agricultural and financial markets suggests Canadian agricultural prices and exports are faced with an increased sensitivity to changes in macroeconomic policies. Some of the instability in the agricultural sector is therefore perceived to be caused by macroeconomic policies developed in pursuit of goals not necessarily related to agriculture. Nevertheless, despite an awareness of the linkages between both foreign and domestic macroeconomic policies and Canadian agriculture, only a small quantity of empirical work in the area has been published in Canada. Although substantially more research has been presented in the United States on macroeconomic impacts on U.S. agriculture, a consensus as to the linkages and relative strengths of the linkages has yet to be achieved. Much of the controversy is due to differing views on the relative importance of certain variables. Several different and often conflicting theoretical approaches are considered acceptable for formulating conceptual frameworks. Empirical work focusing on either direct monetary and fiscal policy or indirect macroeconomic effects from exchange rates, interest rates, and the [illegible] process, places strong restrictions on any conclusions drawn. A first step is to identify the causal relationships between macroeconomic and agricultural data. Given the importance of the agricultural industry to Canada, such analysis is required in order to decide which macroeconomic variables have the most significant linkages to Canadian agriculture.

The focus of the empirical estimation was on the relationship between monetary and financial macroeconomic variables and Canadian agricultural prices and exports. Exogenous international policies were represented by the U.S. money supply and interest rate, the U.S./Canadian exchange rate and the exchange rate index of the G10 countries. Domestic macroeconomic policies were measured by the Canadian money supply, Canadian interest rate and the Consumer Price Index as a proxy for the general price level. In order to avoid as much as possible the inclusion of *a priori* assumptions on the model, the VAR econometric technique was considered the most suitable estimation procedure to achieve the objectives of the study.

B. Summary of Vector Autoregression Analysis

As well as allowing some general implications to be drawn about the relationships between macroeconomic variables and Canadian agricultural prices and exports, the study demonstrated the usefulness of the VAR econometric technique to analyses of this nature. The VAR estimation technique allowed the dynamics of the model to be assessed through impulse response functions and forecast error variance decompositions. The impulse response functions demonstrated the effects of an one standard deviation shock of one variable on another variable. The forecast error decompositions allowed inferences to be made about both the causal linkages between variables and the relative strengths of the relationships.

VAR analysis presents a number of advantages over more standard, structural econometric techniques for the analysis of the causal linkages between variables. The VAR econometric technique avoids most of the restrictions required by more structural approaches through the estimation of moving averages of time series data. VAR models lag each variable on itself and all other variables in the model, therefore avoiding exclusion restrictions or exogeneity assumptions before estimation of the model. Identifying economic relationships in the data in this manner, has proved useful in evaluating how closely economic theory matches the reality of what has occurred without severely restricting the model with assumptions that may or may not be testable. VAR modelling is therefore useful to provide support for the identification of more structural models as well as being a useful econometric tool on its own.

VAR estimation also has a number of restrictions that must be understood. Orthogonal ordering to avoid estimation problems due to contemporaneous correlations between error terms results in a strong assumption of recursivity in the model. Recent studies using VAR estimation procedures have applied new orthogonalization techniques that use model estimation to avoid conventional ordering problems. While the standard Choleski decomposition was used in this study, estimation using the more recent procedures is an area for more research.

Three VAR models were estimated: two unrestricted models comparing different exchange rates, and one model estimated with the use of Bayesian priors. The lack of major changes between the different models suggests a certain robustness in the models. The only econometric problem of major concern was the serial correlation present in the agricultural export equation.

C. Summary of Results

A number of general conclusions can be drawn from the results of the model. The forecast error decompositions suggest that events in agriculture explain more of the variance in agricul[illegible]ces and exports than do events in the macroeconomy. The macroeconomic variables with the most relative importance to agricultural prices and exports are the two interest rates. Although exchange rates did not influence agricultural exports as much as expected, this may be due to the policies of the monetary authorities. If the Bank of Canada manages the interest rate to prevent instability caused by a fluctuating exchange rate, the interest rate will possibly have more importance than the exchange rate. Nevertheless, the exchange rate is partially determined by factors exogenous to the domestic economy. The effects of the exchange rate on exports can therefore not be dampened solely by changes in the interest rates Other factors such as fixed agricultural trade contracts may be important A perception in Canadian agricultural circles that the exchange rate is the most important variable affecting Canadian agricultural trade may have to be revised.

The impulse response functions provide support for some of the perceptions surrounding the effects of changes in macroeconomic policy on agriculture. A note of caution must be applied to the impulse response functions however, as the statistical significance of shocks to the FPI on several macroeconomic variables cannot be readily explained by economic theory Nevertheless, there are a number of interesting results from the impulse response functions. High domestic interest rates have a negative influence on agricultural prices. In the slightly longer run, high interest rates lower agricultural exports, presumably due to higher opportunity costs for storage. As expected, the direct influence of the money supply is relatively insignificant. The indirect effect of changes in the money supply through its effect on other macroeconomic variables may be more important.

The influence of American macroeconomic policy on Canadian agriculture should not be underestimated. The effect of U.S. macroeconomic variables on the Canadian macroeconomy has indirect implications for agriculture. U. S. monetary policy that causes high interest rates in the U.S. also increases the interest rate in Canada as well as raising the U.S./Canadian exchange rate. The U.S. interest rate also has a direct negative effect on Canadian agricultural exports and prices. Results of the study suggest that Canadian macroeconomic policies may be significantly frustrated by the policies of other governments. The influence of international macroeconomic policy, as represented by U.S. variables in this study, suggests that trade negotiations will have to include consideration of the macroeconomic goals of different governments.

D. Limitations of the Study

The empirical analysis presented in the study is able to provide a number of broad conclusions about the economic relationships between the domestic and international economies and Canadian agricultural prices and exports. The aggregate nature of the agricultural variables, however, limits the study to very general interpretations. The Farm Price Index consists of the farm gate prices for fifty farm products. Not all of the products within the FPI are traded in the export markets. The prices received for agricultural products designated for domestic markets may be influenced directly by domestic macroeconomic policy and only indirectly, if at all, by events in the international economy. On the other hand, macroeconomic policy of foreign governments may have a substantial influence on the prices set in the international commodity markets in which Canadian agricultural exports compete.

Aggregating agricultural exports prevents drawing conclusions about the relationship of macroeconomic variables to specific commodities. Agricultural commodities with varying market structures and performance may have differing degrees of sensitivity to changes in macroeconomic policies.

By narrowing the study to examination of the relationship between monetary and financial variables and agricultural prices and expo[rts], the empirical model fails to consider the influence of other important macroeconomic policies. Changes in fiscal policy, for example, may have some influence on agriculture. Specific government expenditure in the form of subsidies is perceived to have a substantial impact on the agricultural sector. While exclusion of fiscal policy variables presents a limitation of the study, it also points to an area for further research.

Replacing the Consumer Price Index w[illegible] [illegible] [illegible]flator to represent the general price level could po[illegible] contributed more to the study. The unavailability of a monthly series for the GNP [illegible]ex may have limited the study in this regard. As mentioned previously, a trade w[illegible] exchange rate may also have been of more value.

Concern with restrictions in the VAR estimation technique exposes the empirical estimates to questions about the validity of the causal inferences that have been made. The choice of variable order, one of the most restrictive assumptions within a VAR model, is not considered a problem in this analysis [illegible] ordering of variables allowed the macroeconomic variables to have the maximum possible effect on the agricultural variables. Furthermore, changes in the ordering of variables produced only very minor changes in the impulse response functions and forecast error decompositions. Comparison of the unrestricted VAR model and the Bayesian model indicated that overparameterization of variables in the unrestricted model was not a problem. However, one should be aware of potential underestimation of the variance in the residuals due to autocorrelation in the agricultural export equations.

E. Recommendations for Further Research

The possible extensions of the empirical work presented in the study are numerous. The purpose of the study was to analyze the influence of different macroeconomic variables on Canadian agriculture. The VAR estimation procedure can be extended into more specific policy analysis and forecasting. For example, the VAR models estimated can be used to analyze the effects of specific past events in the macroeconomy on the agricultural sector.

Various extensions to the model could prove very valuable. Alternate variables, such as a more general price level or a trade weighted exchange rate may contribute more to the model. A larger, more g l model could be constructed by setting up blocks of international variables which feed through to the Canadian economy as a group, but not individually.

A number of tests for several interesting problems can be performed on a model of this nature. It has only been relatively recently that the international community has been operating under floating exchange rates. Tests for structural change as a result of the switch from fixed exchange rates can, as an example, be accomplished through this model.

Future research more specifically related to agriculture could extend the model to consider the influences of macroeconomic variables on less aggregate agricultural variables. Di ..ient commodities as a result of different marke es can be more or less sensitive to changes in both domestic and foreign macroeconon licies. M emphasis could be placed on the short versus the longer term thus using the model to test for evidence of cost-price squeeze phenomenon in the agricultural industry. T' ffects of n inal versus real shocks should also be considered.

The empirical work presented in the study can be viewed as a first step towards more structural analysis. Ordering of a VAR model using the Choleski decomposition procedure, imposes a strict recursivity on the model. Var models, however, can also be identified through restrictions on the covariance matrix th can connect or exclude variables in some equations thus allowing for more structural interpretations. The re ..lts presented in the study can aid in identification of more structural VAR models which n provide interpretations more ... able for direct policy analysis.

Bibliography

Agriculture Canada. *Handbook of Selected Agricultural Statistics.* Ottawa, Canada: 1988.

Agriculture Canada. *Canada's Trade in Agricultural Products 1985, 1986, and 1987.* Ottawa, Canada. International Trade Policy Directorate, July, 1988.

Anderson, W.J. and J.A Gellner. "Canadian Agricultural Policy in the Export Sector." *Canadian Journal of Agricultural Economics.* Vol. 32, 1984, pp. 170-185.

Angeloni, Ignazio. "The Dynamic Behavior of Business Loans and the Prime Rate: A Comment." *Journal of Banking and Finance.* Vol. 9, 1985, pp. 577-580.

Backus, David. "Empirical Models of the Exchange Rate: Separating the Wheat from the Chaff." *Canadian Journal of Economics.* Vol. 17, 1984, pp. 824-846.

--------. "The Canadian-U.S. Exchange Rate: Evidence From a Vector Autoregression." *The Review of Economics and Statistics.* Vol. 68, 1986, pp. 628-637.

Baker, C. B. "Agricultural Effects of Changes in Financial Markets." *American Journal of Agricultural Economics.* Vol. 66, no. 5, 1984, p. 541-548.

Barclay, Tom and Luther Tweeten. "Macroeconomic Policy Impacts on the United States Agriculture." *Agricultural Economics* Vol. 1, 1988, pp. 291-307.

Barnett, Richard C., David A. Bessler, and Robert L. Thompson. "The Money Supply and Nominal Agricultural Prices." *American Journal of Agricultural Economics.* Vol. 65, 1983, pp. 303-307.

Batten, Dallas S. and Michael T. Belongia. "Monetary Policy, Real Exchange Rates, and U.S. Agricultural Exports." *American Journal of Agricultural Economics.* Vol. 68, 1986, pp. 423-427.

Bernanke, Ben S. *Alternative Explanations of the Money-Income Correlation.* Working Paper No.1842. National Bureau of Economic Research, Cambridge, MA. February, 1986.

Bessler, David J. "Relative Prices and Money: A Vector Autoregression on Brazilian Data." *American Journal of Agricultural Economics.* Vol. 66, 1984, pp. 25-30.

--------. "An Analysis of Dynamic Economic Relationships: An Application to the U.S. Hog Market." *Canadian Journal of Agricultural Economics.* Vol. 32, 1984, pp. 109-124.

-------- and John L.Kling. "Forecasting Vector Autoregressions with Bayesian Priors." *American Journal of Agricultural Economics* Vol. 68, 1986, pp. 144-151.

Boothe, P., K. Clinton, A. Cote, and D. Longworth. "International Asset Substitutability: Theory and Evidence for Canada," in *Postwar Macroeconomic Developments.* John Sargent, editor. Toronto: University of Toronto Press, 1986, pp. 271-281.

------- and S. Poloz. "Unstable Money Demand and the Monetary Model of the Exchange Rate." *Canadian Journal of Economics.* Vol. 21, no. 4, 1988, pp. 785-798.

Bordo, Michael D. and Eshan U. Choudhri. "The Link Between Money and Prices in an Open Economy: The Canadian Evidence from 1971 to 1980." *Federal Reserve Bank of Saint Louis Review.* Vol. 64, 1984, August-September, pp. 13-23.

Bradshaw, Girard W. and David Orden. "Time Series Models for Exchange Rate and Agricultural Price Forecasts," in *Risk Analysis for Agricultural Production Firms: Concepts, Informal Requirements and Policy Issues*. Proceedings of a Seminar Sponsored by Southern Regional Project S-180, "An Economic Analysis of Risk Management Strategy for Agricultural Production Firms," in Savannah, Georgia, March 20-23, 1988. Raleigh, North Carolina: Department of Economics and Business. Agricultural Research Service, North Carolina State University, July, 1988, pp. 100-125.

Bredahl Maury E. and Paul Gallagher. "Comment on "Effects of an Exchange Rate Change on Agricultural Trade," *Agricultural Economics Research*. Vol. 29, 1977, pp. 45-48.

Brinkman, George L. "The Competitive Position of Canadian Agriculture." *Canadian Journal of Agricultural Economics*. Vol. 35, 1987, pp. 263-288.

CANSIM Statistics Canada.

Chambers Robert G. "Interrelationships between Monetary Instruments and Agricultural Commodity Trade." *American Journal of Agricultural Economics*. Vol. 63, 1981, pp. 934-941.

-----. "Agricultural and Financial Market Interdependence in the Short Run." *American Journal of Agricultural Economics*. Vol. 66, 1984, pp. 12-24.

-----, and Richard E. Just. "A Critique of Exchange Rate Treatment in Agricultural Trade Models" *American Journal of Agricultural Economics*. Vol. 61, 1979, pp. 249-257.

-----, and Richard Just. "Effects of Exchange Rate Changes on U.S. Agriculture: A Dynamic Analysis." *American Journal of Agricultural Economics*. Vol. 63, 1981, pp. 32-46.

Coffin, Garth H. "The Internationalization of Canadian Agriculture." *Canadian Journal of Agricultural Economics*. Vol. 35, 1987, pp. 691-707.

Courchene, Thomas J. *Abandoning Monetary Targets: An Evaluation*. Toronto: C.D. Howe Institute, 1983.

Denbaly, M.S. Mark and Gary W. Williams, "U.S. Money Supply and the Exchange Rate: Long Run Effects on the World Feed Grain Market." *American Journal of Agricultural Economics*. Vol. 10, 1988, pp. 49-62.

Devadoss, S. and William H. Meyers. "Relative Prices and Money: Further Results for the United States." *American Journal of Agricultural Economics*. Vol. 60, no. 4, Nov. 1987, pp. 838-842.

Dickey, David and Wayne A. Fuller. "Likelihood Ratio Statistics [illegible] Autoregressive Time Series With a Unit Root." *Econometrica*. Vol. 49, no. 4, July, [illegible], pp. 1057-1072.

Doan, T. and R. Litterman. *User's Manual: Regression Analysis of Time Series (RATS)*. Version 2.0. Minneapolis, Minnesota: VAR Econometrics, 1986.

Dornbusch, Rudiger. "Expectations and Exchange Rate Dynamics." *Journal of Political Economy*. Vol. 84, 1976, pp. 1161-1176.

-----, and Stanley Fischer. "Exchange Rates and the Current Account." *The American Economic Review*. Vol. 70, no. 5, 1980, pp. 960-971.

[illegible] John and Thomas Grennes. "Alternative Measures of Effective Exchange Rates for

Agricultural Trade." *European Review of Agricultural Economics* Vol. 14, 1987, pp. 427-442.

Emminger, Otmar. "The International Role of the Dollar." *Economic Review*. Federal Reserve Bank of Kansas. September/October, 1985, pp. 17-24.

Engle, Robert F. and Byung Sam Yoo. "Forecasting and Testing in Co-integrated Systems." *Journal of Econometrics*. Vol. 35, 1987, pp. 143-159.

-------- and C.W.J. Granger. "Co-integration and Error Correction: Representation, Estimation, and Testing." *Econometrica*. Vol.55, no. 2, 1987, pp. 251-276.

Fackler, Paul L. "Vector Autoregressive Techniques for Structural Analysis." Paper from the Department of Economics and Business, North Carolina State University.

Floyd, John E. *Focus on the Canadian Dollar*. Vancouver: The Fraser Institute, 1985.

Frankel, Jeffrey A. "Commodity Prices and Money: Lessons from International Finance." *American Journal of Agricultural Economics*. Vol. 66, 1984, pp. 560-566.

-------. "Expectations and Commodity Price Dynamics: The Overshooting Model." *American Journal of Agricultural Economics*. Vol. 68, 1986, pp. 344-348.

Freshwater David. "Farm Finance and the Public Sector: A Macroeconomic Perspective." *Canadian Journal of Agricultural Economics*. Vol. 35, 1987, pp. 709-733.

Ford, Steve. *A Beginner's Guide to Vector Autoregression*. University of Minnesota: Department of Agricultural and Applied Economics, Staff Paper P86-28, Sept. 1986.

Fuller, Wayne. *Introduction to Statistical Time Series*. New York: John Wiley and Sons, 1976

Granger, C. W. J. and Paul Newbold. *Forecasting Economic Time Series*. New York: Academic Press, 1977.

Higginson, N. *North American Hog Price Relationships*. Unpublished M. Sc. thesis, University of Alberta, 1987.

--------, Murray Hawkins, and Wiktor Adamowicz. "Pricing Relationships in Interdependent North American Hog Markets: The Impact of the Countervailing Duty." Unpublished paper, University of Alberta, 1988.

Howitt, Peter. *Monetary Policy in Transition: A Study of the Bank of Canada Policy 1982-85*. Toronto: C. D. Howe Institute, 1986.

Hughes, Dean W. and John B. Penson. "Effects of Selected Macroeconomic Policies on Agriculture: 1984-1990." *Agricultural Finance Review*. Vol. 45, 1985, pp. 81-91.

Judge, George G., R. Carter Hill, William E. Griffiths, Helmut Lutkepohl, and Tsoung C. Lee. *Introduction to the Theory and Practice of Econometrics*. New York: John Wiley and Sons, Inc., 1982.

Kaylen, Michael S. "Vector Autoregression Forecasting Models: Recent Developments Applied to the U. S. Hog Market." *American Journal of Agricultural Economics*. Vol. 70, no. 1, August, 1988, pp. 701-712.

Kling, John L. "The Dynamic Behavior of Business Loans and the Prime Rate: A Reply." *Journal of Banking and Finance*. Vol. 9, 1985, pp. 581-584.

Kloek, T. and H.K. van Dijk. "Bayesian E... ...tes of Equation System Parameters: An Application of Integration by Monte C... ..." *Econometrica*. Vol. 46. no. 1. January, 1978, pp. 1-19.

Kost, William. "Effects of an Excha... R..te Change on Agricultural Trade." *Agricultural Economics Research*. Vol. 28, 1... o, pp. 99-106.

Kuszczak, John and John D. Murray, *A VAR Analysis of Economic Interdependence: Canada, the United States, and The Rest of the World*. Bank of Canada Technical Report No. 46, March, 1987.

Lamm, R. McFall. "The Role of Agriculture in the Macroeconomy: A Sectoral Analysis." *Applied Economics*. Vol. 12, 1980, pp. 19-35.

Litterman, Robert B. "Forecasting With Bayesian Vector Autoregressions-Five Years of Experience." *Journal of Banking and Economic Statistics*. Vol. 4, no. 1, January, 1986, pp. 25-38.

McTaggart, Douglas. "An Approach to Modeling Macroeconomic Linkages in Trade Models: With an Application to Agriculture," in *The International Agricultural Trade Research Consortium: Agricultural Trade Modelling, The State of Practice and Research Issues*. Karen ...ai and Ralph Seeley, editors. Washington D.C.: U. S. Department of Agriculture, 1987. Staff Report No. AGES861215.

Moazzami, Bakhtiar, Kenneth Norrie and Michael Percy."The Timing of Prairie Settlement: Long-Run Equilibrium and Sh... Run Adjustment." Unpublished paper, Department of Economics, University of Alb... July, 1988, pp. 1-25.

Montgomery, Douglas C. and Lynwood A. Joh... ...ecasting and Time Series Analysis*. New York: McGraw - Hill Book Company,

Nerlove, Marc, David M. Gr...er, and Jose L. Carvalho. *Analysis of Economic Time Series: A Synthesis*. New York: Academic Press, 1979.

Orden, David. "Money and Agriculture: The Dynamics of Money-Financial Market-Agricultural Trade Linkages." *Agricultural Economics Research*. Vol.38, 1986, pp. 14-28.

------. "Agriculture, Trade, and Macroeconomics: The U.S. Case." *Journal of Policy Modeling*. Vol. 8, 1986, pp. 27-51.

Paarlberg, Philip L. and Robert G. Chambers, editors. *Macroeconomics, Agriculture, and Exchange Rates*. Boulder, Colorado: Westview Press, 1988.

Penson, John B. and Ronald A. Babula, "Japanese Monetary Policies and Agricultural Exports," *The Journal of Agricultural Economics Research*. Vol. 40, no. 1, Winter, 1988, pp. 11-18.

Pindyck, R. S. and D.L. Rubinfeld. *Econometric Models and Economic Forecasts*. New York: McGraw-Hill Book Co., 1976.

Rausser, Gordon C. "Macroeconomics and United States Agricultural Policy" in *U.S. A...ure P...licy: The 1985 Farm Legislation*. Bruce L. Gardner, editor. Washington ... Ameri...n Enterprise Institute for Public Policy Research, 1985, pp. 207-256.

...n, John and David Orden. "Cointegration and Long-Run Monetary Neutrality: A

Vector Error-Correction Model of Money and Price Dynamics in New Zealand." Paper presented at the AAEA meetings, Knoxville, Tennessee, Aug.1-3, 1988, p 1-26.

Sanni, T. A. Vector Autoregression on Nigerian Money and Agricultural Aggregates." *Canadian Journal of Agricultural Economics*. Vol. 34, 1986, pp. 67-85.

Saunders, Peter J. "Causality of U.S. Agricultural Prices and Money Supply: Further Empirical Evidence." *American Journal of Agricultural Economics*. Vol. 70, August, 1988, pp. 588-596.

Scarth, William M. *Macroeconomics: An Introduction to Advanced Methods*. Toronto: Harcourt Brace Jovanovich, 1988.

Schuh. G. Edward. "The Exchange Rate and U.S. Agriculture." *American Journal of Agricultural Economics*. Vol. 56, 1974, pp. 1-13.

--------. "The New Macroeconomics of Agriculture." *American Journal of Agricultural Economics*. Vol. 58, 1976, pp 802-811.

Sims, Christopher A. "Macroeconomics and Reality." *Econometrica*. Vol. 48, January, 1980, pp. 1-48.

--------. "Policy Analysis with Econometric Models," *Brookings Papers on Economic Activity*. Vol. 1, 1982, pp. 107-164.

--------. "Are Forecasting Models Usable for Policy Analysis?" *Quarterly Review*. Federal Reserve Bank of Minneapolis Winter, 1986, pp. 2-16.

Starleaf, Dennis. "Macroeocnomic Policies and Their Impact upon the Farm Sector." *American Journal of Agricultural Economics*. Vol. 64, 1982, pp. 854-860.

Taylor, Julia Susan. *The Impacts of Monetary Macroeconomic Policy on Canadian Agricultural Prices*. Unpublished M. Sc. thesis, University of Saskatchewan, 1987

Tiao, G. C. and G. E. P. Box. "Modeling Multiple Time Series with Applications." *Journal of American Statistical Association*. Vol. 76, 1981, pp. 802-816.

Thompson, Robert L. "On the Power of Macroeconomic Linkages to Explain Events in U.S. Agriculture: Discussion." *American Journal of Agricultural Economics*. Vol. 63, 1981, pp 888-890.

Appendix A

The following tables list the data series used in the estimation of the three VAR models.

Table A.1: Canadian Variables.

Date	CDNM1	TPI	CPI	AGEX	FPI
1971:01	6.041	4.59	41.2	69260	33.48961
1971:02	6.171	4.51	41.4	74931	33.37783
1971:03	6.321	3.3	41.5	89264	33.52329
1971:04	6.339	3.05	41.8	56962	33.25573
1971:05	6.517	3.06	42	110326	33.12355
1971:06	6.647	3.15	42.1	137354	32.64773
1971:07	6.611	3.58	42.4	137941	32.14400
1971:08	6.8	3.88	42.7	132574	33.68137
1971:09	6.913	3.93	42.6	120973	33.96739
1971:10	6.921	3.79	42.7	137424	34.00204
1971:11	7.095	3.31	42.8	128944	34.49465
1971:12	7.211	3.25	43.1	153168	34.67406
1972:01	7.167	3.29	43.3	63093	35.90700
1972:02	7.21	3.48	43.4	55235	35.33110
1972:03	7.256	3.51	43.5	70845	34.10223
1972:04	7.336	3.65	43.7	49874	34.65069
1972:05	7.39	3.68	43.8	143293	36.13478
1972:06	7.47	3.58	43.8	157540	35.81357
1972:07	7.547	3.48	44.4	130614	35.48830
1972:08	7.673	3.47	44.7	153565	41.28216
1972:09	7.851	3.57	44.9	100768	41.61297
1972:10	7.998	3.57	44.9	201707	41.29026
1972:11	8.146	3.61	45	196243	42.06665
1972:12	8.229	3.66	45.3	147693	43.16862
1973:01	8.354	3.79	45.7	90349	45.34069
1973:02	8.372	3.92	46	108458	45.67191
1973:03	8.373	4.29	46.1	94804	45.23991
1973:04	8.604	4.73	46.6	143190	45.58714
1973:05	8.705	5.08	46.9	183592	48.15103
1973:06	8.642	5.4	47.4	182125	48.75959
1973:07	8.865	5.65	47.8	197025	49.99871
1973:08	8.823	6.03	48.4	251991	68.61020
1973:09	8.914	6.41	48.7	122670	66.32979
1973:10	9.003	6.51	48.8	183794	65.41980
1973:11	8.961	6.46	49.2	238774	65.15979
1973:12	8.957	6.38	49.5	244732	65.66618
1974:01	9.08	6.28	49.9	204265	67.77520
1974:02	9.098	6.11	50.4	143246	66.52587
1974:03	9.198	6.28	50.9	195991	62.66320
1974:04	9.687	7.13	51.2	145748	63.80525
1974:05	9.849	8.24	52.1	359787	66.41917
1974:06	9.384	8.68	52.8	273473	65.40852
1974:07	9.284	8.92	53.1	279851	64.12217
1974:08	9.195	9.09	53.7	286678	66.60847
1974:09	9.219	9.03	54	188044	66.41733
1974:10	9.137	8.6	54.5	264732	65.68113
1974:11	9.201	7.73	55.1	303181	65.88507
1974:12	9.19	7.32	55.6	238410	65.72416
1975:01	9.495	6.65	55.9	319633	66.03586
1975:02	9.871	6.34	56.3	125615	63.13639
1975:03	10.255	6.29	56.6	90776	60.34745

1975:04	10.159	6.54	56.9	167886	62.41030
1975:05	10.258	6.9	57.4	303256	66.82066
1975:06	10.372	6.96	58.2	360165	67.78290
1975:07	10.482	7.29	59.6	260434	67.38356
1975:08	10.736	7.72	59.6	163686	69.79964
1975:09	10.804	8.37	59.7	249259	69.80240
1975:10	10.972	8.31	60.3	321366	68.64288
1975:11	11.853	8.44	60.8	265257	67.07454
1975:12	11.553	8.58	60.9	326040	66.44895
1976:01	11.187	8.59	61.2	280773	67.54855
1976:02	11.233	8.7	61.5	2[illegible]6812	67.08945
1976:03	11.083	9.04	61.7	112868	66.61079
1976:04	11.054	8.97	62	124227	67.14333
1976:05	11.081	8.94	62.5	249146	66.61146
1976:06	11.107	8.99	62.8	332815	66.43813
1976:07	11.193	9.02	63	330651	65.15589
1976:08	11.295	9.12	63.3	209490	63.38834
1976:09	11.285	8.97	63.6	213573	63.96059
1976:10	11.319	9.07	64	244857	61.84971
1976:11	11.443	8.88	64.2	231173	62.84925
1976:12	11.341	8.41	64.5	255179	63.66158
1977:01	11.515	8.08	65	198920	61.68787
1977:02	11.606	7.67	65.6	182211	62.04939
1977:03	11.877	7.61	66.3	166150	63.22494
1977:04	11.93	7.55	66.7	145374	63.98403
1977:05	12.05	7.26	67.2	246442	64.98840
1977:06	12.246	7.07	67.7	356448	64.38132
1977:07	12.181	7.12	68.3	304487	62.71295
1977:08	12.246	7.16	68.6	304039	63.52307
1977:09	12.317	7.09	69	206211	63.21331
1977:10	12.378	7.19	69.6	235433	62.97177
1977:11	12.527	7.25	70.1	209221	64.53949
1977:12	12.813	7.18	70.6	310728	65.49930
1978:01	12.846	7.14	70.8	162615	65.07032
1978:02	12.833	7.24	71.3	190602	65.85447
1978:03	12.741	7.62	72.1	155419	66.87898
1978:04	12.905	8.18	72.3	183912	67.30961
1978:05	13.083	8.13	73.3	288451	70.15568
1978:06	13.252	8.24	73.9	314236	71.13940
1978:07	13.356	8.43	75	273180	68.72388
1978:08	13.421	8.77	75.1	345690	76.72617
1978:09	13.603	9.02	74.9	312427	78.39673
1978:10	13.995	9.52	75.7	261518	80.14280
1978:11	14.208	10.29	76.3	366027	82.23525
1978:12	13.732	10.43	76.5	293932	83.18307
1979:01	13.588	10.8	77.1	245767	81.84862
1979:02	13.752	10.78	77.8	157189	85.48064
1979:03	13.491	10.9	78.8	217490	84.71337
1979:04	13.694	10.84	79.3	219965	83.73794
1979:05	14.078	10.84	80.1	262542	83.23948
1979:06	14.368	10.82	80.5	309112	82.50081
1979:07	14.405	10.91	81.1	340211	80.36001
1979:08	14.49	11.32	81.4	325610	87.47052
1979:09	14.552	11.57	82.1	499367	90.08152

1979:10	14.58	12.86	82.7	528773	88.54131
1979:11	14.544	13.61	83.5	424507	89.51362
1979:12	13.87	13.63	84	374031	91.92094
1980:01	14.538	13.54	84.5	268845	88.68050
1980:02	14.601	13.56	85.2	293155	88.31775
1980:03	14.661	14.35	86.1	290920	87.02648
1980:04	14.359	15.64	86.6	316132	84.80212
1980:05	14.192	12.54	87.6	389214	85.22689
1980:06	14.259	11.15	88.6	685915	85.24322
1980:07	14.736	10.1	89.3	510290	86.40308
1980:08	15.017	10.21	90.1	567150	97.87807
1980:09	15.447	10.63	90.9	497900	99.83016
1980:10	15.901	11.57	91.7	635934	101.0540
1980:11	16.263	12.87	92.9	441626	104.0358
1980:12	15.485	16.31	93.4	522070	105.4438
1981:01	15.462	16.77	94.6	402095	100.6
1981:02	15.351	16.87	95.6	323683	100.3
1981:03	15.517	16.64	96.8	343930	100.3
1981:04	15.77	16.92	97.6	329772	101.2
1981:05	15.562	18.61	98.4	596842	101.5
1981:06	15.145	18.83	100	709684	102.8
1981:07	16.111	19.27	100.8	423722	104.2
1981:08	15.156	20.85	101.2	487862	99.4
1981:09	14.546	19.7	102.3	522052	98.4
1981:10	14.423	18.19	103.3	600192	97.8
1981:11	14.048	15.87	104.2	681156	96.6
1981:12	15.334	14.81	104.7	519825	95.8
1982:01	15.216	14.47	105.4	303041	96.78499
1982:02	14.719	14.55	106.7	329339	97.56341
1982:03	14.527	14.83	108	450143	98.92725
1982:04	14.588	15.07	108.6	499763	99.33488
1982:05	14.962	15.08	110.1	678610	101.7555
1982:06	14.683	16.06	111.2	760315	100.8814
1982:07	14.509	15.82	111.8	611161	98.10350
1982:08	13.928	14.42	112.3	485297	100.5389
1982:09	14.256	13.15	112.9	588684	100.9510
1982:10	14.328	11.54	113.6	527842	98.60591
1982:11	14.422	10.72	114.4	604017	98.72369
1982:12	15.272	10.25	114.4	525911	98.82108
1983:01	15.301	9.53	114.1	337067	96.65103
1983:02	15.777	9.4	114.6	345422	97.46328
1983:03	15.729	9.21	115.8	437683	96.58062
1983:04	15.994	9.22	115.8	502292	96.44163
1983:05	15.973	9.12	116.1	740721	96.45578
1983:06	16.264	9.24	117.4	635496	94.67841
1983:07	16.614	9.25	117.9	622379	92.25329
1983:08	16.727	9.35	118.5	653688	100.9093
1983:09	16.808	9.26	118.5	608049	102.4456
1983:10	16.4	9.22	119.2	676884	101.9381
1983:11	16.56	9.31	119.2	561615	102.9320
1983:12	16.562	9.69	119.6	562548	105.7212
1984:01	16.537	9.73	120.2	374934	102.4782
1984:02	16.631	9.77	120.3	388348	101.9692
1984:03	16.766	10.22	121.2	410164	102.4136

1984:04	16.824	10.56	121.5	461540	103.1925
1984:05	16.64	11.27	121.7	781107	104.5048
1984:06	16.529	11.74	122.2	794958	102.6118
1984:07	16.232	12.81	122.9	804915	100.8036
1984:08	15.804	12.21	122.9	734760	103.7049
1984:09	15.888	12.08	123	661021	103.7703
1984:10	16.149	11.83	123.2	615470	102.9921
1984:11	15.873	10.92	124	603803	105.4846
1984:12	15.784	10.13	124.1	353514	106.3800
1985:01	16.16	9.52	124.6	355803	101.4
1985:02	15.905	10.57	125.4	296118	101.6
1985:03	16.142	11.08	125.7	345825	100.6
1985:04	15.908	9.92	126.2	422304	99
1985:05	16.329	9.56	126.5	623991	99
1985:06	16.379	9.35	127.2	501018	99.8
1985:07	16.486	9.16	127.6	288518	98.8
1985:08	16.938	9.02	127.8	354935	93.4
1985:09	16.992	8.95	128	622284	92.8
1985:10	17.121	8.58	128.4	623979	92.9
1985:11	17.183	8.72	128.9	592843	93.1
1985:12	17.594	9.09	129.5	498348	94
1986:01	16.976	10.02	130.1	387694	94.1
1986:02	16.569	11.55	130.6	306637	94.2
1986:03	16.528	10.5	130.9	270396	93
1986:04	15.786	9.14	131.1	336449	91.7
1986:05	16.313	8.41	131.7	431292	92.3
1986:06	16.559	8.6	131.9	415890	93.4
1986:07	16.968	8.29	132.9	438643	95.4
1986:08	17	8.33	133.3	327118	92.5
1986:09	17.502	8.32	133.3	316418	92.5
1986:10	17.707	8.32	134	435051	92.9
1986:11	18.183	8.27	134.7	458999	93.6
1986:12	18.267	8.21	134.9	475039	91.9
1987:01	18.593	7.81	135.2	319610	89.7
1987:02	19.278	7.33	135.8	262167	89.5
1987:03	19.061	7	136.4	327874	88.8
1987:04	20.163	7.52	137	455796	90.1
1987:05	20.552	8.06	137.8	532797	92.8
1987:06	20.654	8.3	138.2	405639	94.2
1987:07	20.358	8.53	139.2	379211	94.2
1987:08	20.363	8.95	139.3	346079	91
1987:09	20.327	9.19	139.3	358373	90.3
1987:10	20.773	8.85	139.8	578444	88.6
1987:11	20.37	8.24	140.4	466505	87.3
1987:12	19.758	8.45	140.5	450432	87.5

Table A.2: U.S. and Other Variables.

Date	USM1	TBUS	US/CDN	G10
1971:01	217.8	4.494	1.011640	100.28
1971:02	219.7	3.773	1.007531	100.65
1971:03	221.1	3.323	1.006263	100.78
1971:04	222.3	3.78	1.007619	100.64
1971:05	224.4	4.139	1.008734	100.43
1971:06	225.9	4.699	1.021207	99.19
1971:07	227.3	5.405	1.021145	99.18
1971:08	228	5.078	1.013323	99.6
1971:09	228.9	4.668	1.012872	99.34
1971:10	229.6	4.489	1.004406	99.95
1971:11	230.3	4.191	1.003735	99.96
1971:12	230.8	4.023	0.999247	100.01
1972:01	232.6	3.403	1.005921	99
1972:02	234.8	3.18	1.004747	98.84
1972:03	236.8	3.723	0.998394	99.35
1972:04	238.1	3.723	0.995593	99.69
1972:05	238.4	3.648	0.988664	100.39
1972:06	239.3	3.874	0.979375	101.38
1972:07	241.3	4.059	0.983859	101.04
1972:08	243.5	4.014	0.982228	101.23
1972:09	245.8	4.651	0.982875	101.2
1972:10	247.7	4.719	0.982574	101.34
1972:11	249.1	4.774	0.987202	100.94
1972:12	252	5.061	0.996677	100
1973:01	254.3	5.307	0.999147	99.74
1973:02	254.9	5.558	0.995531	99.03
1973:03	254.4	6.054	0.996555	98.1
1973:04	255.6	6.289	1.00061	97.91
1973:05	257.8	6.348	1.000481	97.72
1973:06	259.6	7.188	0.998314	97.45
1973:07	260.5	8.015	0.999419	96.9
1973:08	260.8	8.672	1.003834	96.85
1973:09	260.9	8.478	1.008105	96.51
1973:10	262.1	7.155	1.000890	97.14
1973:11	264	7.866	0.998780	98.1
1973:12	265.9	7.364	0.999410	98.47
1974:01	266.9	7.755	0.9914	100.31
1974:02	268.3	7.06	0.97669	101.36
1974:03	269.7	7.986	0.972	101.28
1974:04	270.2	8.229	0.967266	101.43
1974:05	270.7	8.43	0.962136	101.79
1974:06	271.6	8.145	0.9664	101.63
1974:07	272.6	7.752	0.976081	100.77
1974:08	273.1	8.744	0.979781	100.83
1974:09	274.1	8.363	0.98625	100.25
1974:10	275.4	7.244	0.982963	100.42
1974:11	276.8	7.585	0.98715	99.84
1974:12	277.6	7.179	0.98809	99.55
1975:01	277.2	6.493	0.994745	98.54
1975:02	278.1	5.583	1.00054	97.62
1975:03	280.2	5.544	1.00029	97.45

1975:04	279.8	5.694	1.011081	96.7
1975:05	282.5	5.315	1.028142	95.05
1975:06	286.2	5.193	1.026361	95.31
1975:07	287	6.164	1.030709	95.53
1975:08	288.2	6.463	1.035295	95.53
1975:09	289.2	6.383	1.026209	96.62
1975:10	288.8	6.081	1.024990	96.75
1975:11	291.3	5.468	1.013715	97.85
1975:12	291.2	5.504	1.013828	98.03
1976:01	292.4	4.961	1.006371	98.73
1976:02	294.6	4.852	0.99371	99.98
1976:03	296	5.047	0.9858	101.09
1976:04	297.9	4.878	0.983333	101.59
1976:05	299.7	5.185	0.98002	102.03
1976:06	299.6	5.443	0.973590	102.85
1976:07	300.8	5.278	0.972161	102.87
1976:08	302.8	5.153	0.985318	101.36
1976:09	303.4	5.075	0.974961	102.41
1976:10	306.6	4.93	0.97263	102.87
1976:11	307.4	4.81	0.985723	101.59
1976:12	310.4	4.354	1.018718	98.11
1977:01	313.3	4.597	1.01089	98.76
1977:02	315.6	4.662	1.027865	97.04
1977:03	317.5	4.613	1.051086	94.77
1977:04	320	4.54	1.051085	94.64
1977:05	320.6	4.942	1.048538	94.88
1977:06	322.1	5.004	1.057477	93.99
1977:07	324.5	5.146	1.060995	93.34
1977:08	326.2	5.5	1.074891	92.2
1977:09	328.3	5.77	1.073252	92.4
1977:10	331.1	6.188	1.098755	89.84
1977:11	332.9	6.16	1.109233	88.6
1977:12	335.4	6.063	1.09723	89.22
1978:01	339.2	6.448	1.101114	88.6
1978:02	339.6	6.457	1.11316	87.53
1978:03	340.9	6.319	1.125604	86.32
1978:04	344.3	6.306	1.141565	84.99
1978:05	347.9	6.43	1.118872	87.04
1978:06	349.9	6.707	1.121609	86.43
1978:07	352	7.074	1.1245	85.61
1978:08	353.6	7.036	1.140282	83.87
1978:09	357.4	7.836	1.16629	81.94
1978:10	358.2	8.132	1.182680	80.22
1978:11	360.1	8.787	1.172757	81.45
1978:12	363.1	9.122	1.179473	80.98
1979:01	363.9	9.351	1.189831	80.19
1979:02	365.1	9.265	1.19545	79.91
1979:03	367.5	9.457	1.173872	81.48
1979:04	371.7	9.493	1.14633	83.71
1979:05	372.9	9.592	1.155627	83.18
1979:06	377.4	9.045	1.172271	81.85
1979:07	381.4	9.262	1.163447	81.98
1979:08	383.7	9.45	1.170565	81.56
1979:09	385.9	10.182	1.165226	81.99

1979:10	386.3	11.472	1.175254	81.57
1979:11	386.8	11.868	1.179638	81.55
1979:12	389.1	12.071	1.169578	81.91
1980:01	392.5	12.036	1.163863	82.12
1980:02	395.8	12.814	1.156009	82.86
1980:03	394.7	15.526	1.173090	82.24
1980:04	387.5	14.003	1.185614	81.45
1980:05	388.7	9.15	1.173085	81.44
1980:[illegible]	393.8	6.995	1.151523	82.6
1980:07	398.7	8.126	1.151913	82.52
1980:08	406	9.259	1.159123	82.22
1980:09	411.8	10.321	1.164619	81.57
1980:10	415.7	11.58	1.169045	81.28
1980:11	417.7	13.888	1.186047	80.49
1980:12	414.9	15.661	1.196785	79.93
1981:01	418	14.724	1.190747	80.2
1981:02	420.4	14.905	1.190747	80.33
1981:03	424.2	13.478	1.191236	80.97
1981:04	430.1	13.635	1.190795	81.41
1981:05	428.9	16.295	1.200919	81.37
1981:06	428.7	14.557	1.203995	81.65
1981:07	431	14.699	1.211449	81.67
1981:08	433.1	15.612	1.222971	81.2
1981:09	433.6	14.951	1.200699	82.26
1981:10	433.8	13.873	1.202761	81.95
1981:11	436.9	11.269	1.187394	82.63
1981:12	441.9	10.926	1.185109	82.78
1982:01	450.3	12.412	1.192414	82.56
1982:02	448.1	13.78	1.214029	81.61
1982:03	447.9	14.493	1.220395	81.49
1982:04	449.8	12.821	1.224752	81.42
1982:05	451.5	12.148	1.233919	80.42
1982:06	452.3	12.108	1.275277	78.54
1982:07	453.1	11.914	1.269885	79.1
1982:08	457.7	9.006	1.245131	80.81
1982:09	463.5	8.196	1.234680	81.68
1982:10	470.2	7.75	1.229934	82.34
1982:11	476.4	8.042	1.226209	82.64
1982:12	480.5	8.013	1.238185	81.16
1983:01	485.1	7.81	1.228434	81.59
1983:02	491.1	8.13	1.227304	81.93
1983:03	496.4	8.304	1.226195	82.19
1983:04	497.9	8.252	1.232154	81.9
1983:05	506.6	8.19	1.228790	81.95
1983:06	510.9	8.82	1.232159	82.09
1983:07	514.9	9.12	1.232399	82.23
1983:08	517.4	9.39	1.233643	82.48
1983:09	518.9	9.05	1.232414	82.54
1983:10	521.6	8.71	1.231874	82.26
1983:11	523	8.71	1.236719	82.22
1983:12	525.3	8.96	1.246849	81.79
1984:01	531.4	8.93	1.248328	81.89
1984:02	534.2	9.03	1.247952	81.62
1984:03	537.3	9.44	1.270036	79.76

1984:04	539.2	9.69	1.279409	79.37
1984:05	542.5	9.9	1.294295	78.87
1984:06	547.3	9.94	1.303823	78.38
1984:07	546.9	10.13	1.323976	77.74
1984:08	548.9	10.49	1.303386	79.04
1984:09	551.5	10.41	1.314347	78.88
1984:10	548.3	9.97	1.318768	78.82
1984:11	553.8	8.79	1.316309	78.71
1984:12	558.5	8.16	1.320152	78.91
1985:01	562.9	7.76	1.323840	79.12
1985:02	569.3	8.22	1.352994	77.91
1985:03	572.2	8.56	1.383423	76.06
1985:04	575.7	7.99	1.364899	76.28
1985:05	582.5	7.56	1.375668	75.7
1985:06	590.9	7.01	1.367309	75.93
1985:07	595.8	7.05	1.352440	76.07
1985:08	604.8	7.18	1.357327	75.52
1985:09	611.4	7.08	1.370239	74.92
1985:10	614.1	7.17	1.366522	74.16
1985:11	619.9	7.2	1.376514	73.23
1985:12	626.3	7.07	1.394904	72.09
1986:01	628.9	7.04	1.406577	71.33
1986:02	625.2	7.03	1.403494	70.88
1986:03	634	6.59	1.400894	70.65
1986:04	641.2	6.06	1.387518	71.21
1986:05	651.7	6.12	1.375338	71.49
1986:06	661.3	6.21	1.389704	70.8
1986:07	670.8	5.84	1.380518	70.84
1986:08	680.5	5.57	1.388309	70.15
1986:09	687.4	5.19	1.387071	70.22
1986:10	694.9	5.18	1.388309	70.2
1986:11	706.4	5.35	1.386052	70.55
1986:12	725.4	5.49	1.379799	70.74
1987:01	731.4	5.45	1.360319	71.06
1987:02	731.3	5.59	1.333884	72.29
1987:03	734.2	5.56	1.319213	72.94
1987:04	744.7	5.76	1.318923	72.55
1987:05	746.5	5.75	1.341194	71.14
1987:06	742.1	5.69	1.338549	71.57
1987:07	743.6	5.78	1.325813	72.57
1987:08	746.5	6	1.325571	72.52
1987:09	747.5	6.32	1.315280	72.75
1987:10	756.2	6.4	1.309495	73.01
1987:11	752.7	5.81	1.316109	71.84
1987:12	750.8	5.91	1.307433	71.84

Appendix B

The following tables report the forecast error decompositions for the macroeconomic variables of Model 1, containing the U.S./Canadian exchange rate. Only selected months for two years are presented. The following graphs present the impulse response functions for the macroeconomic variables of Model 1.

Table B.1: Decomposition of Variance on U.S. Money Supply.

Step	Stan Error	USM1	CDNM1	TBU	US/CDN	TBI	CPI	AGEX	FPI
1	1.94737	100.00	.00	.00	.00	.00	.00	.00	.00
2	2.52351	94.60	.61	3.04	.59	.26	.18	.00	.67
3	2.66889	90.48	1.59	2.87	1.69	.51	.57	.50	1.75
4	2.71800	89.56	1.71	2.91	1.64	.73	.55	1.03	1.82
8	2.99090	75.15	5.73	4.12	1.80	1.75	.96	1.21	9.23
12	3.10459	71.23	5.97	5.42	1.91	2.37	1.47	2.58	9.01
16	3.15660	70.47	6.07	5.39	1.91	2.72	1.55	3.06	8.79
20	3.17622	69.85	6.24	5.51	1.97	2.85	1.56	3.16	8.82
24	3.18695	69.48	6.33	5.53	1.96	2.87	1.58	3.24	8.97

Table B.2: Decomposition of Variance on Canadian Money Supply.

Step	Stan Error	USM1	CDNM1	TBU	US/CDN	TBI	CPI	AGEX	FPI
1	.199003	5.38	94.61	.00	.00	.00	.00	.00	.00
2	.213525	5.28	84.34	4.92	2.33	1.76	.44	.38	.51
3	.239738	5.10	69.14	4.87	6.98	12.14	.41	.40	.92
4	.246580	4.97	65.40	8.33	7.15	12.07	.61	.47	.97
8	.281645	12.01	51.09	11.81	7.66	9.69	3.31	2.20	2.19
12	.297725	14.76	46.77	10.89	7.22	10.06	3.23	4.38	2.65
16	.307727	14.18	45.16	11.39	7.07	9.99	3.30	4.51	4.36
20	.309952	14.24	44.64	11.72	7.06	9.99	3.27	4.55	4.48
24	.311342	14.33	44.32	11.81	7.05	10.03	3.28	4.69	4.46

Table B.3: Decomposition of Variance on U.S. Interest Rate.

Step	Stan Error	USM1	CDNM1	TBU	US/CDN	TBI	CPI	AGEX	FPI
1	.533284	.322	.193	99.48	.00	.00	.00	.00	.00
2	.605219	9.79	2.98	83.55	.04	.07	.15	.23	3.16
3	.640727	12.95	3.04	77.89	.05	.21	.18	.42	5.23
4	.661378	12.27	3.20	74.57	.12	.90	.72	.53	7.64
8	.726756	11.64	6.91	69.98	1.20	1.53	.95	.90	6.86
12	.749514	12.19	7.68	67.07	1.17	2.62	.98	1.51	6.74
16	.760019	12.19	8.17	65.94	1.56	2.68	1.07	1.53	6.84
20	.763756	12.17	8.34	65.40	1.56	2.79	1.08	1.72	6.90
24	.766146	12.20	8.40	65.23	1.58	2.84	1.08	1.74	6.88

Table B.4: Decomposition of Variance on U.S./Canadian Exchange Rate.

Step	Stan Error	USM1	CDNM1	TBU	US/CDN	TBI	CPI	AGEX	FPI
1	.0085	.366	.252	4.15	95.22	.000	.00	.000	.000
2	.0095	3.78	.697	15.36	77.86	.666	1.26	.026	.332
3	.0096	3.71	.802	15.11	77.28	.920	1.35	.255	.555
4	.0098	3.75	.987	14.71	75.05	1.55	2.01	1.25	.668
8	.0105	4.74	2.27	15.00	65.23	4.70	2.30	3.49	2.23
12	.0109	5.88	2.86	15.15	62.22	5.03	2.83	3.39	2.59
16	.0110	6.14	3.59	15.00	60.86	5.23	2.86	3.58	2.70
20	.0110	6.35	3.59	14.94	60.43	5.35	2.89	3.69	2.71
24	.0111	6.45	3.63	14.95	60.18	5.35	2.91	3.71	2.77

Table B.5: Decomposition of Variance on Canadian Interest Rate.

Step	Stan Error	USM1	CDNM1	TBU	US/CDN	TBI	CPI	AGEX	FPI
1	.378469	3.83	.91	30.89	10.11	54.25	.00	.00	.000
2	.483274	6.87	3.98	42.49	8.83	34.40	1.26	1.31	.835
3	.526068	8.67	5.56	36.27	7.46	29.06	1.47	2.95	8.53
4	.553354	10.15	5.15	32.84	7.38	27.43	1.83	2.82	12.36
8	.624044	11.50	4.87	35.79	8.98	23.33	1.85	2.72	10.93
12	.638673	11.78	4.98	35.82	8.75	22.89	1.95	3.10	10.68
16	.644924	12.42	5.06	35.46	8.65	22.59	1.97	3.07	10.73
20	.647236	12.44	5.15	35.29	8.60	22.51	2.00	3.15	10.81
24	.648286	12.47	5.26	35.22	8.60	22.47	2.00	3.15	10.80

Table B.6: Decomposition of Variance on CPI.

Step	Stan Error	USM1	CDNM1	TBU	US/CDN	TBI	CPI	AGEX	FPI
1	.216795	.825	.003	.031	.038	.012	99.08	.000	.000
2	.299836	.451	.192	.385	.084	.469	97.71	.024	.680
3	.307691	.524	.289	1.097	.082	1.09	93.04	2.50	1.36
4	.319651	.714	.339	2.920	.151	1.30	87.91	5.38	1.26
8	.342083	4.07	2.64	2.908	.891	2.04	79.07	6.66	1.69
12	.351086	5.93	3.38	2.818	1.10	2.76	75.38	6.79	1.81
16	.355378	6.24	3.35	2.960	1.10	3.29	73.81	7.05	2.17
20	.357664	6.44	3.56	3.240	1.14	3.30	72.92	6.99	2.38
24	.358384	6.49	3.56	3.373	1.19	3.30	72.63	6.99	2.43

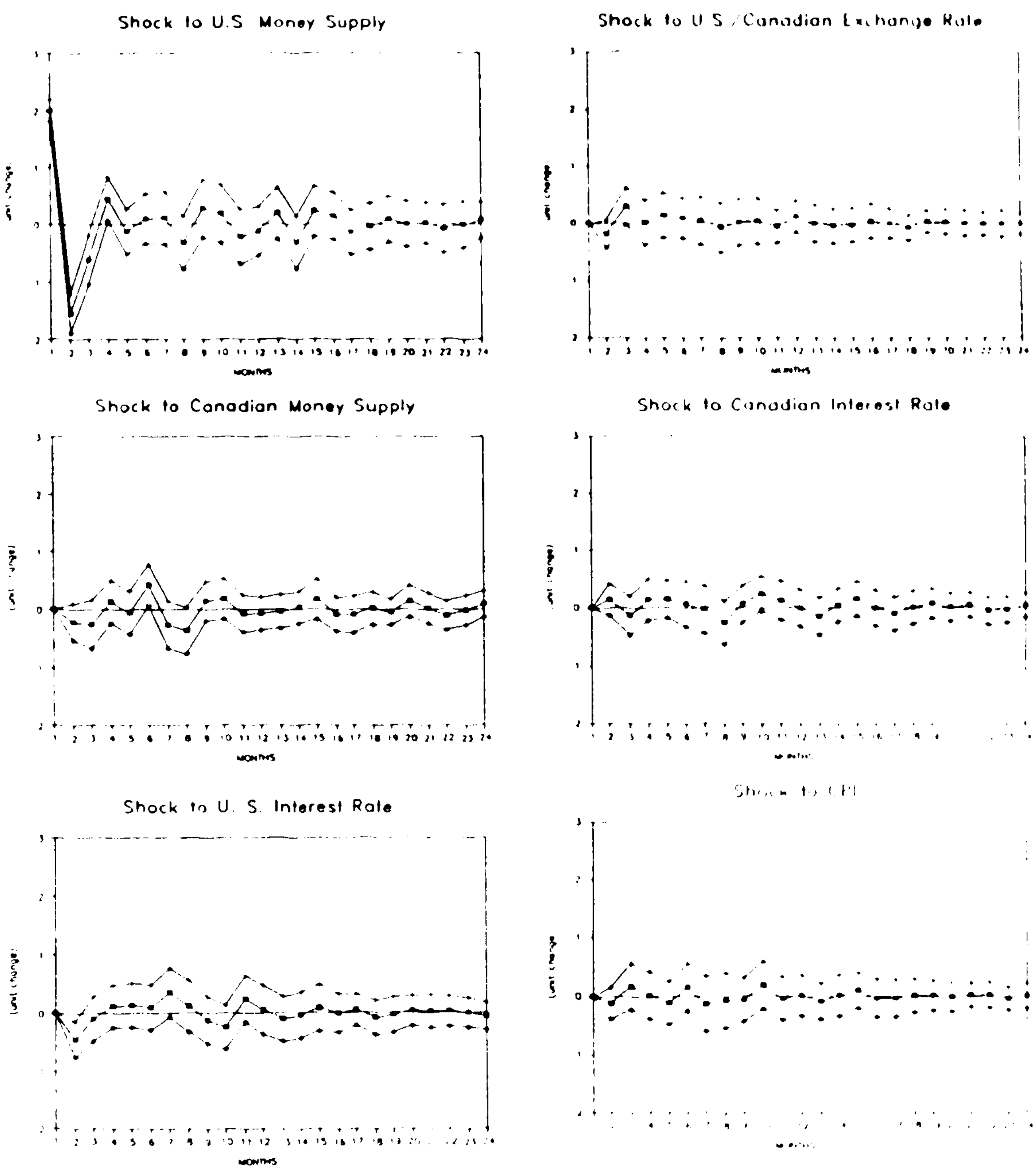
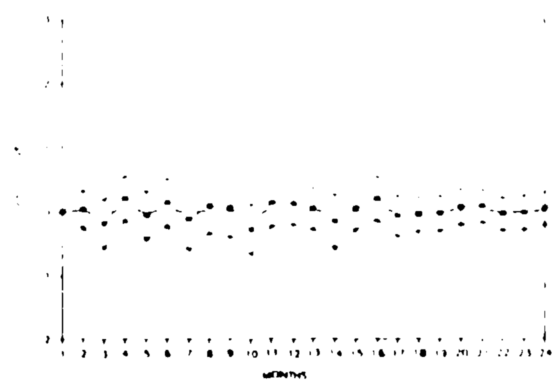


Figure B.1 Response of U. S. Money Supply to Shocks in Macroeconomic Variables.

Shock to Agricultural Exports



Shock to FPI

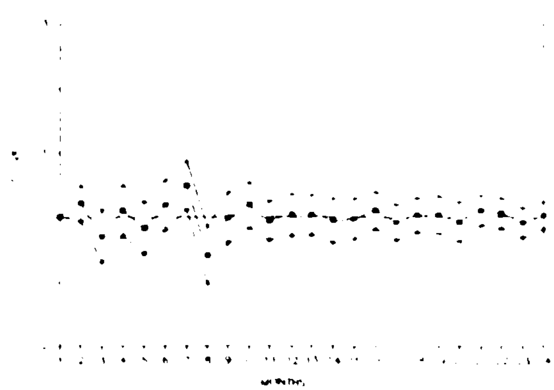


Figure B.2 Response of U. S. Money Supply to Shocks in Agricultural Variables.

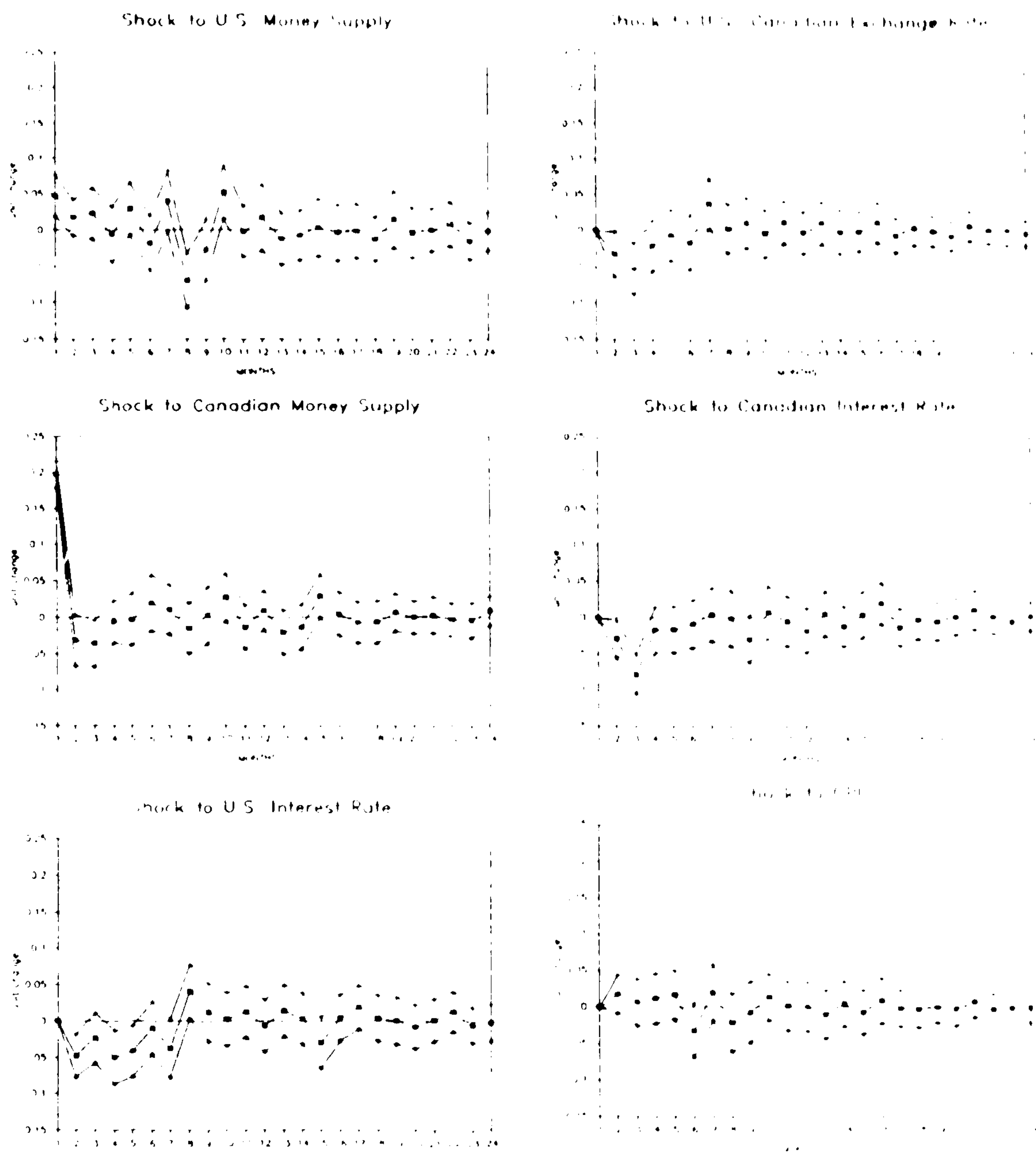


Figure B.3 Response of Canadian Money Supply to Shocks in Macroeconomic Variables.

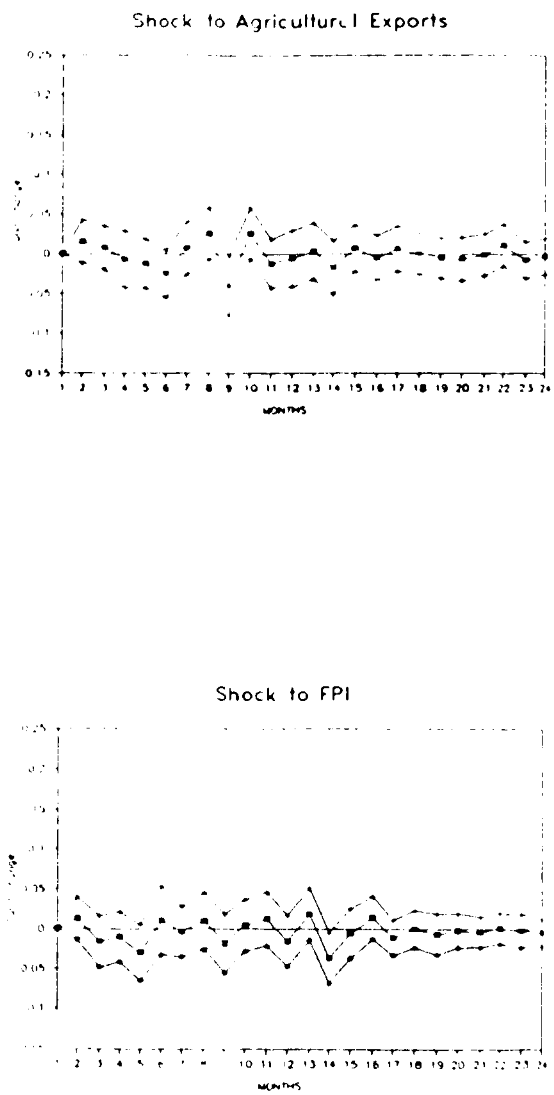


Figure B.4 Response of Canadian Money Supply to Shocks in Agricultural Variables.

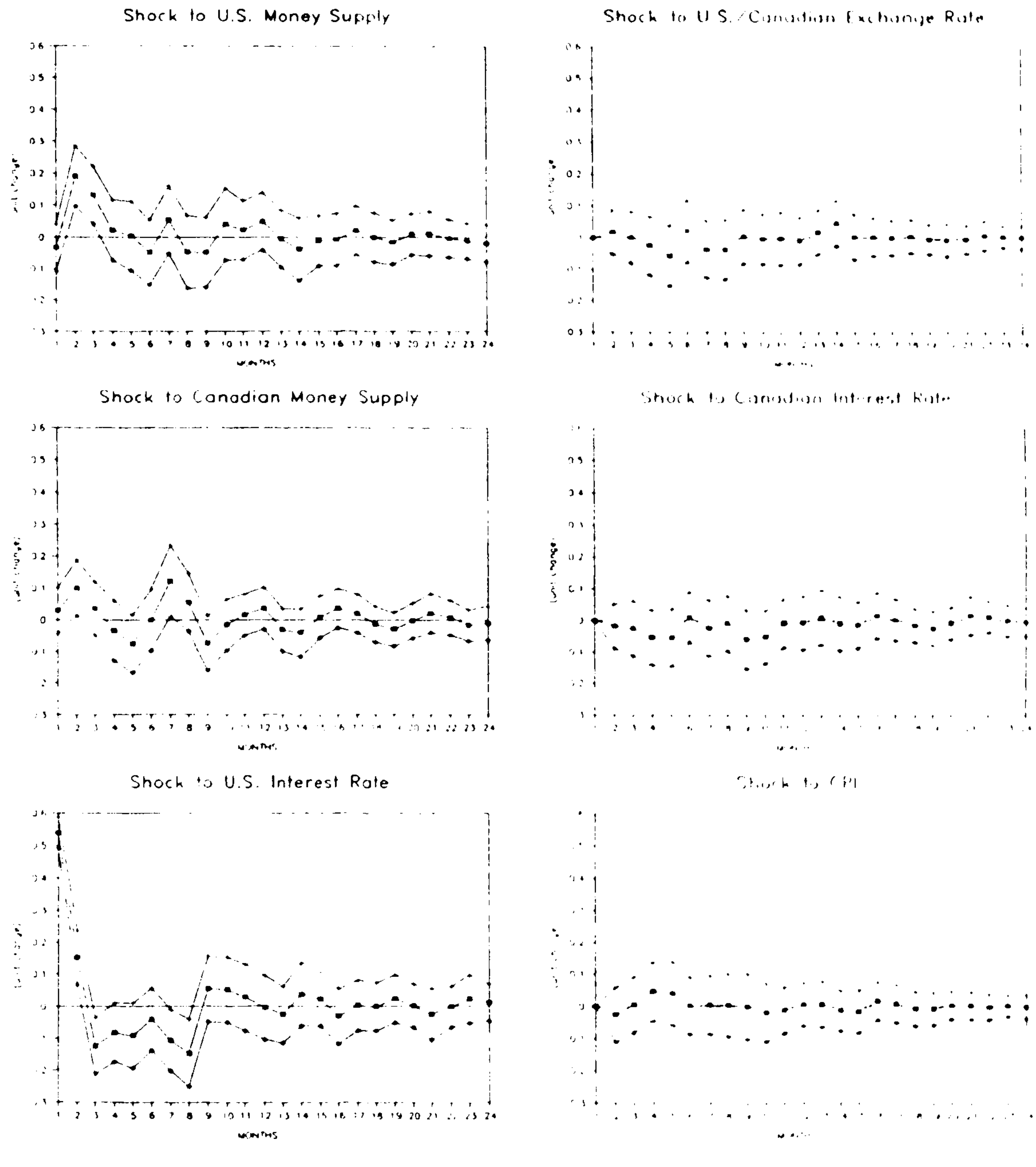
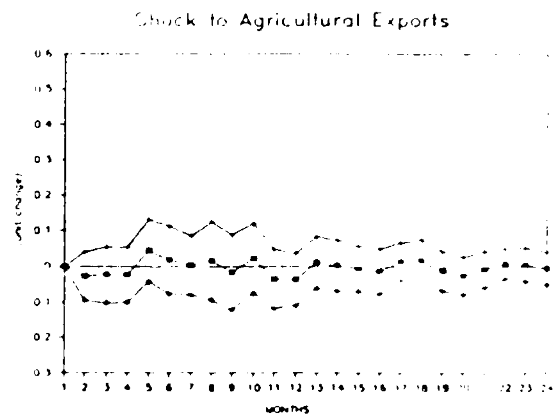


Figure B.5 Response of U. S. Interest Rate to Shocks in Macroeconomic Variables.



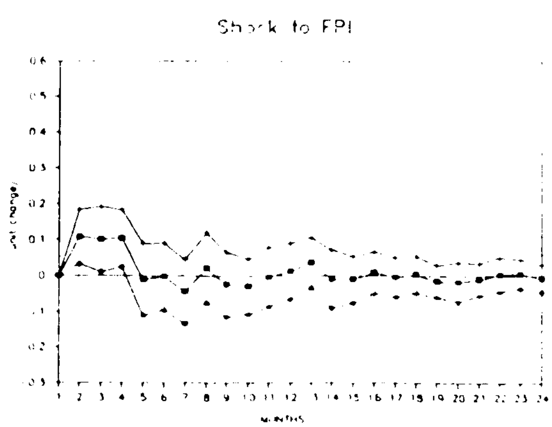


Figure B.6 Response of U. S. Interest Rate to Shocks in Agricultural Variables.

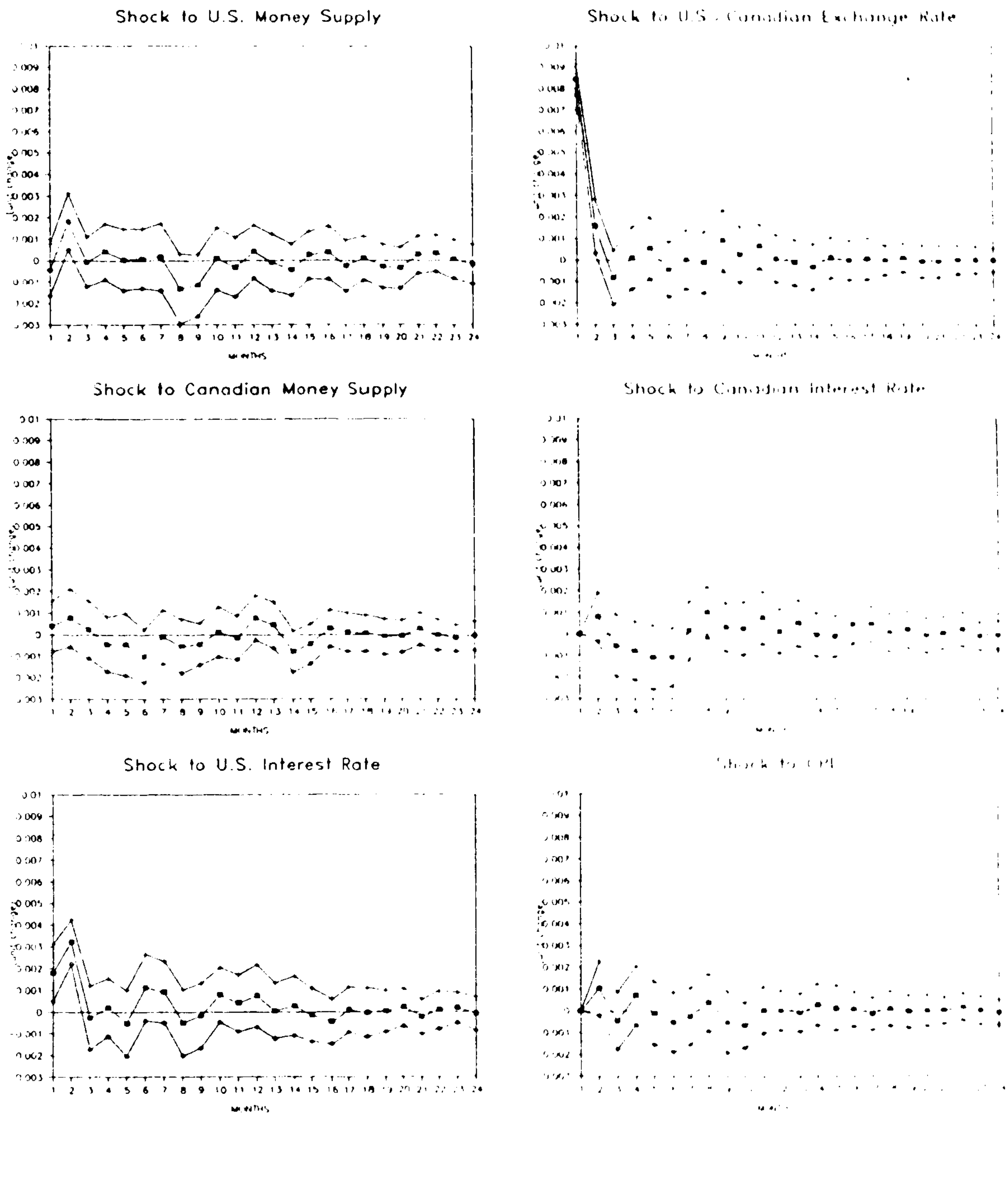
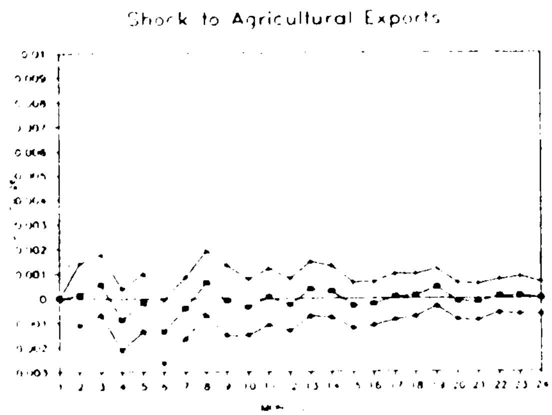


Figure B.7 Response of U.S./Canadian Exchange Rate to Shocks in Macroeconomic Variables.



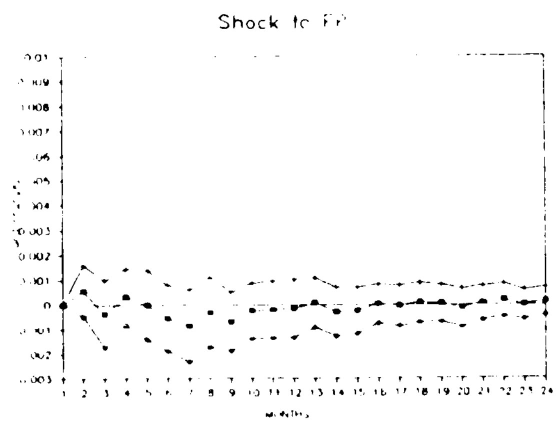


Figure B.8 Response of U.S./Canadian Exchange Rate to Shocks in Agricultural Variables.

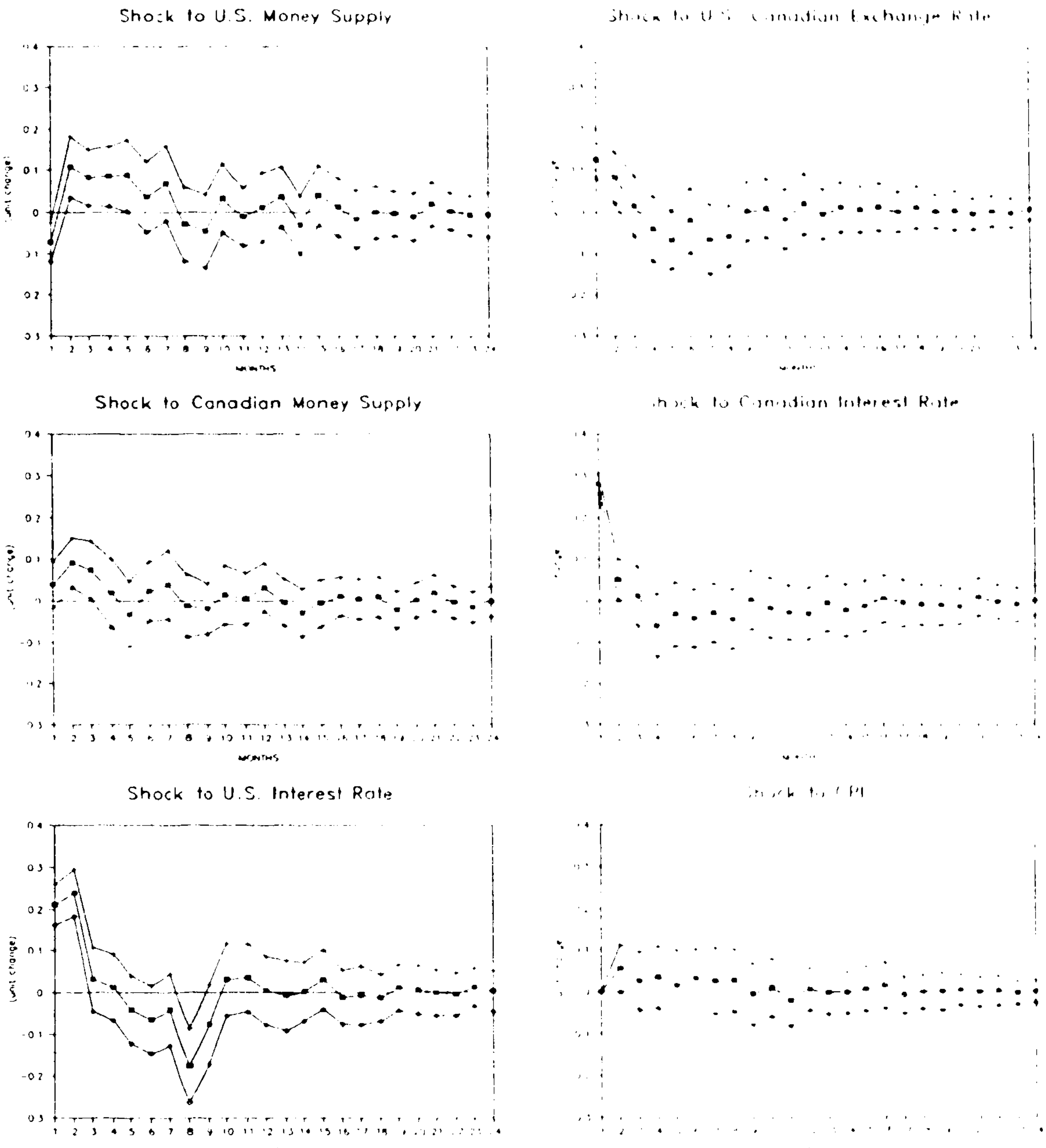
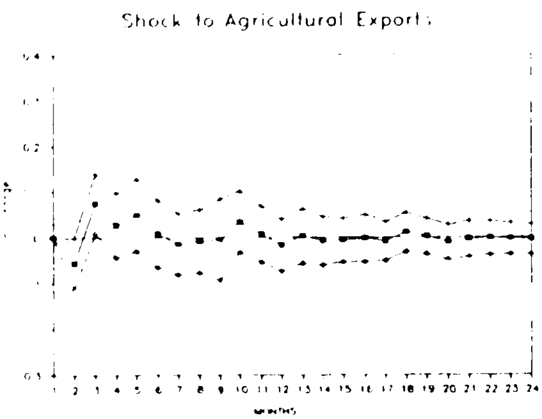


Figure B.9 Response of Canadian Interest Rate to Shocks in Macroeconomic Variables.



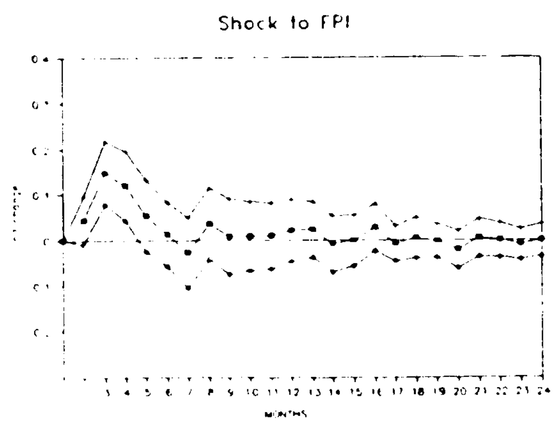


Figure B.10 Response of Canadian Interest Rate to Shocks in Agricultural Variables.

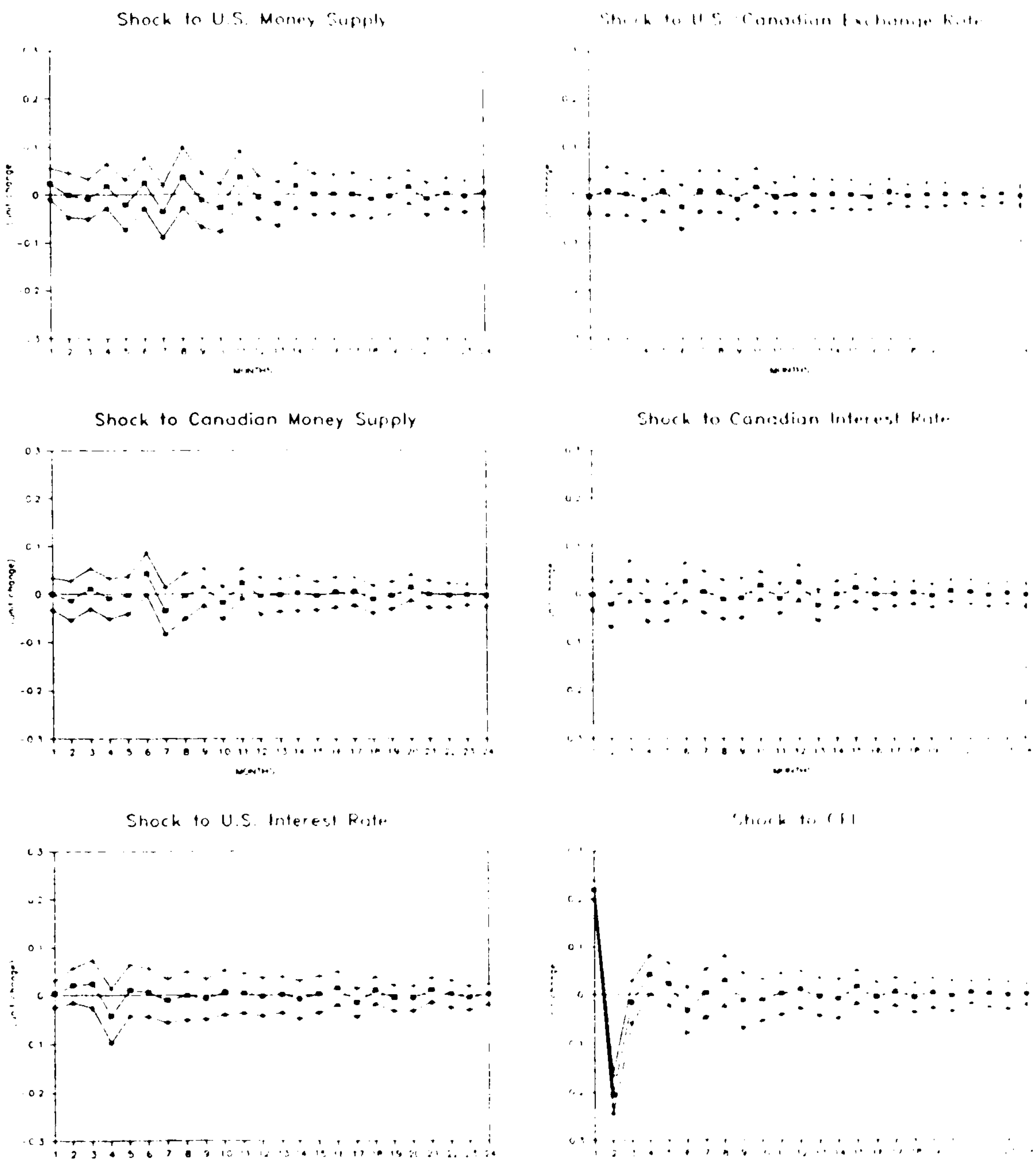
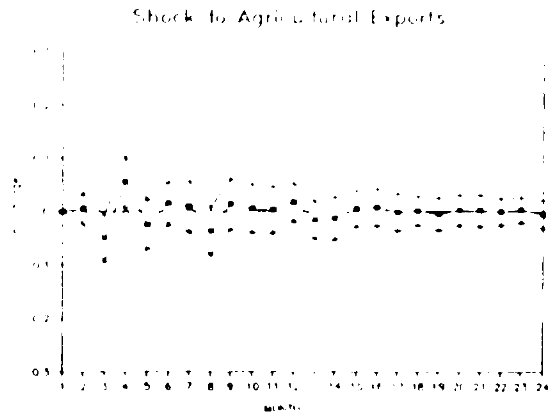


Figure B.11 Response of Consumer Price Index to Shocks in Macroeconomic Variables.



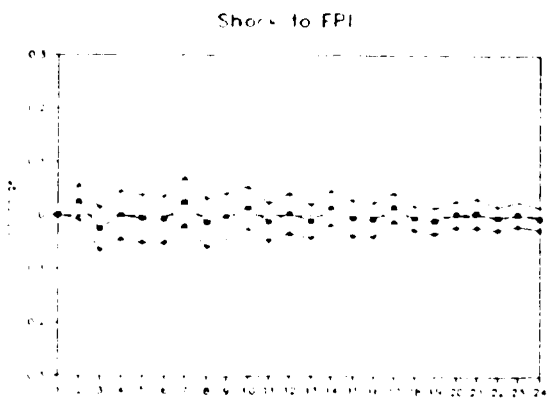


Figure B.12 Response of Consumer Price Index to Shocks in Agricultural Variables.

Appendix C

The following tables report the test results, forecast error decompositions and impulse response functions for the macroeconomic variables of Model 2, containing the G10 exchange rate index. Only selected months for two years are presented for the variance decompositions.

Table C.1: Model 2 Tests for Lag Length

Lags	Chi-Square	Significance Level	Decision•
6 vs 5	(64) = 120.08	.00001	
7 vs 6	(64) = 86.29	.03317	reject 6
8 vs 7	(64) = 61.50	.56555	accept 7

• = 95 per cent confidence level
( ) represent degrees of freedom restriction

Table C.2: Model 2 Summary Statistics

Equation	R^2	R^{2A}	D-W	SSR	SSE	Q(39)	Sig Level
G10	.4297	.1170	2.001	77.39	.790	43.74	.2772
USM1	.6207	.4128	2.034	743.7	2.43	23.52	.9762
CDNM1	.5735	.3396	1.946	7.886	.252	25.62	.9512
TBUS	.5366	.2825	2.038	54.61	.664	31.08	.8130
TBI	.6616	.4760	1.994	27.76	.473	32.36	.7651
CPI	.6982	.5327	1.996	9.174	.272	31.04	.8143
AGEX	.7786	.6572	2.032	8E+11	83162	69.19	.0025
FPI	.4828	.1991	2.016	616.9	2.23	38.23	.5048

Table C.3: Model 2 Significance of Lags

Dependent Variable	Lagged Variables: G10	USM1	CDNM1	TBUS	TBI	CPI	AGEX	FPI
G10	.0126• (2.689)	.3804 (1.077)	.9593 (.2838)	.1155 (1.698)	.6796 (.6909)	.5537 (.8432)	.0776 (1.884)	.1268 (1.653)
USM1	.8606 (.4616)	0.0• (11.954)	.0278• (2.344)	.0381• (2.206)	.9602 (.281)	.9637 (.272)	.7984 (.546)	.0345• (2.250)
CDNM1	.8440 (.4850)	.0072• (2.929)	.0145• (2.627)	.0232• (2.424)	.00001• (5.910)	.1054 (1.741)	.6876 (.6814)	.3746 (1.089)
TBUS	8440 (.4849)	.0204• (2.479)	.0061• (2.999)	.1151 (1.699)	.7736 (.577)	.9915 (.165)	.6692 (.703)	.0565 (2.029)
TBI	.1818 (1.476)	.0047• (3.108)	.0013• (3.662)	.00008• (4.83[illegible])	.1734 (1.500)	.6589 (.7156)	.0547 (2.043)	.0257• (2.378)
CPI	.8642 (.4563)	.6927 (.6753)	.4390 (.9937)	.0661 (1.958)	.2373 (1.339)	.0000• (17.41)	.1370 (1.615)	.5541 (.8426)
AGEX	.5513 (.8462)	.1297 (1.642)	.3163 (1.185)	.4762 (.9429)	.1658 (1.521)	.9176 (.3712)	.0000• (23.53)	.1920 (1.449)
FPI	.3115 (1.193)	.3801 (1.080)	.5270 (.8767)	.1029 (1.752)	.1709 (1.507)	.9940 (.1476)	.1052 (1.742)	.5455 (.8535)

• = do not accept H_0: lags are not significantly different from zero.

Table reports the F statistics in brackets.

Table C.4: Model 2 Covariance/Correlation Matrix

Variable	G10	USM1	CDNM1	TBUS	TBI	CPI	AGEX	FPI
G10	.4010	.0028	-.0502	-.0660	-.2232	.0876	-.0608	-.0714
USM1	.0034	3.807	.2367	-.0709	-.1977	.0812	.0938	.0067
CDNM1	-.0064	.0933	.0409	.0249	.0319	.0090	-.1149	-.0440
TBUS	-.0222	-.0736	.0027	.2830	.5760	[illegible]	.1315	.0976
TBI	-.0536	-.1463	.0024	.1162	.1437	-.0050	.2059	.1005
CPI	.0121	.0345	.0004	.0027	-.0004	.0475	.1091	.1775
AGEX	-2567.5	12193.	-1548.2	4662	5204.5	1585.6	.44E+10	.0947
FPI	-.0808	.0235	-.0159	.0928	.0682	.0692	11284.	3.196

Table C.5: **Decomposition of Variance on G10 Exchange Rate.**

Step	Stan Error	G10	USM1	CDNM1	TBU	TBI	CPI	AGEX	FPI
1	.633229	100.00	.00	.000	.00	.000	.000	.000	.000
2	.676791	90.95	1.67	.033	5.30	.916	.582	.526	.008
3	.693313	87.16	1.71	.675	5.30	1.66	.602	.546	2.32
4	.714413	82.35	1.62	.636	5.18	3.05	1.52	2.24	3.37
8	.790479	69.52	3.20	1.51	6.50	4.31	2.10	4.98	7.85
12	.816921	65.64	3.78	1.78	6.94	5.02	2.85	4.88	9.08
16	.824912	64.66	3.85	2.15	7.03	5.23	2.87	4.97	9.20
20	.828287	64.18	4.00	2.21	7.04	5.37	2.89	5.04	9.22
24	.829808	64.00	4.09	2.22	7.07	5.36	2.90	5.04	9.28

Table C.6: **Decomposition of Variance on U.S. Money Supply.**

Step	Stan Error	G10	USM1	CDNM1	TBU	TBI	CPI	AGEX	FPI
1	1.95103	.001	99.99	.000	.000	.000	.000	.000	.000
2	2.53774	.242	95.30	.567	3.23	.052	.222	.000	.375
3	2.65799	.753	91.95	1.70	3.06	.137	.609	.495	1.27
4	2.70748	.777	90.00	1.73	3.04	.572	.604	1.19	1.41
8	2.97924	1.09	75.83	5.42	4.22	1.98	1.15	1.31	8.97
12	3.09513	1.42	71.63	5.68	5.58	2.86	1.61	2.34	8.84
16	3.14859	1.60	70.56	5.80	5.63	3.20	1.61	2.88	8.68
20	3.16801	1.61	69.94	5.99	5.70	3.47	1.60	2.98	8.66
24	3.17788	1.62	69.60	6.09	5.73	3.49	1.61	3.04	8.78

Table C.7: **Decomposition of Variance on Canadian Money Supply.**

Step	Stan Error	G10	USM1	CDNM1	TBU	TBI	CPI	AGEX	FPI
1	.202133	.252	5.60	94.13	.00	.00	.000	.000	.000
2	.215059	.688	5.50	85.05	4.95	3.07	.403	.153	.162
3	.239773	2.03	5.41	70.23	4.77	16.27	.436	.178	.648
4	.246884	2.43	5.31	66.27	8.15	16.22	.614	.270	.720
8	.282101	3.47	12.95	51.77	11.73	12.97	3.14	1.91	2.02
12	.297578	3.56	15.19	47.67	10.94	12.65	3.01	4.55	2.40
16	.307449	3.57	14.55	46.01	11.35	12.64	3.08	4.73	4.03
20	.309763	3.60	14.66	45.45	11.67	12.68	3.06	4.72	4.12
24	.311235	3.61	14.72	45.12	11.78	12.72	3.06	4.86	4.10

Table C.8: Decomposition of Variance on U.S. Interest Rate.

Step	Stan Error	G10	USM1	CDNM1	TBU	TBI	CPI	AGEX	FPI
1	.531945	.435	.500	.1559	98.90	.000	.000	.000	.000
2	.605762	.669	9.75	3.19	82.63	.074	.102	.325	3.23
3	.642897	.743	12.81	3.42	76.91	.481	.146	.631	4.83
4	.663748	.926	12.13	3.43	73.82	1.37	.767	.873	6.65
8	.726345	1.50	11.64	6.90	69.52	2.21	1.04	1.00	6.14
12	.749561	1.48	12.11	7.70	66.65	3.35	1.06	1.53	6.07
16	.760259	2.00	12.05	8.23	65.44	3.50	1.13	1.54	6.08
20	.764020	2.01	12.05	8.39	64.86	3.64	1.15	1.71	6.15
24	.766960	2.07	12.06	8.46	64.63	3.72	1.14	1.75	6.13

Table C.9: Decomposition of Variance on Canadian Interest Rate.

Step	Stan Error	G10	USM1	CDNM1	TBU	TBI	CPI	AGEX	FPI
1	.379287	4.98	3.88	.482	29.98	60.66	.00	.00	.00
2	.489069	5.63	7.20	3.90	41.10	38.22	1.32	1.41	1.18
3	.531395	4.87	8.88	6.28	35.24	32.38	1.57	2.67	8.07
4	.557826	4.45	10.21	6.00	32.08	31.22	2.04	2.44	11.51
8	.624551	4.24	11.37	5.92	35.30	28.19	2.23	2.40	10.32
12	.638973	4.40	11.55	5.90	35.53	27.55	2.27	2.70	10.06
16	.645589	4.47	12.13	6.03	35.18	27.08	2.27	2.70	10.10
20	.648038	4.47	12.17	6.08	35.00	26.91	2.29	2.77	10.27
24	.649158	4.50	12.18	6.18	34.92	26.86	2.29	2.76	10.27

Table C.10: Decomposition of Variance on CPI.

Step	Stan Error	G10	USM1	CDNM1	TBU	TBI	CPI	AGEX	FPI
1	.218018	.766	.654	.003	.123	.022	98.42	.000	.000
2	.298928	.956	.350	.203	.319	.598	96.70	.067	.798
3	.307284	.924	.380	.298	.908	1.14	91.91	2.82	1.61
4	.319424	.950	.599	.313	2.67	1.44	86.73	5.78	1.49
8	.341617	1.51	3.86	2.71	2.73	1.77	78.26	7.17	1.96
12	.350869	1.64	6.04	3.35	2.66	2.69	74.47	7.17	1.94
16	.355500	1.64	6.38	3.30	2.98	3.22	72.72	7.27	2.45
20	.357842	1.71	6.53	3.54	3.24	3.22	71.82	7.21	2.68
24	.358521	1.75	6.55	3.55	3.36	3.24	71.56	7.21	2.74

Table C.11. Model 2 Decomposition of Variance on AGEX

Step	Std Error	G10	USM1	CDNM1	TBUS	TBI	CPI	AGEX	FPI
1	66659.0	.3610	.8821	2.088	1.976	3.410	.981	90.29	.000
2	105739.	.1470	.3767	2.083	5.167	8.382	1.579	80.97	1.296
3	109465.	.2141	.5322	1.959	5.326	12.629	1.699	76.15	1.486
4	110314.	.5451	.5241	2.084	5.265	12.830	1.724	74.99	2.030
5	111915.	1.124	.5385	2.107	5.774	12.574	1.899	73.18	2.799
6	113708.	1.271	.7750	2.079	5.712	12.248	1.840	71.86	4.214
7	115231.	1.257	.9942	3.213	5.937	12.486	1.820	70.08	4.215
8	118393.	1.198	2.341	3.772	6.783	12.422	1.840	67.38	4.259
9	120243.	1.161	2.630	3.689	6.581	13.163	2.044	66.58	4.155
10	121703.	1.146	2.585	3.635	6.439	13.558	2.300	66.26	4.074
11	122402.	1.153	2.556	3.594	6.671	13.524	2.310	66.12	4.069
12	122626.	1.149	2.731	3.615	6.653	13.530	2.346	65.89	4.080
13	123150.	1.167	3.099	3.604	6.597	13.687	2.350	65.36	4.135
14	123845.	1.167	3.169	3.578	6.957	13.541	2.353	64.79	4.447
15	124426.	1.159	3.182	3.576	7.317	13.555	2.335	64.25	4.623
16	124628.	1.198	3.171	3.629	7.338	13.622	2.347	64.05	4.649
17	124716.	1.227	3.199	3.638	7.328	13.646	2.351	63.96	4.655
18	124792.	1.228	3.197	3.638	7.319	13.632	2.444	63.88	4.659
19	124848.	1.229	3.195	3.675	7.314	13.620	2.467	63.84	4.664
20	124903.	1.240	3.192	3.743	7.307	13.611	2.466	63.78	4.661
21	125009.	1.263	3.246	3.766	7.343	13.591	2.463	63.67	4.656
22	125093.	1.265	3.275	3.762	7.397	13.583	2.466	63.60	4.650
23	125149.	1.264	3.275	3.760	7.410	13.590	2.479	63.57	4.652
24	125168.	1.274	3.279	3.760	7.411	13.592	2.480	63.55	4.653

Table C.12: Model 2 Decomposition of Variance on FPI

Step	Std Error	G10	USM1	CDNM1	TBUS	TBI	CPI	AGEX	FPI
1	1.78785	.5097	.0048	.2569	.9197	.2249	3.247	.1980	94.64
2	1.85112	3.465	.2748	.3638	.8935	2.774	3.159	.4813	88.59
3	1.89890	4.164	1.203	.3524	2.484	4.038	3.026	.5454	84.19
4	1.97767	3.883	1.613	.3817	6.372	5.512	2.892	1.486	77.86
5	2.00919	3.801	2.037	.7228	7.601	5.391	3.272	1.440	75.73
6	2.04852	3.661	2.525	.8771	8.347	5.289	3.150	1.433	74.72
7	2.09712	3.523	3.829	.8381	8.649	6.230	3.284	2.332	71.31
8	2.11515	3.855	4.109	.8518	8.502	6.233	3.257	2.945	70.25
9	2.13314	3.806	4.349	1.005	8.819	6.185	3.213	3.548	69.08
10	2.13833	3.840	4.583	1.055	8.792	6.161	3.277	3.531	68.76
11	2.15193	4.278	4.801	1.043	8.940	6.227	3.283	3.503	67.92
12	2.15426	4.289	4.867	1.094	8.929	6.215	3.304	3.512	67.79
13	2.16399	4.263	5.136	1.136	9.026	6.402	3.292	3.558	67.19
14	2.17349	4.253	5.460	1.197	.188	6.346	3.387	3.527	66.64
15	2.17877	4.234	5.443	1.191	9.237	6.331	3.387	3.633	66.54

16	2.18216	4.223	5.575	1.188	9.217	6.325	3.377	3.711	66.38
17	2.18420	4.226	5.611	1.217	9.211	6.355	3.373	3.743	66.26
18	2.18812	4.300	5.617	1.213	9.196	6.380	3.361	3.780	66.15
19	2.18912	4.296	5.612	1.222	9.223	6.411	3.358	3.776	66.10
20	2.19268	4.284	5.697	1.220	9.279	6.391	3.359	3.780	65.99
21	2.19565	4.273	5.849	1.238	9.259	6.434	3.358	3.774	65.82
22	2.19700	4.269	5.847	1.251	9.288	6.427	3.366	3.771	65.78
23	2.19877	4.262	5.870	1.280	9.316	6.417	3.360	3.804	65.69
24	2.19984	4.258	5.927	1.290	9.309	6.412	3.369	3.809	65.63

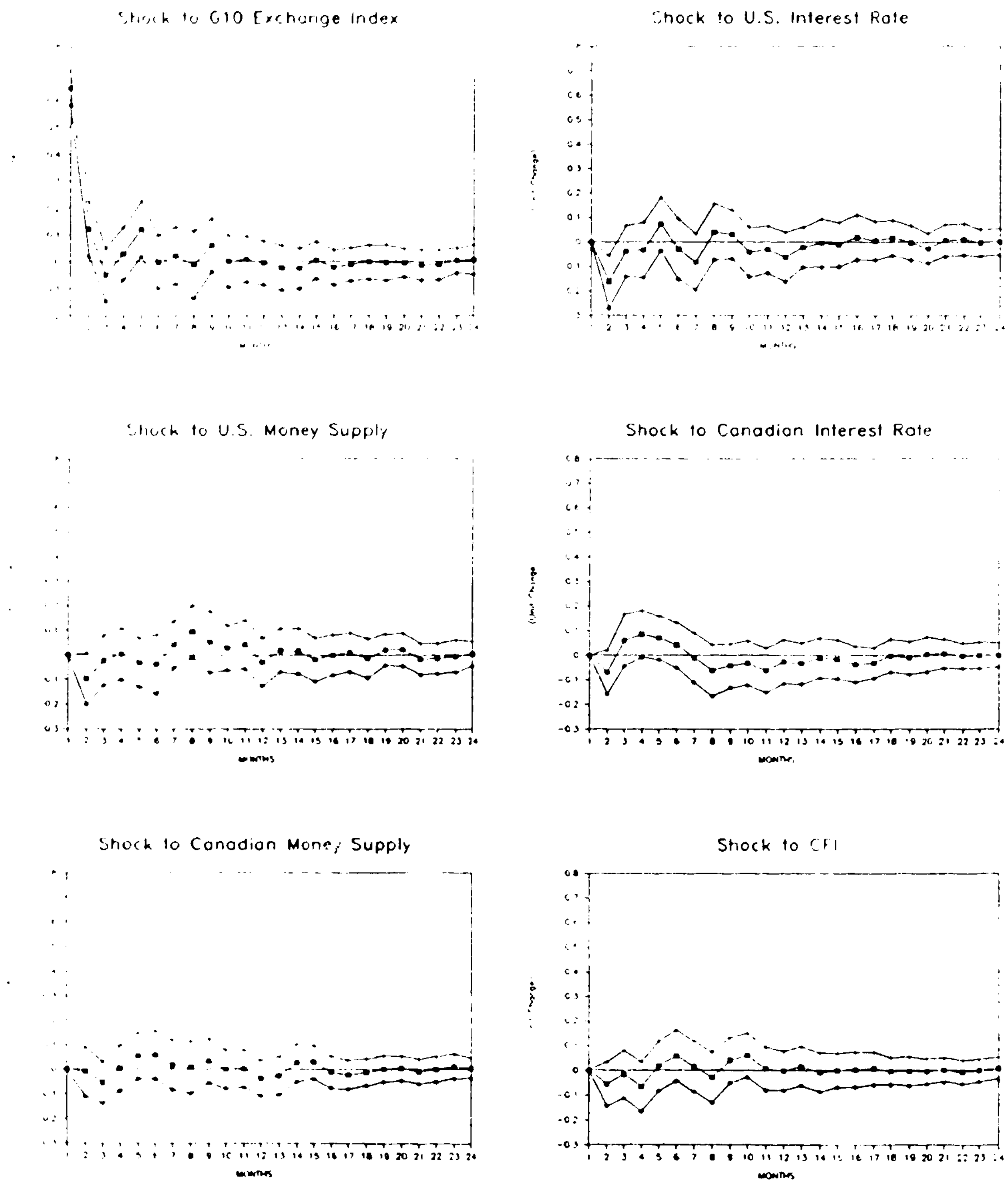
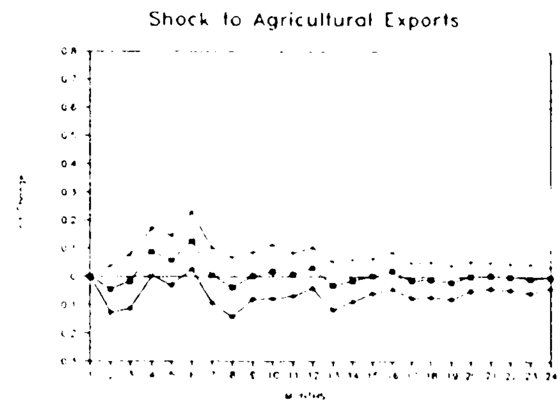


Figure C.1 Response of G10 Exchange Index to Shocks in Macroeconomic Variables.



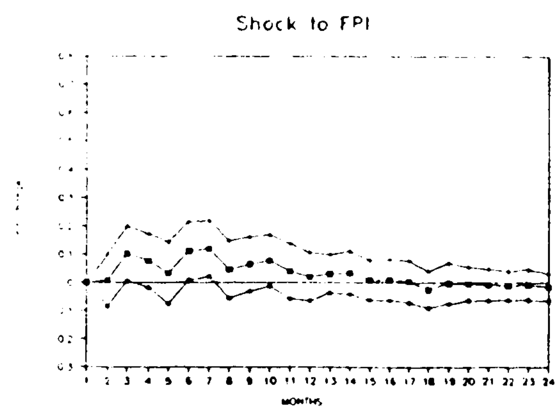


Figure C.2 Response of G10 Exchange Index to Shocks in Agricultural Variables.

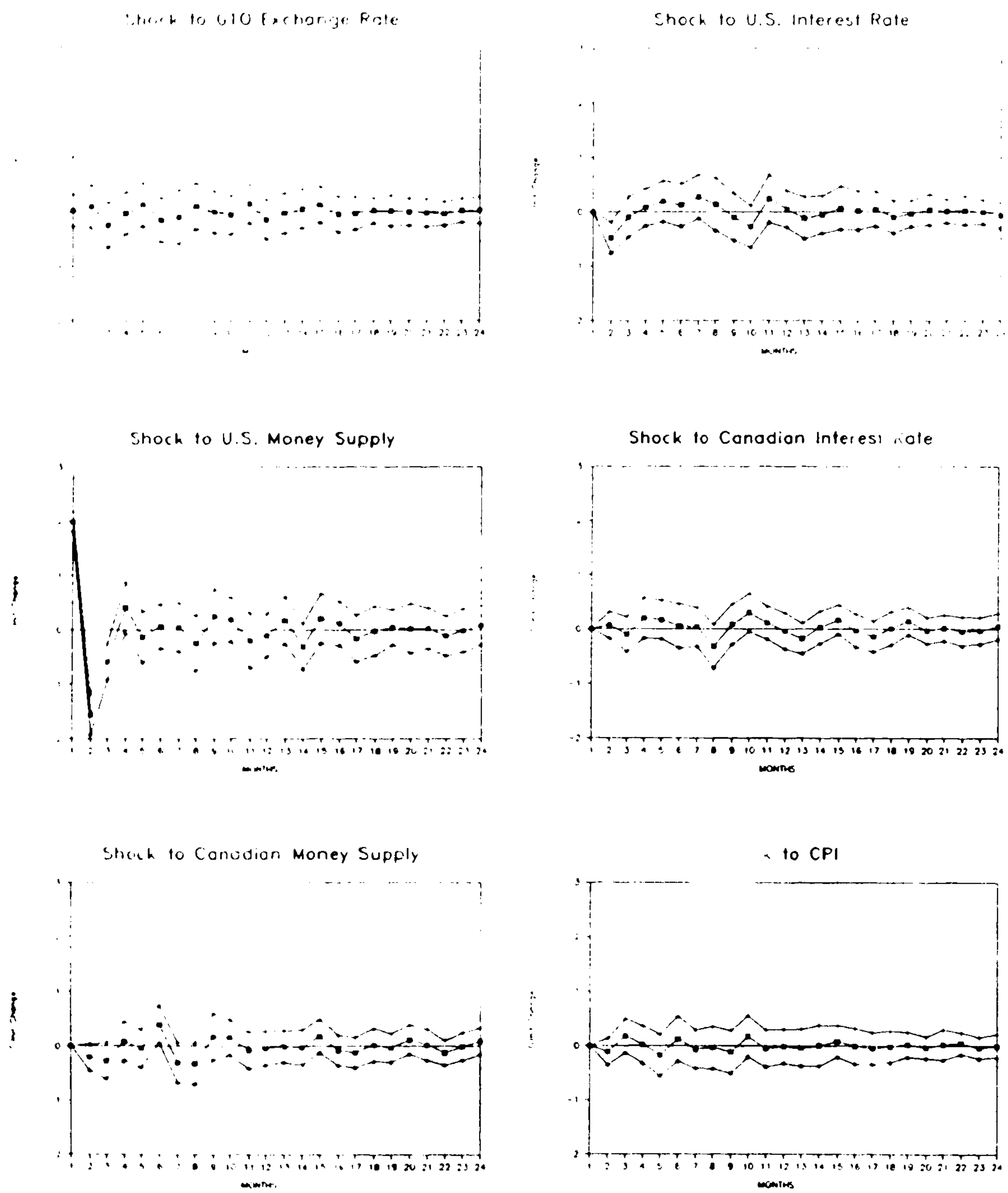
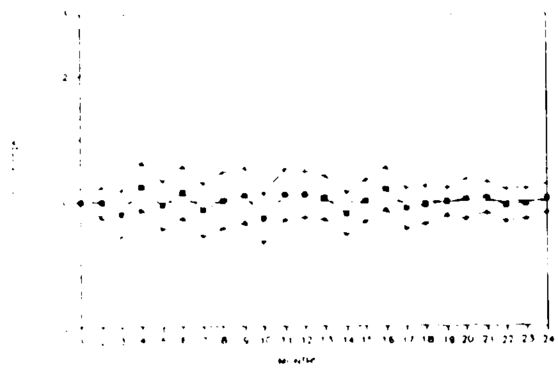


Figure C.3 Response of U. S. Money Supply to Shocks in Macroeconomic Variables.

Shock to Agricultural Exports



Shock to FPI

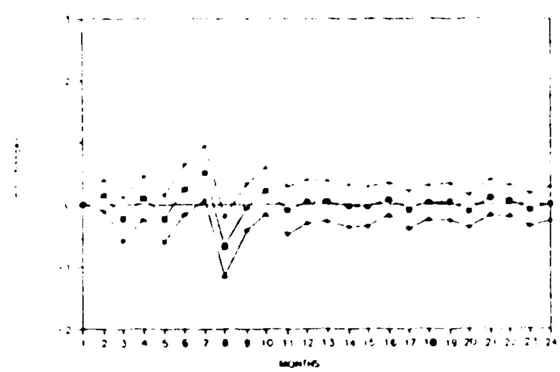


Figure C.4 Response of U. S. Money Supply to Shocks in Agricultural Variables.

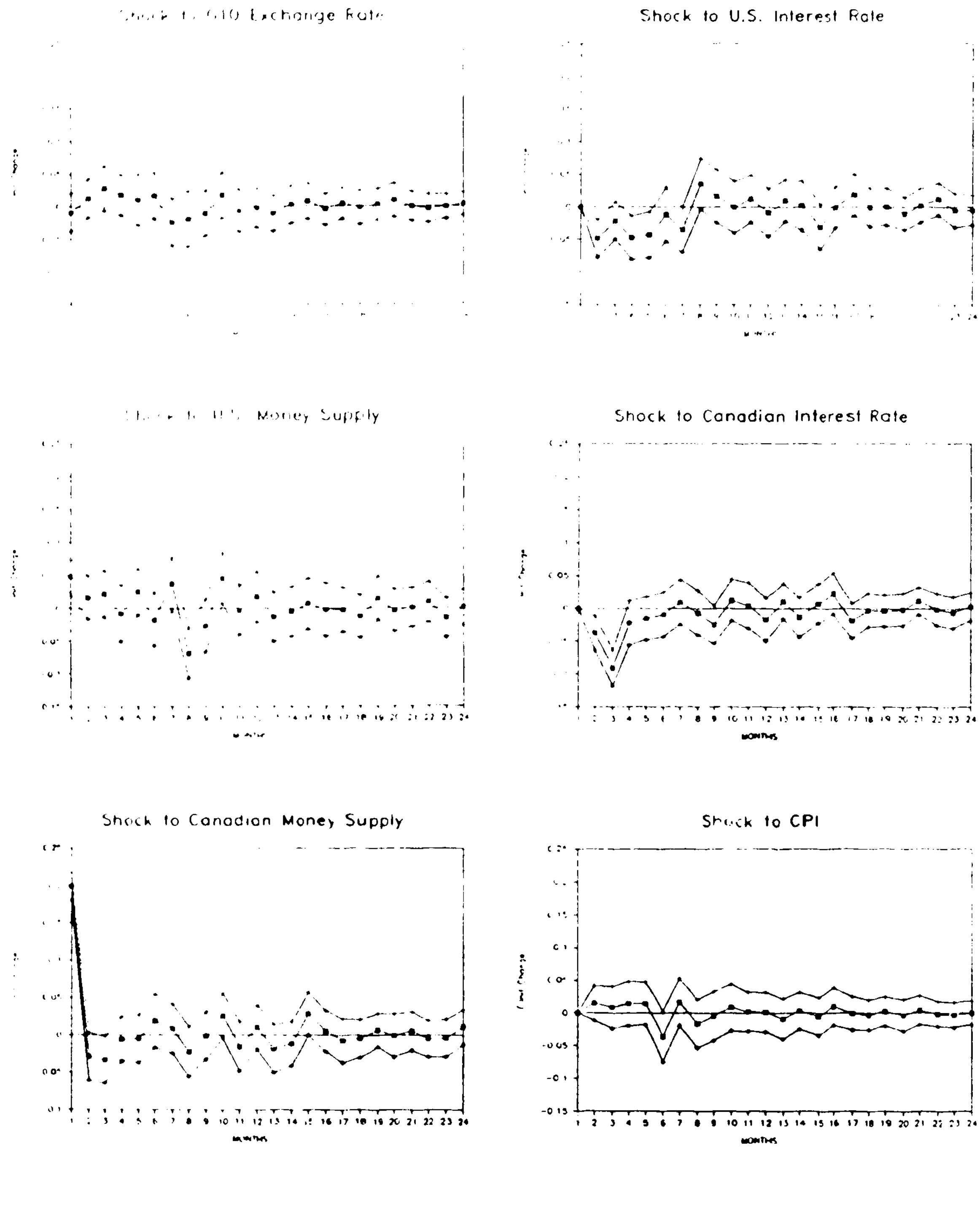
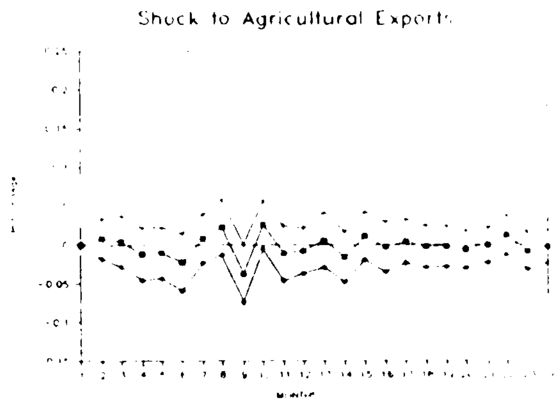


Figure C.5 Response of Canadian Money Supply to Shocks in Macroeconomic Variables.



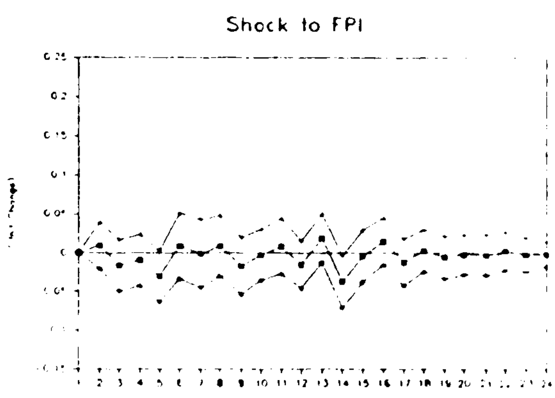


Figure C.6 Response of Canadian Money Supply to Shocks ir :u bles.

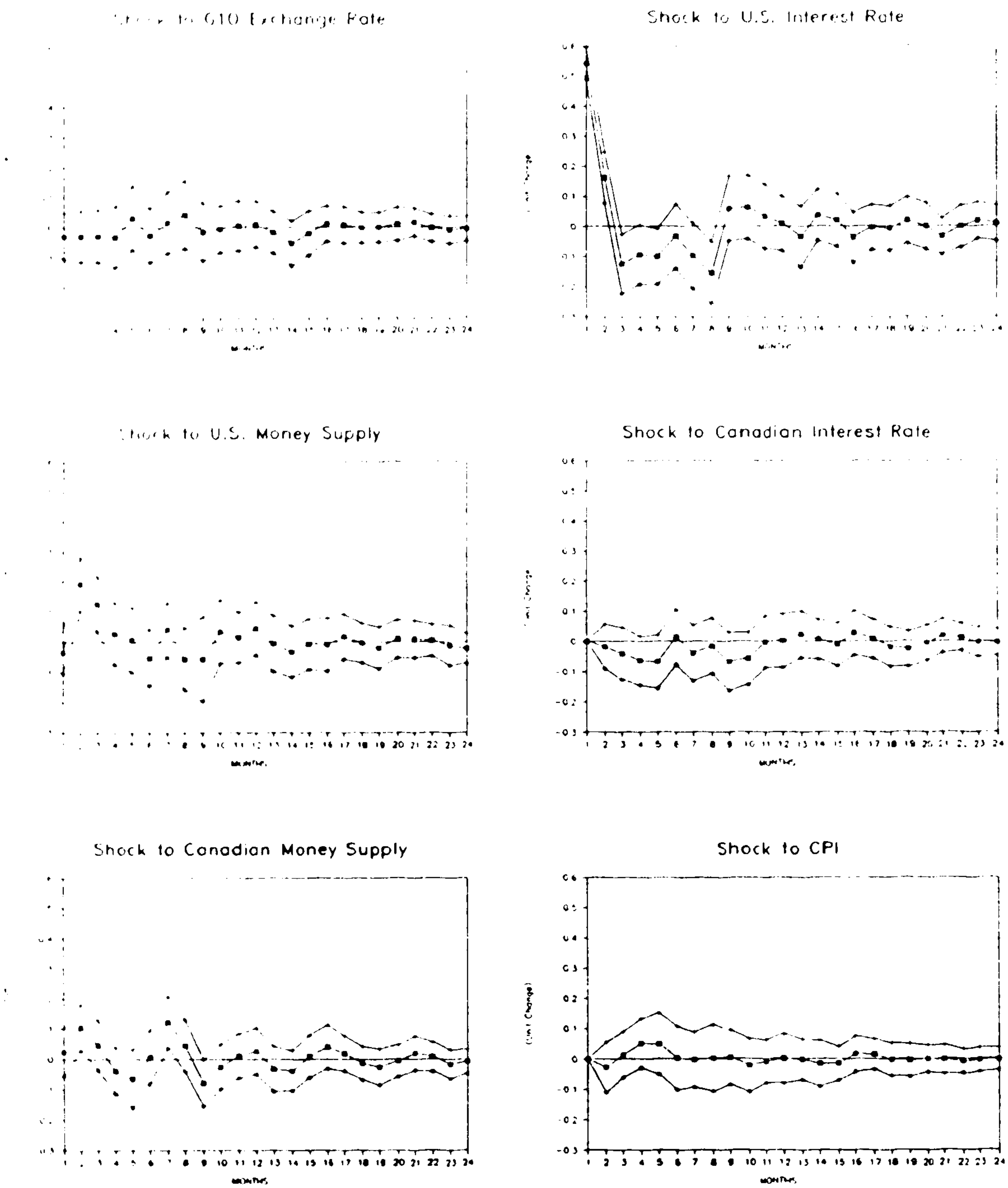
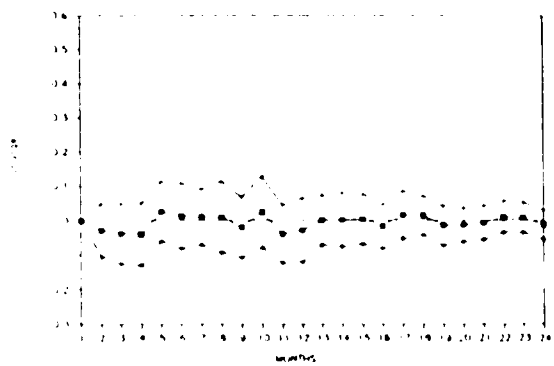


Figure C.7 Response of U. S. Interest Rate to Shocks in Macroeconomic Variables.

Shock to Agricultural Exports



Shock to FPI

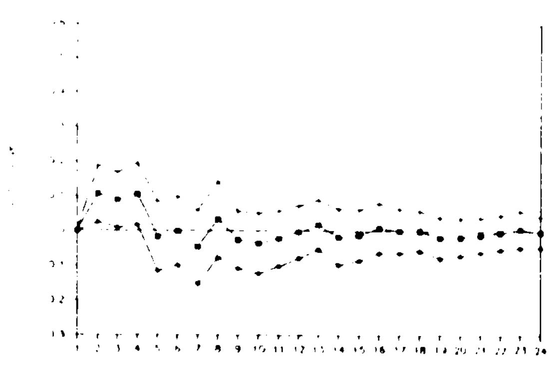


Figure C.8 Response of U. S. Interest Rate to Shocks in Agricultural Variables.

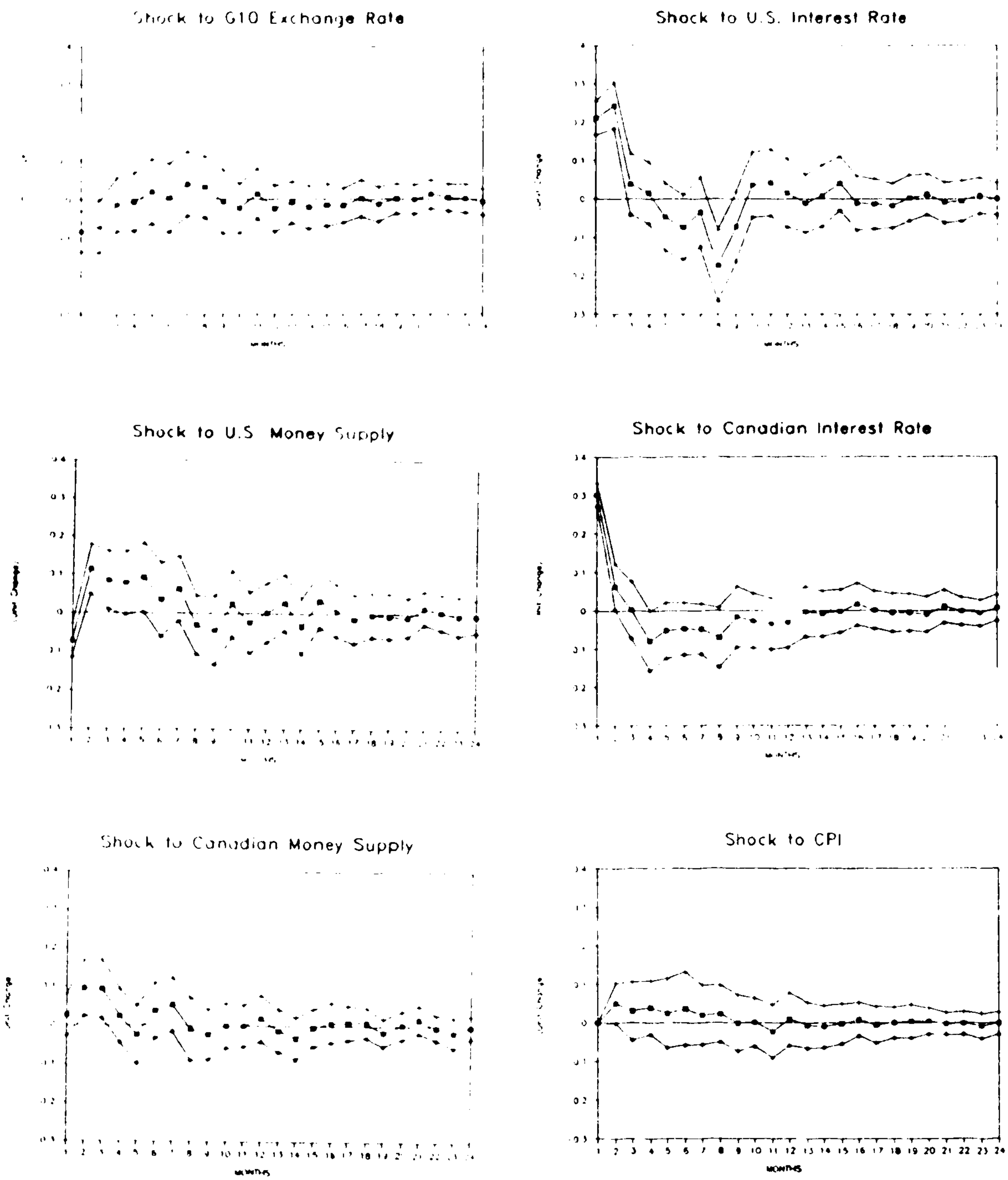
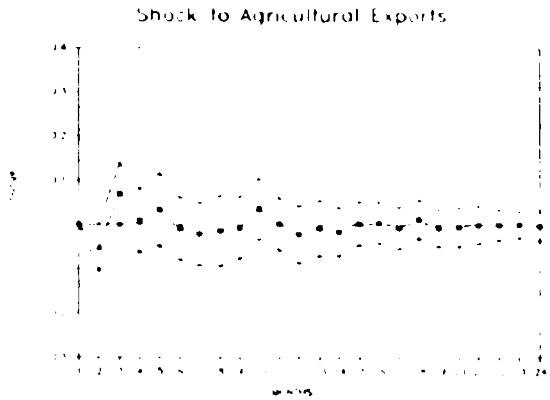


Figure C.9 Response of Canadian Interest Rate to Shocks in Macroeconomic Variables.



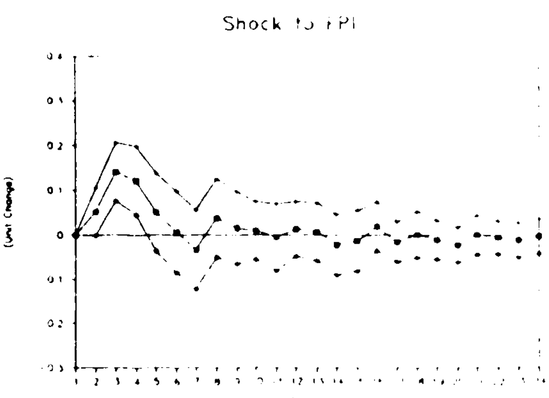


Figure C.10 Response of Canadian Interest Rate to Shocks in Agricultural Variables.

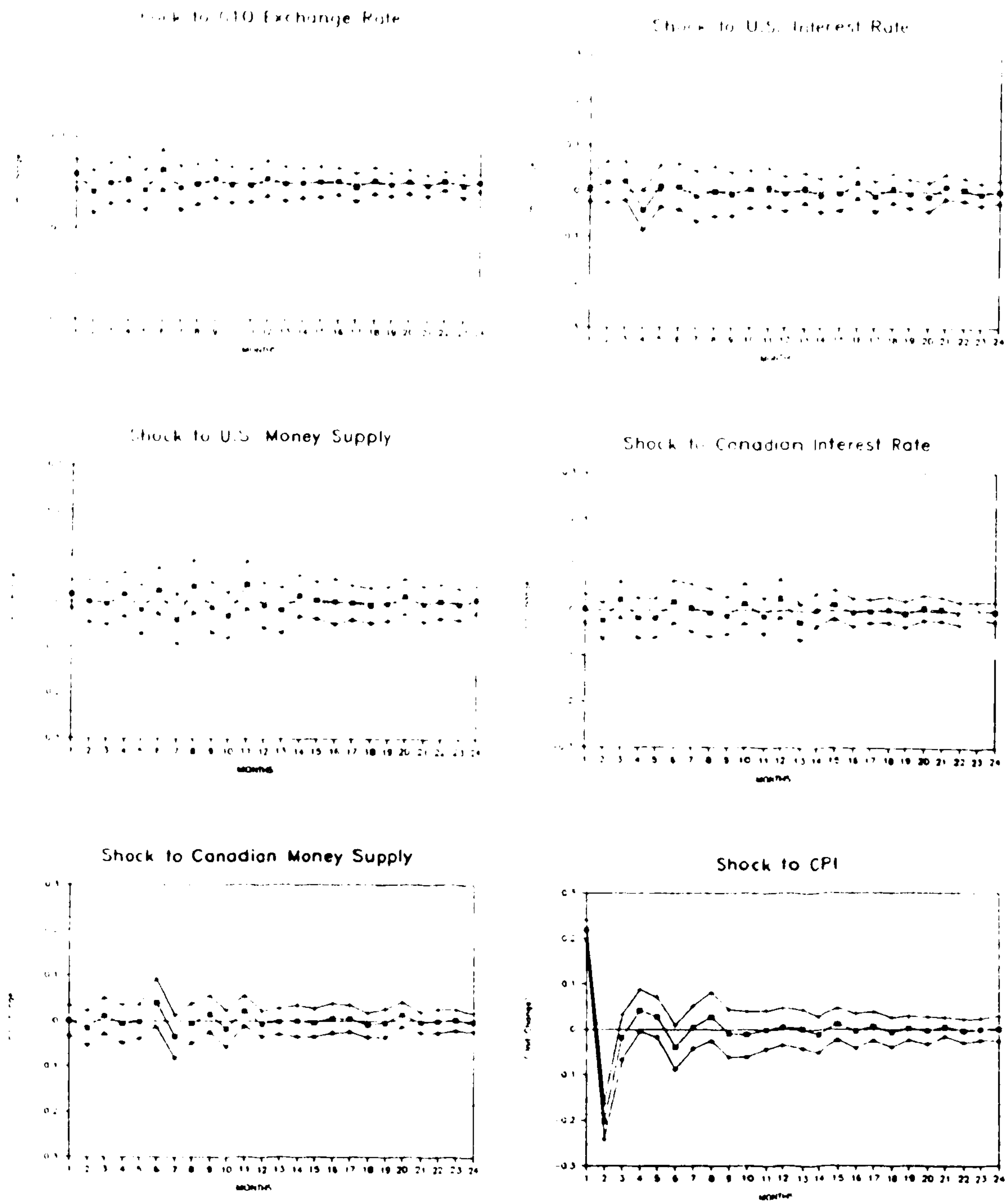
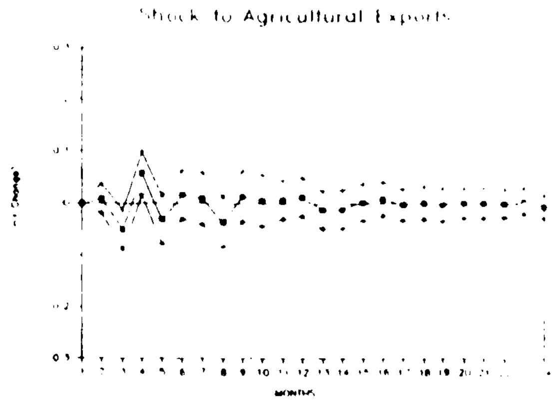


Figure C.11 Response of Consumer Price Index to Shocks in Macroeconomic Variables.



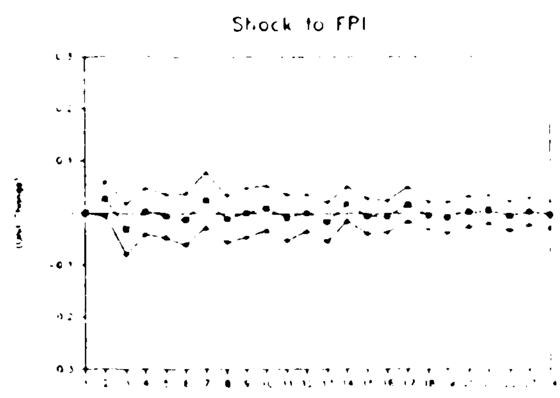


Figure C.12 Response of Consumer Price Index to Shocks in Agricultural Variables.

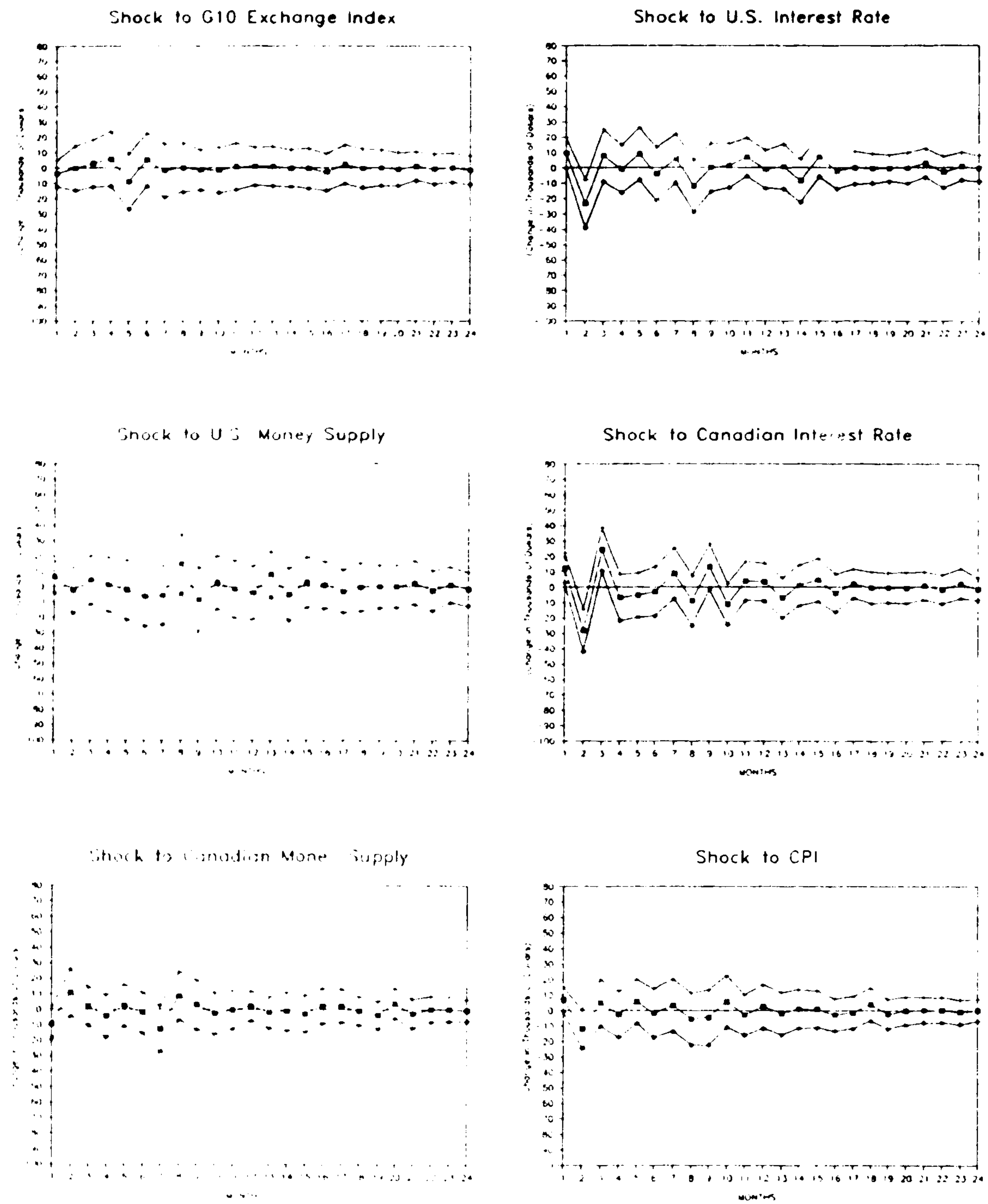
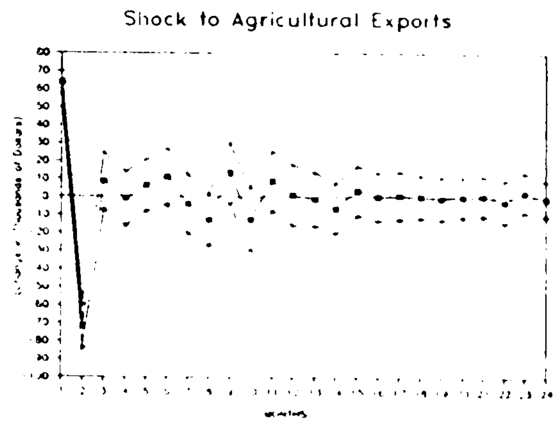


Figure C.13 Response of Agricultural Exports to Shocks in Macroeconomic Variables.



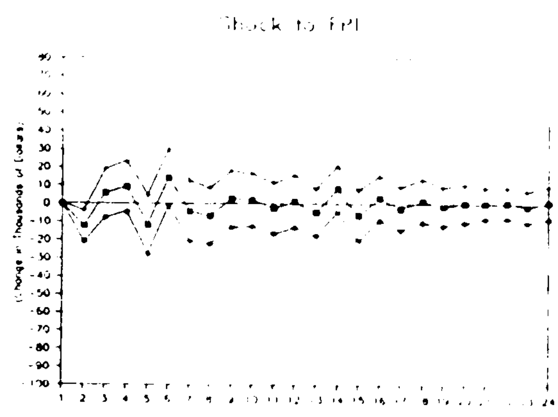


Figure C.14 Response of Agricultural Exports to Shocks in Agricultural Variables.

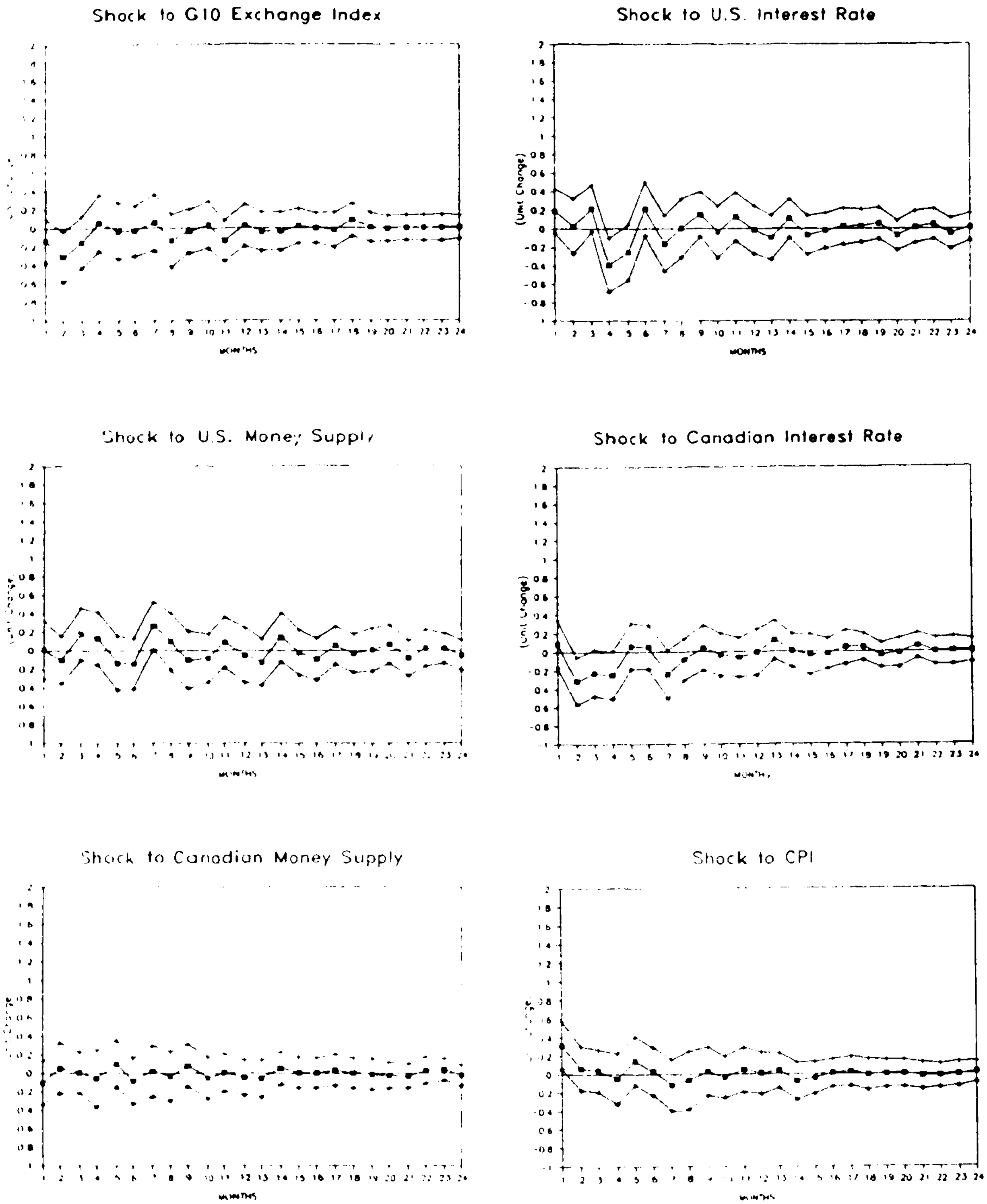
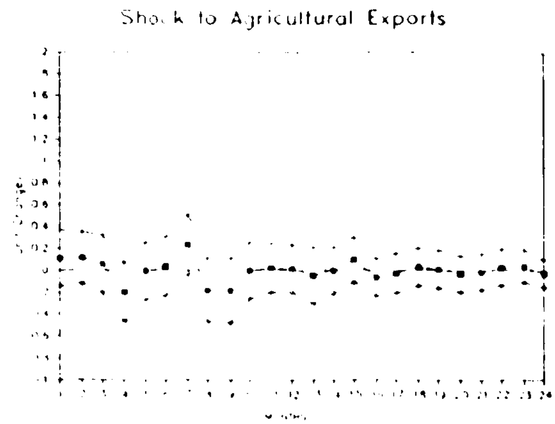


Figure C.15 Response of Agricultural Prices to Shocks in Macroeconomic Variables.



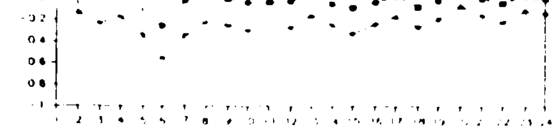


Figure C.16 Response of Agricultural Prices to Shocks in Agricultural Variables.

Appendix D

The following tables report the forecast error decompositions for the macr economic variables of Model 3. Only selected months for two years are presented.

Table D.1: Decomposition of Variance on U.S. Money Supply.

Step	Stan Error	USM1	CDNM1	TBU	US/CDN	TBI	CPI	AGEX	FPI
1	2.19858	100.00	.000	.000	.0000	.0000	.000	.0000	.000
2	2.38139	96.45	.710	1.93	.1758	.0019	.515	.0030	.199
3	2.50204	94.47	1.57	2.19	.3386	.0470	.718	.2506	.393
4	2.51918	93.99	1.56	2.29	.5312	.1255	.719	.3844	.389
8	2.64676	[illegible].91	3.60	2.91	.8804	.4929	1.25	.4002	4.52
12	2.66748	85.12	3.63	3.01	.9155	.6053	1.41	.5330	4.75
16	2.67736	84.83	3.69	3.02	.9101	.6224	1.46	.6989	4.75
20	2.67916	84.75	3.71	3.03	.9169	.6248	1.46	.7147	4.77
24	2.67967	84.73	3.71	3.04	.9174	.6258	1.46	.7198	4.78

Table D.2: Decomposition of Variance on Canadian Money Supply.

Step	Stan Error	USM1	CDNM1	TBU	US/CDN	TBI	CPI	AGEX	FPI
1	.225875	3.06	96.93	.00	.00	.00	.00	.000	.000
2	.232635	3.24	92.86	1.57	1.33	.40	.09	.386	.088
3	.241656	3.52	86.26	2.44	3.86	3.12	.17	.440	.163
4	.245456	3.45	83.61	3.57	4.37	4.17	.18	.427	.193
8	.265664	7.80	72.19	5.92	4.73	4.29	2.19	2.05	.807
12	.270249	8.75	70.01	6.27	4.70	4.39	2.28	2.66	.898
16	.272402	8.81	69.17	6.61	4.68	4.38	2.35	2.76	1.19
20	.272577	8.82	69.10	6.63	4.68	4.38	2.35	2.78	1.22
24	.272642	8.82	69.07	6.64	4.69	4.38	2.36	2.79	1.22

Table D.3: Decomposition of Variance on U.S. Interest Rate.

Step	Stan Error	USM1	CDNM1	TBU	US/CDN	TBI	CPI	AGEX	FPI
1	.571681	1.45	.317	98.22	.000	.000	.000	.000	.00
2	.634460	2.57	2.144	93.94	.120	.081	.000	.003	1.13
3	.646947	3.60	2.845	90.75	.283	.250	.002	.005	2.25
4	.658562	3.48	2.747	88.96	.422	.522	.058	.052	3.74
8	.698066	4.17	4.448	85.79	.931	.693	.211	.224	3.51
12	.704636	4.54	4.517	84.98	.926	.743	.241	.435	3.60
16	.706834	4.57	4.603	84.67	.980	.746	.259	.473	3.69
20	.707553	4.57	4.635	84.59	.979	.749	.262	.501	3.70
24	.707747	4.57	4.643	84.57	.980	.749	.264	.506	3.70

Table D.4: Decomposition of Variance on U.S./Canadian Exchange Rate.

Step	Stan Error	USM1	CDNM1	TBU	US/CDN	TBI	CPI	AGEX	FPI
1	.009148	.707	.204	2.59	96.49	.000	.000	.000	.000
2	.009863	1.26	.596	5.65	91.37	.001	.788	.127	.197
3	.009902	1.25	.691	5.63	90.68	.143	.887	.475	.225
4	.009949	1.24	.685	5.60	89.82	.636	1.05	.606	.350
8	.010341	1.65	1.85	5.85	83.65	2.08	1.77	1.80	1.31
12	.010459	2.06	2.17	6.19	82.03	2.22	1.86	1.90	1.53
16	.010483	2.23	2.27	6.20	81.68	2.25	1.86	1.93	1.54
20	.010490	2.25	2.28	6.23	81.58	2.26	1.86	1.95	1.54
24	.010491	2.26	2.29	6.23	81.56	2.26	1.86	1.96	1.55

Table D.5: Decomposition of Variance on Canadian Interest Rate.

Step	Stan Error	USM1	CDNM1	TBU	US/CDN	TBI	CPI	AGEX	FPI
1	.428137	6.67	.540	24.91	8.61	59.25	.000	.00	.000
2	.506010	4.78	3.38	30.38	7.67	51.13	.564	1.15	.909
3	.529760	4.52	5.54	29.42	7.00	47.51	.689	1.41	3.87
4	.542490	4.42	6.46	28.32	7.05	45.30	.708	1.34	6.37
8	.574447	5.00	6.27	29.27	9.42	40.73	.774	1.63	6.89
12	.580631	5.17	6.30	30.02	9.30	39.87	.786	1.74	6.78
16	.582430	5.31	6.32	30.07	9.25	39.65	.798	1.73	6.82
20	.582825	5.32	6.33	30.09	9.24	39.61	.798	1.75	6.83
24	.582928	5.32	6.34	30.09	9.24	39.60	.799	1.75	6.83

Table D.6: Decomposition of Variance on CPI.

Step	Stan Error	USM1	CDNM1	TBU	US/CDN	TBI	CPI	AGEX	FPI
1	.243758	.335	.005	.152	.278	.098	99.12	.000	.000
2	.281246	.257	.014	.268	.459	.091	98.79	.096	.015
3	.286413	.353	.137	.350	.444	.090	96.96	1.55	.099
4	.291897	.491	.242	.920	.501	.128	94.32	3.29	.096
8	.301626	2.63	1.00	1.00	.736	.319	89.51	4.38	.401
12	.303624	3.25	1.17	1.14	.744	.405	88.42	4.43	.412
16	.304124	3.36	1.20	1.14	.753	.419	88.16	4.45	.485
20	.304334	3.39	1.22	1.17	.753	.422	88.05	4.46	.512
24	.304379	3.40	1.22	1.17	.754	.423	88.03	4.46	.514