RURAL ECONOMY

Macroeconomic Impacts on Canadian Agricultural Prices

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Project Report 92-04

Farming for the Future Project Report 89-0478

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Table of Contents

Table of Figures

Table of Tables

I Abstract

Interest in modeling the relationship between the macroeconomy and the agricultural economy has risen steadily since Schuh's 1974 article which illustrated the potential effects of macroeconomic policy shocks on the agricultural sector. A variety of authors has examined the effects of exchange rates, interest rate, money supply and general price level shocks on agricultural variables (prices, exports, etc.). A variety of techniques has also been used to examine these relationships. Both structural econometric models and time series approaches have been employed. In this study a new econometric technique, Vector Autoregressive (VAR) modeling, is used to investigate the impact of macroeconomic factors on the Canadian agricultural sector.

Vector Autoregressive models (VARs) are dynamic simultaneous equation models. VAR models allow the data to provide a representation of the changes in the system without the restrictions on coefficients that are usually used in the estimation of simultaneous equation econometric models. VAR models focus on the dynamic paths of the variables in the system. They provide a concise summary of the dynamic interrelationships in an economic system. In this study, several forms of VAR models are used to examine the dynamic interaction of agricultural prices, exports and macroeconomic variables.

There are a number of significant conclusions from the empirical analysis performed in this study. First, there appear to be significant macroeconomic impacts on the Canadian agricultural sector. Other studies of macroeconomic-sectoral linkages have found limited impact of macroeconomic factors. This study, however, using a relatively new methodology, has discovered a stronger integration. The strongest linkage appears to be between interest and exchange rates and agricultural output prices. There is little direct impact from domestic inflation. Such a result is not surprising given the international nature of Canadian agriculture. Input prices do not appear to be as significantly affected by macroeconomic shocks as are output prices. Such a result may be interpreted as providing support to the hypothesis that input and output prices in agriculture exhibit the "fixed-price flex-price" phenomenon.

The methods used in this study are relatively new and they provide a flexible approach to modeling economic time series. It is apparent that the "identification conditions" assumed by the researcher significantly affect the empirical results. In this study we have modified existing techniques to provide more plausible identification restrictions on the model. The results indicate that the agricultural sector, in particular through agricultural output prices, is sensitive to exchange rate and interest rate variation. The techniques used here may be applied in future research to investigate the impact of macroeconomic variables on specific commodities and on regions of the country.

II Introduction

The central theme of this study is to examine the relationship between macroeconomic variables and the agricultural sector of the economy. Historically, macroeconomic influences on the agricultural sector have received little attention; traditionally emphasis has been on partial equilibrium analysis. This may have been the result of the land intensive nature of agriculture, its small business nature, or its special distinctiveness as a fundamental sector in our economy. Today, as the agricultural sector becomes more integrated into the world economy, it can no longer be analyzed in isolation. Farming has evolved to become an international business and, as any business, it is sensitive to macroeconomic forces. This responsiveness will continue as the sector becomes more capital intensive and as the farmers or operation managers of the agricultural firms become more sophisticated in their use of financial markets.

A Background

Interest in modeling the relationship between the macroeconomy and the agricultural economy has risen steadily since Schuh's 1974 article which illustrated the potential effects of macroeconomic policy shocks on the agricultural sector. A variety of authors has examined the effects of exchange rate, interest rate, money supply and general price level shocks on agricultural variables (price, exports, etc.). A variety of techniques has also been used to examine these relationships. Both structural econometric models and time series approaches have been employed.

Earlier research in the area of "macro-agriculture" linkages concentrated on three separate issues. The first of these was the effect of the exchange rate on agricultural prices and exports. The second was the effect of money supply shocks on agricultural prices and the third was the impact of interest rates on agricultural prices.

The impact of exchange rate movements on agricultural prices and exports has been of considerable interest to agricultural economists. Schuh's article began a long series of debates about the size of the exchange rate effect on agricultural exports. This debate has been analyzed using structural models and Vector Autoregressive (VAR) models. A few such studies are discussed below.

The theoretical relationship most often tested is the responsiveness of agricultural exports to changes in the exchange rate. Under certain assumptions, a fall in the dollar leads to an increase in exports as agricultural products are in a more competitive position abroad. However, depending on the elasticities, this change may be weak or strong. The literature on exchange rate impacts and 'pass-

through' effects reviews these arguments (see Carter *et al.*, 1990 for a discussion of these concepts). The empirical studies of exchange rate impacts that can be considered traditional econometric studies include Carter *et al.*, 1990; Chambers and Just, 1982; Batten and Belongia, 1986; and others. In most of these studies, the direct impact of the exchange rate on agricultural prices and/or exports is significant.

Money supply changes, to some economists, act as a lag in the economy. These changes adjust to the general level of price increases in the economy. Other economists (the Monetarists led by Milton Friedman) believe that money supply changes drive price level changes in the economy and that these money supply changes are the determining factors of the health of the economy. Researchers have empirically tested these two opposing views. Barnett, Bessler and Thompson (1983) tested this using Granger causality. Their findings show that the money supply changes "helped to cause the rise in food prices rather than merely accommodating them."

The third element frequently examined is the interest rate. As the agricultural sector has become more capital intensive it is natural to expect that the sector would become more sensitive to the cost of capital or to the interest rate. The capital intensive nature of agriculture not only involves the use of larger and more costly machinery but the use of lines of credit and demand loans for purchases such as fertilizer and pesticides. (Baker has stated that interest charges as a percentage of production expenses in American agriculture has increased from 3.1 percent in 1950 to 15.7 percent in 1983.)

The result of an interest rate change on the agriculture sector varies with the time frame and with the researchers' specific interest in the price of inputs or the price of outputs. Starleaf (1982) found that through the exchange rate, interest rates are inversely related to the demand for farm exports. Chambers (1982) found that increasing interest rates caused an increase in storage costs which brought more farm output to market. In the long run, interest rates vary directly with farm costs.

The previous three variables, exchange rates, money supply and interest rates, do not act independently. The three macroeconomic variables acting in concert may have a greater influence on agriculture in Canada than any one variable acting on its own. Therefore, the interaction of these variables on the agriculture sector (including prices and exports) will be examined here.

B Objectives

1. To assess the influence of various macroeconomic forces on the levels of agricultural prices (and exports of agricultural products).

2. To assess the impact of macroeconomic forces on prices paid by producer as well as on the price they receive, and the resulting impact on agricultural terms of trade.

3. To examine models of agricultural price response to monetary shocks and their implications for agricultural and macroeconomic policy.

4. To examine the influence of macroeconomic variability on the variability of agricultural prices and assess consequent implications for stabilization policies.

C Outline of Study

In the next section, Chapter II and Appendix A, the calculations of terms of trade of Canadian agriculture are presented. The objective of this terms of trade analysis is to examine the trend in output versus input prices over time and to relate this trend to macroeconomic factors. This analysis is presented in response to objectives 1 and 2 above. In Chapter III and Appendix B, a Vector Autoregressive (VAR) model is constructed and tested. This section also examines the time responses of agricultural variables to shocks in macroeconomic variables. The section extends the analysis with the VAR model to include decomposition of variation in agricultural prices. The VAR analysis is presented to address objectives 1, 3 and 4. The VAR model is an empirical method designed to identify linkages in economic time series and in this case it is used to examine the relationships between agricultural and macroeconomic factors. The final section of this report briefly summarizes the major conclusions and presents some policy implications and benefits of this study.

III Estimation of the Terms of Trade for Canadian Agriculture

A Background

Agriculture represents a net exporting sector of the Canadian economy. In 1987 Canada imported $6,100.10 million worth of agricultural products while it exported $7,948.60 million. These agricultural exports represented 75.96 percent of all the agricultural produce and 6.35 percent of total Canadian exports.

The following section examines the relative prices of inputs and outputs as experienced by farmers (the terms of trade). In trade literature the (net barter) terms of trade are equivalent to the ratio of prices of goods exported to the prices of goods imported. Other literature has the ratio of the prices of the exporting sector over those of a competing or alternative sector (often agricultural prices are compared with industrial sector prices). In this paper, however, the terms of trade faced by farmers is conceptualized to be the ratio of agricultural output prices to agricultural input prices. As most of the agricultural inputs are from the industrial sector, this ratio approximates an agricultural/industry intersectoral terms of trade.

B Data

The terms of trade were measured using agricultural output prices and agricultural input prices. The main source of data was the CANSIM database; however, some data were collected from other sources and other data were extrapolated. The input prices for the beef, hog and chicken sectors were obtained from the CANSIM database.

The aggregate grain output prices were derived by aggregating the output prices of four major crops (all wheat, oats for grain, barley and canola) that are produced in Canada. The output price of each of these crops was obtained from the CANSIM database by dividing the total values of production of each individual crop by their respective total output quantities. The output quantities and the obtained output prices of each individual crop are further used to construct a Divisia index series of grain output prices.

Beef sector output prices were constructed on the basis of yearly weighted average prices of slaughter cattle sold through public stock yards. The yearly weighted average price per 100 lb of all sales of slaughter cattle on public stock yards were obtained from the **Livestock Market Review** **(1971-85)** published by Agriculture Canada. Since these yearly weighted average output prices were

given by the provincial market centers (Calgary, Edmonton, Winnipeg, Toronto and Montreal), the aggregate yearly weighted average output price of slaughter cattle for Canada was derived by calculating simple arithmetic means of all these provincial prices.

The output prices for the hog sector were compiled in much the same way as the beef prices; an index was constructed on the basis of the yearly weighted average prices of all sales of hogs in public stock yards which are readily available in the **Livestock Market Review (1975-85)** published by Agriculture Canada. As the yearly weighted average prices of all sales of hogs on public stock yards are provided on a provincial basis, the aggregate yearly weighted average prices of hogs for Canada were derived by computing simple arithmetic means of all these provincial prices.

The index of chicken output prices was constructed on the basis of provincial average annual prices of live chickens in the **Poultry Market Review** published by Agriculture Canada. Means of the provincial average annual prices for live chickens under five pounds were used as the aggregate national average prices for live chickens.

C Methodology

The objective here is to estimate the terms of trade for Canadian agriculture. The technique used in this part of the study was relatively simple. It involved taking the output prices and dividing them by the input prices to derive an index to represent the terms of trade of a sector. In each of the five sectors researched (farm, grain, beef, hogs and chickens) 1981 was arbitrarily chosen as the base year, that is the output prices and the input prices were considered to be 100 (and therefore the terms of trade were calculated to be 1). This allowed different sectors to be compared and trends to be easily identified. Geometric mean growth rates are presented for the entire time period and two sub-periods. These growth rates are based on the endpoints of the series and should be interpreted with caution, however, they provide a summary measure of the trends in output prices, input prices and terms of trade.

D Results

The terms of trade results are presented in the following five figures, one for each of the five sectors (farm, grain, beef, hogs and chickens). In each of the figures the horizontal axis represents time while the vertical axis represents the price indexes and terms of trade. (The tabular analysis is presented in Appendix A.)

In Figure 1, for the period 1971 to 1989, aggregate input prices in the Canadian farm sector increased at a faster rate than the aggregate output prices. Input prices increased by 7.04 percent and output prices by only 6.27 percent. As a result, the terms of trade for the Canadian farm sector declined during this period.

According to Figure 2, grain input prices during 1971 to 1984 increased annually by 10.04 percent versus an increase of 9.72 percent in grain output prices. The result was a decline in the terms of trade for the grain sector of 0.29 percent per year. Note that grain input prices during the 1980s grew at a faster rate than grain output prices. This resulted in a negative trend in the terms of trade for the grain sector during this period.

In Figure 3, input prices of the beef sector are observed to increase at a faster rate than output prices, resulting in a decline in terms of trade during the period 1971 to 1985. Input prices increased by 6.79 percent, whereas output prices increased by 4.98 percent per annum. The decline in the terms of trade for the beef sector was 1.70 percent annually.

The sharp fluctuations in both output and input prices of hogs in Canada are illustrated in Figure 4. The terms of trade in the hog sector increased by 0.48 percent per annum during the period 1975 to 1985 due to a growth rate of 0.32 percent annually in hog output prices against a 0.16 percent decline in its input prices. The hog sector, as compared to the grain and the beef sector, has had positive growth rates in its terms of trade throughout the period 1975 to 1985.

As shown in Figure 5, chicken output prices from 1971 to 1985 increased at a faster rate than input prices thereby resulting in a positive growth rate in the terms of trade for the chicken sector. The output prices during the period increased annually by 12.75 percent, whereas the input prices increased by 6.73 percent per annum. As a result, the terms of trade for the chicken sector increased annually by 5.63 percent during the period.

Figure 1: Terms of Trade in the Canadian Agricultural Sector: 1971-1989
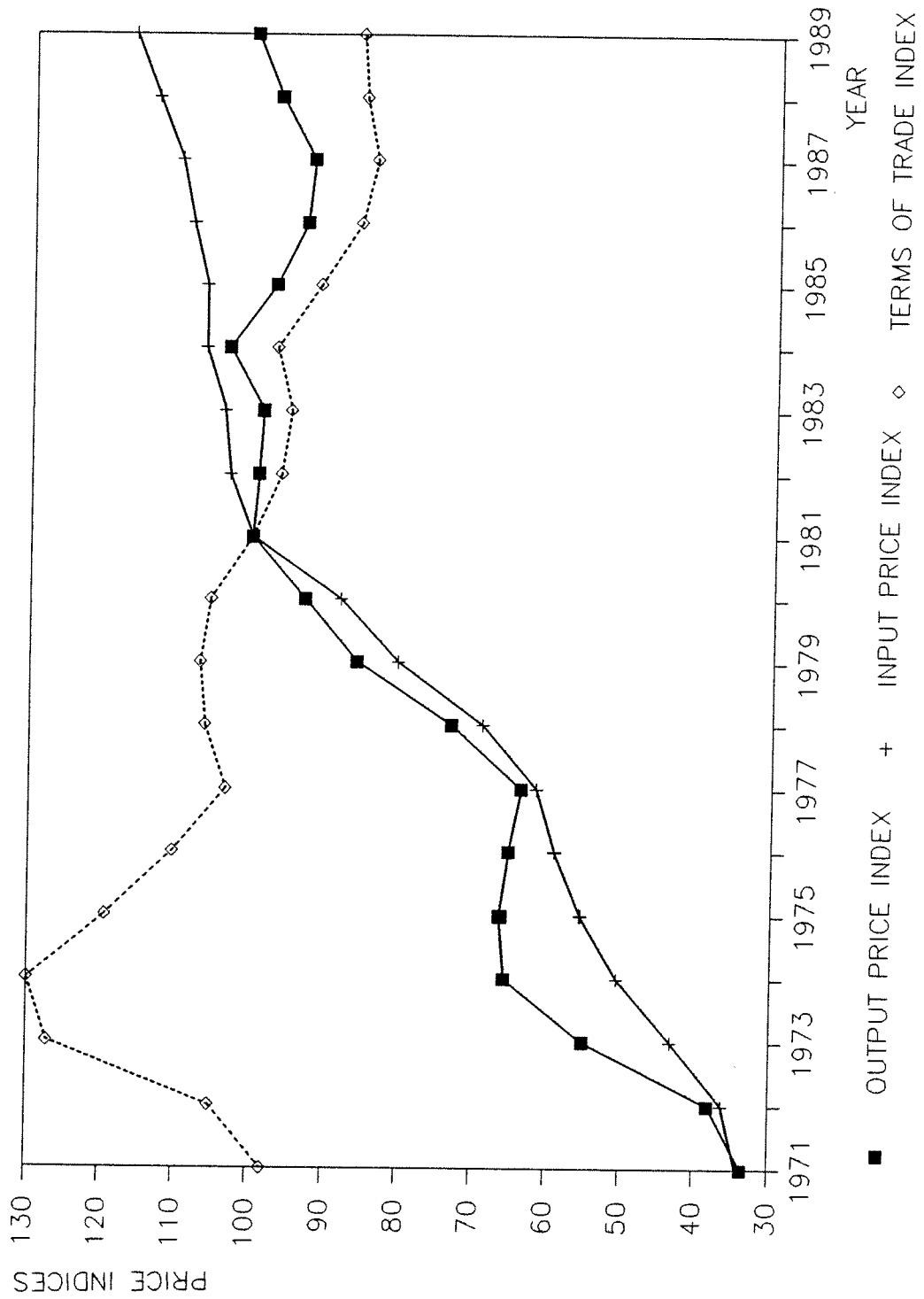
Figure 2: Terms of Trade in the Canadian Grain Sector: 1971-1984
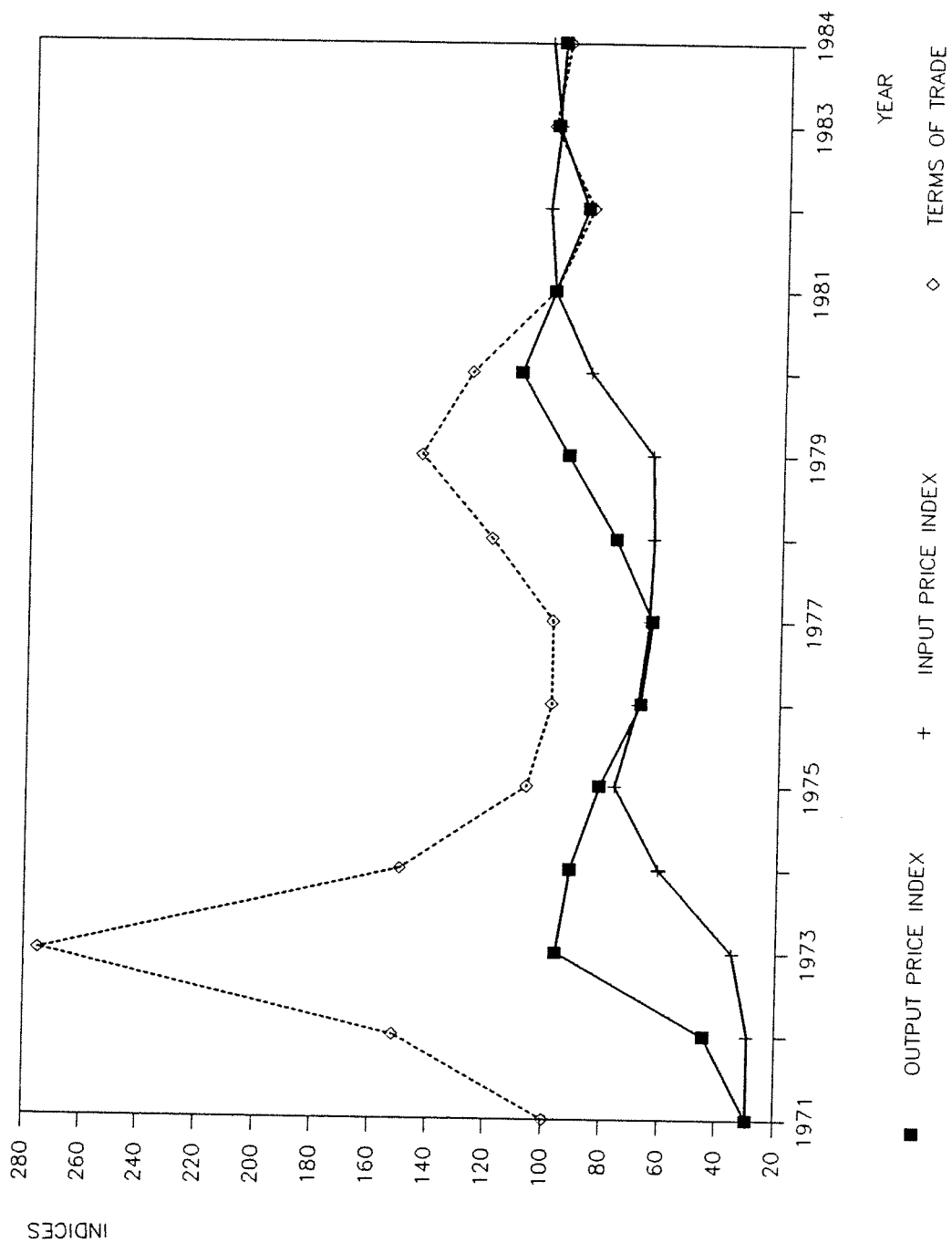
Figure 3: Terms of Trade in the Canadian Beef Sector: 1971-1985
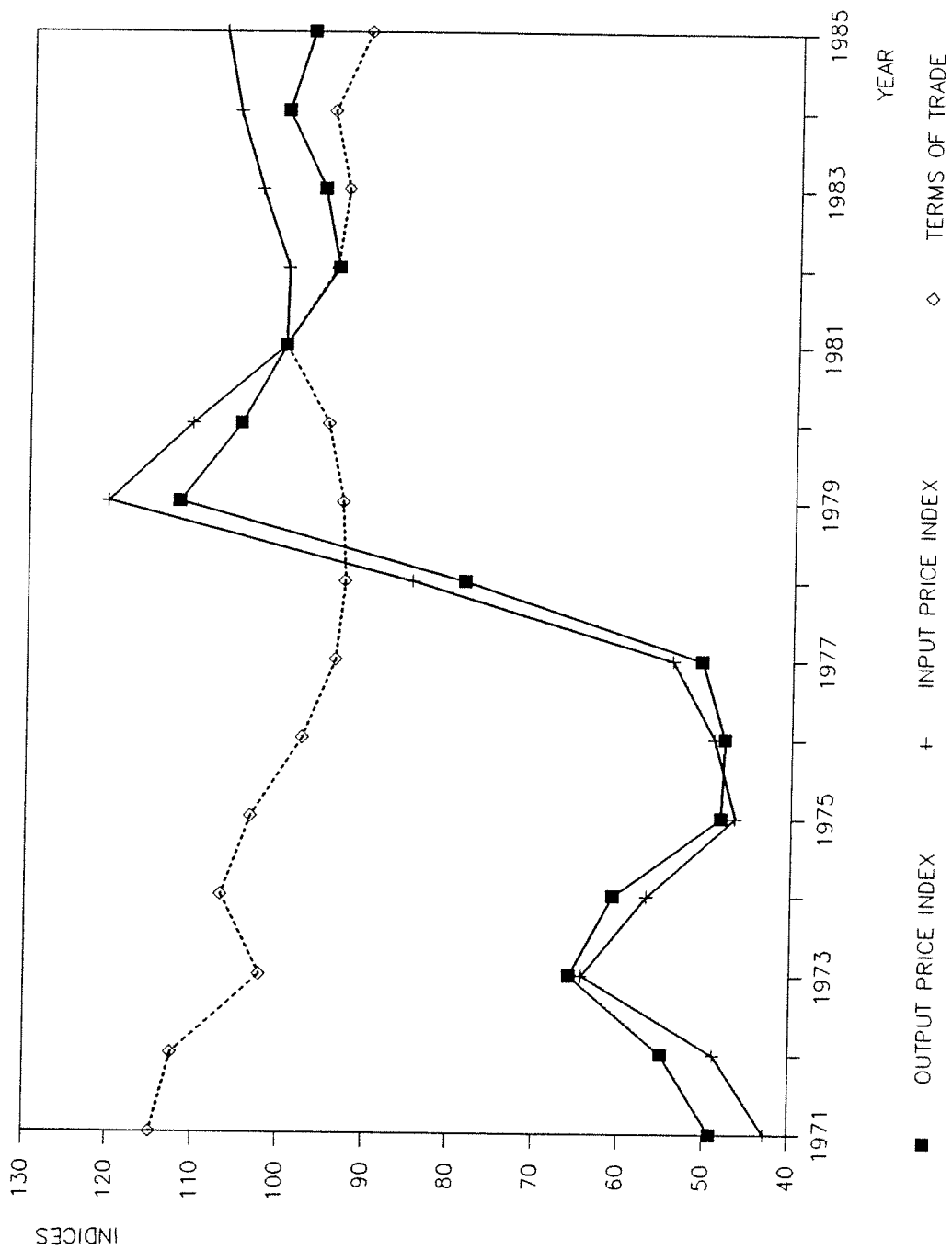
Figure 4: Terms of Trade in the Canadian Hog Sector: 1971-1985

INDICES

YEAR

■ OUTPUT PRICE INDEX   + INPUT PRICE INDEX   ◇ TERMS OF TRADE
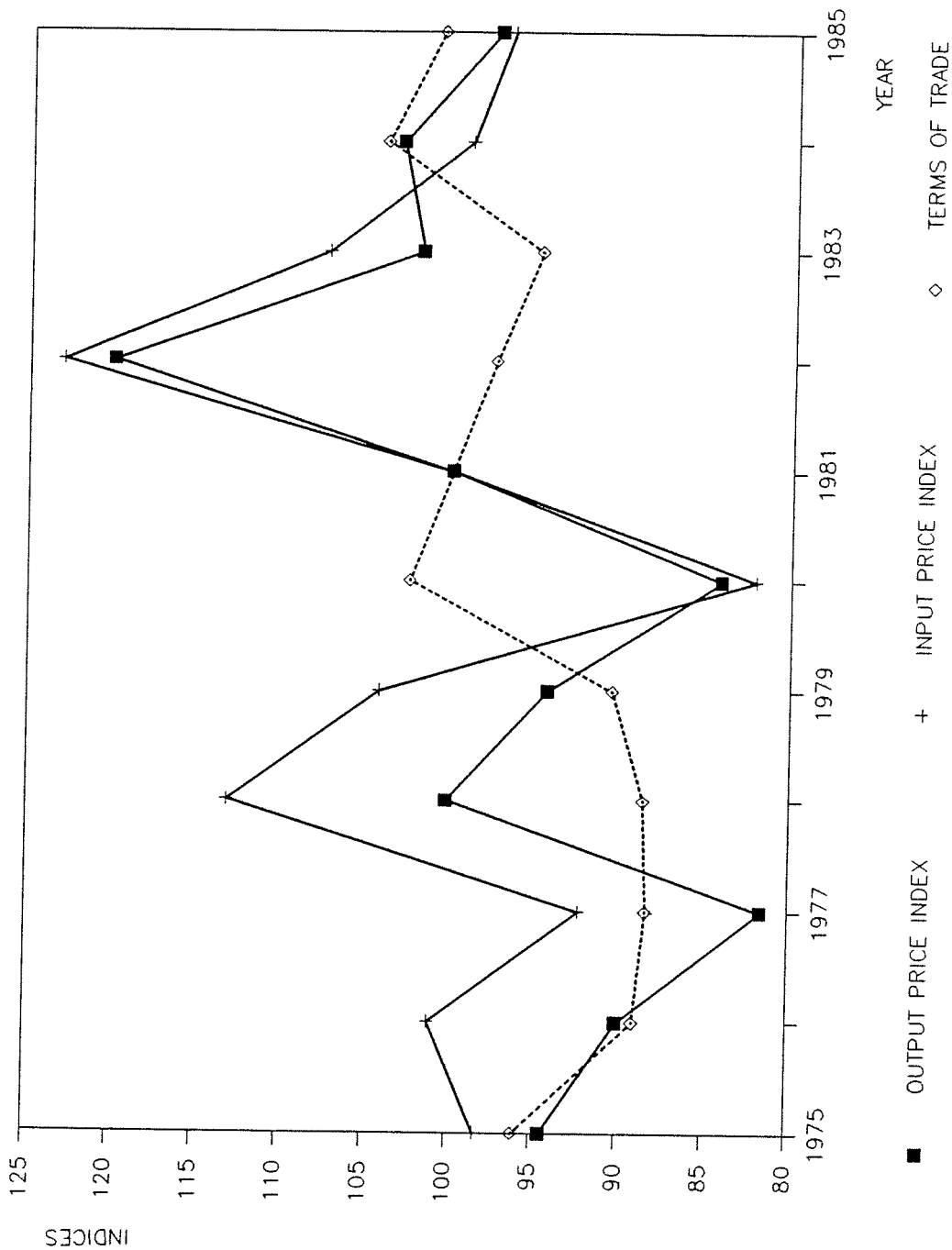
Figure 5: Terms of Trade in the Canadian Chicken Sector: 1971-1985
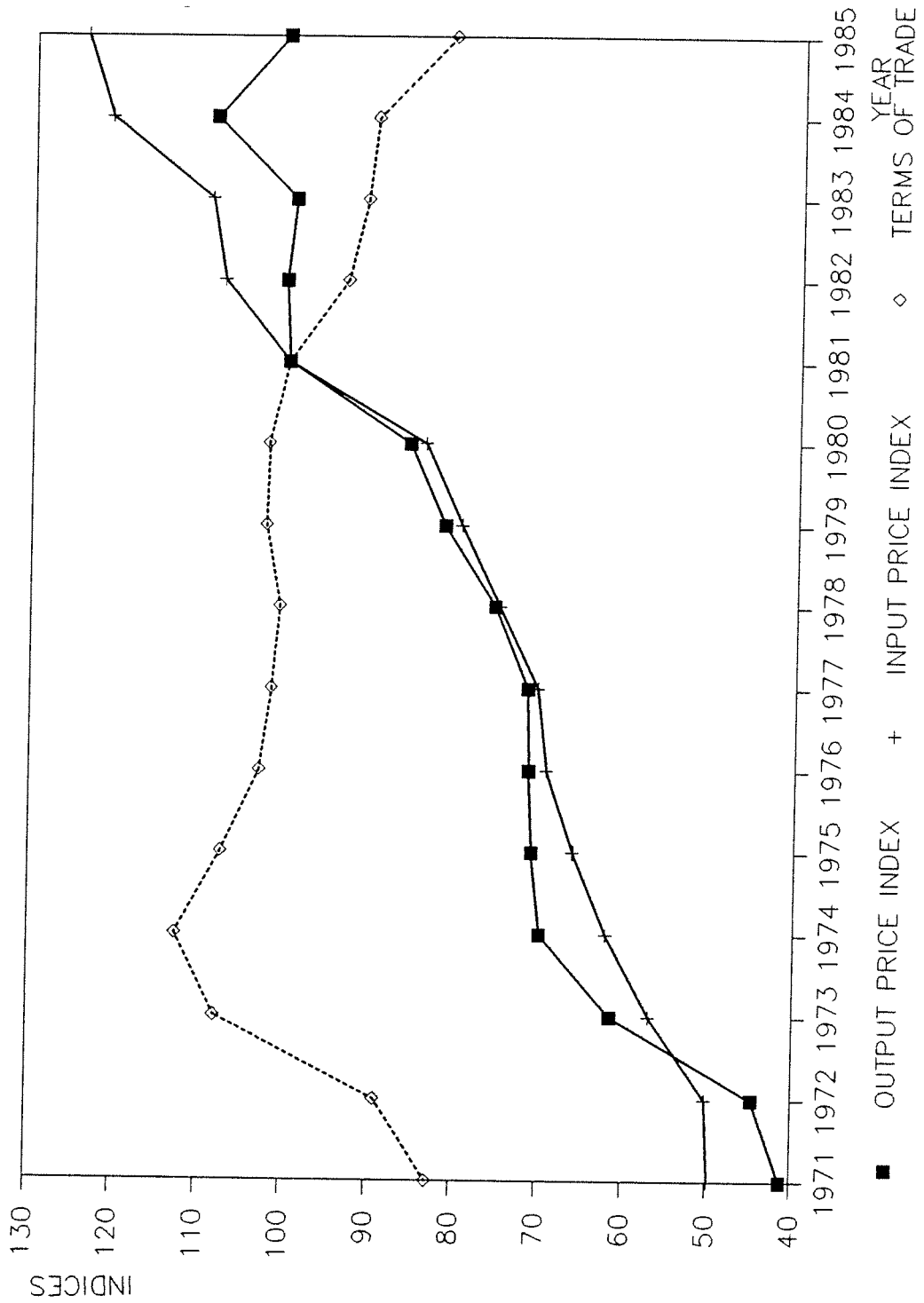
E Terms of Trade Conclusions

It is difficult to summarize the pattern of the terms of trade other than in a general observation that the terms of trade appear to be declining in agriculture as a whole. However, some agricultural sectors are improving in their terms of trade and some are deteriorating. It is also difficult to isolate factors affecting the terms of trade from this analysis. Some of the terms of trade effects may be due to exchange rate and interest rate movements. Some of the changes may be due to global agricultural trade policy. One avenue explored in an attempt to further investigate the problem involves the money illusion hypothesis, which appears in Appendix B. This analysis examines the impact of price changes (inflation) on actual consumption. However, as with the terms of trade, no clear cut conclusions regarding the sources of the variability are derived.

The analysis presented above does provide some interesting questions. In general, the terms of trade in Canadian agriculture appear to be falling over the period studied, however, there is also considerable variability between commodities and over time. Returns in the 1980s appear to be relatively stable but costs are increasing. Some of these cost increases may be due to macroeconomic changes over time. The impact of interest rate changes, for example, may result in increased costs of production. Inflation may also affect agricultural input prices more significantly than agricultural output prices. In this regard, Canadian monetary policy may play a role in the terms of trade effects. Exchange rates and their impact on imported inputs and prices of export crops may also be affecting the terms of trade although the effects may differ across commodities.

The analysis presented above suggests that a more in depth examination of the factors affecting agricultural output prices and input prices is necessary to discover the root causes of terms of trade changes. The next section of this study presents such an investigation. The Vector Autoregressive (VAR) modelling technique is used to examine the association between agricultural prices (input and output), agricultural exports, and macroeconomic factors (interest rates, exchange rates, etc.). This model is designed to explain the variability of agricultural prices and exports and the contribution of macroeconomic variables to this variability.

IV Vector Autoregressive Model

A Conceptual Background

1 Theoretical Background

As previously stated, the agriculture sector has historically been analyzed using a partial equilibrium framework. One of the objectives of this study is to show that agriculture should be examined in the larger framework of the macroeconomy.

The average farm in Canada has become more capital intensive; in 1971 the real average capital of farms was $155,773 and by 1984 the figure had more than doubled to $318,827. This suggests that the agriculture sector would have become more sensitive to macroeconomic variables such as the interest rate. Over the last three decades inflation has been highly variable. To the agriculture sector this means that not only do input prices vary but output prices vary as well. There will also be a foreign market effect as foreign money supply and inflation would have a variety of effects on the domestic agriculture sector. Exchange rates may vary and may have detrimental effects on agricultural exports or may make imports of inputs more attractive. The net effect of macroeconomic changes on the agricultural economy is an empirical question. The impact depends on the linkages between the agricultural economy and the other sectors of Canada as well as the international economy.

One of the more popular statistical tools used in the area of modeling the relationship between the macroeconomy and the agricultural economy is vector autoregressive (VAR) modeling. The VAR approach provides an alternative to the structural econometric approach. As outlined below, VAR models are a form of dynamic simultaneous equations model. As in any simultaneous equations exercise, the VAR model requires identification restrictions to interpret the model in a causal framework. The approach in VAR modeling is to develop a statistical model before the imposition of identification restrictions.

The commonly used VAR model in most agricultural economics applications uses an identification which implies the system being modeled has a recursive structure: variables affect each other in the order specified by the modeler. This recursive structure means that the variable at the top of the ordering will have a contemporaneous effect on all the variables in the model, and that the variable at the bottom of the ordering will have a contemporaneous effect on itself only. Most evaluations of the importance of this assumption have relied on changing the order in the recursive specification and

examining the impact on the model. In this study, we relax the recursive ordering assumption and model the agriculture-macroeconomy relationship using a more structural identification of the VAR model. This identification includes simultaneous interactions between the behavioral equations in the VAR. We find that this movement towards a more structural model results in a very different characterization of the response of agricultural variables to macroeconomic influences. In particular, there appears to be a stronger relationship between macroeconomic factors and agricultural prices and exports.

2 Background

A VAR is essentially a dynamic simultaneous equations system. The dependent variables are, by definition, all endogenous variables and the independent variables are lagged observations of all variables in the system[1]. All variables affect each other through a system of lags. This allows the data to provide a representation of the changes in the system without "zero restrictions" (*i.e.* restricting the coefficient of some explanatory variables in an equation to zero) as required in traditional simultaneous equation techniques. While VAR models do not impose zero restrictions on the parameters in the traditional simultaneous equation fashion, the model does require identification restrictions to provide information on the response of system variables to shocks.

Traditional econometric modeling of a simultaneous system would require the construction of a structural model using theory and the placement of restrictions on this structural model in order to be able to identify the parameters of the structural model from the reduced form or statistically estimated model. Typically, the reduced form is based on a reduced parameter space and the identifying restrictions are used to derive the structural parameters (see Mount, 1989). The VAR approach uses the set of lags of all of the endogenous variables in each behavioral equation as the reduced form. The economic structure is identified using the variance matrix of the residuals to place identifying restrictions on the matrix of contemporaneous coefficients. For example, the Cholesky decomposition of the covariance matrix results in orthogonal behavioral shocks and a contemporaneous coefficient structure that implies a recursive ordering between variables.

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1 Where they are considered to be important, exogenous (or deterministic) variables may be included in the set of independent variables in the system.

While both the VAR approach and traditional econometric approaches require identification restrictions, the nature of these restrictions is quite different. The traditional approaches tend to place little emphasis on lags in equations while the VAR approach emphasizes it. The traditional approach places strict interpretations on the parameters of each equation while the VAR approach interprets the system as a whole and analyzes responses to the behavioral shocks (see Orden and Fackler, 1989). The traditional approach uses zero restrictions on parameters for identification while the VAR approach uses the covariance matrix of the reduced form residuals and the assumption of orthogonal behavioral shocks to establish identification. In VAR models, the statistical model is developed first and then the structural model is identified. This is opposite to the approach followed in traditional econometrics and is favoured by some statistical theorists (Spanos, 1990).

The VAR approach begins with a dynamic equation system of the form

$$\sum_{s=0}^{\infty} A(s) \ Y(t-s) = \sum_{s=0}^{\infty} v(t-s) \tag{1}$$

where $Y(t)$ and $v(t)$ are $k \times 1$ vectors and $A(s)$ is a $k \times k$ matrix of coefficients for each time period (s) previous to current time (t). The model in (1) relates the observable data (Y) to sources of variation in the economy (v). The shocks in $v(t)$ are assumed to "represent behaviorally distinct sources of variation that drive the economy over time" (Orden and Fackler, 1989, p 496). The vector $v(t)$ has an expected value of zero and an assumed diagonal covariance matrix, Ω. The covariance matrix is assumed to be diagonal so that individual shocks ($v(t)$) apply to only one behavioral equation at a time. Thus we can evaluate the effect of shocks to each behavioral equation on each variable in the system.

Assuming that errors from previous lags do not affect the current values, equation (1) can be rewritten in autoregressive form as

$$A(0)Y(t) = -\sum_{s=1}^{\infty} A(s)Y(t-s) + v(t) \tag{2}$$

The matrix $A(0)$ is the set of contemporaneous parameters on $Y(t)$. Multiplying through by $A(0)^{-1}$ yields

$$Y(t) = \sum_{s=1}^{\infty} D(s)Y(t-s) + u(t) \tag{3}$$

where $D(s) = -A(0)^{-1}A(s)$ and $u(t) = A(0)^{-1}v(t)$. The vector $u(t)$ is the one step ahead prediction error in $Y(t)$ and the covariance matrix of $u(t)$ is Σ. Equation (3) is the autoregressive equation which is estimated given an assumption on the lag length. It is the reduced form model.

Since all the variables are related in the system it is not possible to disentangle the effects of one variable on another using the autoregressive representation. However, the autoregressive representation can be used to find the moving average representation which expresses the level of a particular variable as a function of the error process. Inverting the autoregressive system in (3) into a moving average representation results in:

$$Y(t) = \sum_{s=0}^{\infty} G(s)u(t-s), \tag{4}$$

where $G(s)$ is a matrix of moving average coefficients derived from (3). However, we wish to examine the effect of the behavioral shocks $(v(t))$ on the variables $(Y(t))$. In order to isolate the impact of $v(t)$ on $Y(t)$ we use the fact that $u(t) = A(0)^{-1}v(t)$. Given an estimate of the covariance of $u(t)$ we can estimate the parameters of $A(0)^{-1}$.

It is at this point that most VAR modelers make a relatively restrictive assumption. Most use the estimated covariance of $u(t)$ or Σ, and assume $A(0)^{-1}$ to be a triangular matrix. The parameters of $A(0)^{-1}$ are derived using a Cholesky decomposition[2]. The use of a Cholesky decomposition (or orthogonalization) provides an identification for the model. However, this identification is an implied recursive model structure with equations at the top of the ordering affecting those below but not *vice versa*. However, other forms of identification which do not result in recursive models are available (Orden and Fackler, 1989; Sims, 1986, Bernanke, 1986). The approach developed by Fackler is used in this paper. A likelihood approach is used to estimate the identified parameters in $A(0)^{-1}$. The model is identified by providing restrictions on elements of the $A(0)^{-1}$ matrix. These restrictions, which need not produce an upper triangular matrix as in the Cholesky decomposition, can produce a form of structural model. The identification condition requires that there be $K(K-1)/2$ restrictions on the parameters of the $A(0)^{-1}$ matrix.

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2 The Cholesky decomposition approach assumes that the v(t) have unit variance and are orthogonal and the matrix $A(0)^{-1}$ is derived by solving the equation $\Sigma = A(0)^{-1}A(0)^{-1}$.

Given an identification for $A(0)^{-1}$ the moving average representation can be written as

$$Y(t) = \sum_{s=0}^{\overline{}} G(s)A(0)^{-1}v(t) \qquad (5)$$

This is the impulse response function (IRF) which describes the effect of shocks to the behavioral relations on variables in the system[3]. The IRF summarizes the dynamic multipliers as implied by our identification. A shock may be represented by the placement of the value unity in one element of the vector $v(t)$. The IRF provides the response of all variables in the system to this unit shock.

The moving average representation can also be used to decompose the forecast error variance of one of the variables in the system into portions attributable to each element in $Y(t)$. Using the autoregressive structure of the VAR model, the conditional expectation of $Y(t+h)$ given $Y(t)$, $Y(t-1)$,..., can be determined. These are the h-step ahead forecasts of the series $Y(t)$. The forecast error covariance can also be established since it depends only on information up to time t. Forecast error decompositions are derived from the result that the contribution of each variable to forecast error is linear thus allowing the evaluation of each separate variable's impact on forecast error. This linearity of forecast error results from the orthogonalization procedure used in VAR models explained above.

The forecast error variance decompositions provide a useful measure of the strength of explanation between variables at different forecast horizons. Interpreted together with IRFs, decompositions can provide valuable insight into the dynamics of variables under investigation.

3 Previous Research

Most previous research in the area of "macro-agriculture" linkages has concentrated on three separate issues. The first of these is the effect of the exchange rate on agricultural prices and exports. The second is the effect of money supply shocks on agricultural prices and the third is the impact of interest rates on agricultural prices.

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3 See Judge *et al.* (1988) p. 771-775 for an illustration of the derivation and use of impulse response functions or innovation accounting.

The theoretical relationship most often tested is the responsiveness of agricultural exports to changes in the exchange rate. Under certain assumptions, a fall in the dollar leads to an increase in exports as agricultural products are in a more competitive position abroad. However, depending on the elasticities, this change may be strong or weak. The literature on exchange rate impacts and "pass-through" effects reviews these arguments (see Carter *et al.*, 1990, for a discussion of these concepts). The empirical studies of exchange rate impacts that can be considered traditional econometric studies include Carter *et al.*, 1990; Chambers and Just, 1982; Batten and Belongia, 1986; and others. In most of these studies, the direct impact of the exchange rate on agricultural prices and/or exports is quite significant.

A number of VAR studies on this exchange rate - agricultural prices/exports relationship have also been performed. Orden, 1986a and 1986b, Taylor and Spriggs, 1989, and Bessler and Babula, 1987 all incorporate exchange rates in their models of agriculture-macroeconomy interactions. The VAR approach chosen in these studies is the recursive model identification. The results, in most of these papers, suggest that exchange rates have little impact on agricultural exports, at least for the commodities and time periods chosen. The VAR models also suggest that most of the variation in forecast errors in agricultural variables is due to "own effects" rather than macroeconomic effects. That is, the majority of forecast error variance of agricultural exports, for example, is attributable to exports themselves and not exchange rates or other macroeconomic variables. This has led some to conclude, for example, that "exchange rates have little influence on wheat sales and shipments" (Bessler and Babula, 1987. p. 397).

In one of the few non-recursive VAR modeling efforts, Orden and Fackler (1989) find a difference in the response of agricultural prices to exchange rates depending on the identification assumptions. Under recursive model assumptions, agricultural price responds weakly to shocks in the exchange rate equation, while in a structural model the response is greater and occurs more rapidly. Orden and Fackler, however, focussed on the impact of monetary shocks rather than the exchange rate impacts.

Similar issues arise in empirical studies of the agricultural price - monetary policy issue and the agricultural price - interest rate issue. The VAR modeling studies that have investigated these issues have most commonly used recursive model identification schemes. They tend to find strong own

effects and weak interactions. In the sections below we outline the theory of VAR models. We then examine alternate identification schemes in a model of agricultural economy - macroeconomy interactions.

In a study of the macroeconomic effects on the lumber sector, Jennings *et al.* (1991), used a ten variable, three lag, VAR model. The ten variables included the Canadian-U.S. exchange rate, the interest rate on Canadian three month Treasury bills (nominal rate), the gross national product of Canada (in billions of dollars), the gross national product deflator, the total number of housing starts in North America (thousands of units), a Canadian index of the selling price per cubic meter of lumber, a U.S. index of the selling price per cubic meter of lumber, lumber volume produced in Canada (thousands of cubic meters), lumber volume exported from Canada to the U.S. (thousands of cubic meters), and end of period inventory of lumber held by Canadian producers (thousands of cubic meters).

The authors built a VAR model and tested the hypothesis that lagged macroeconomic variables did not explain lumber sector activity. This hypothesis was rejected at the 95 percent level. The reverse was tested and at the 95 percent level was rejected as well. The authors reached four major conclusions when they examined the Impulse Response Functions and the Variance Decompositions. Firstly, the macroeconomic variables explained a large portion of the error forecast variance of the lumber sector variables. Secondly, a shock to housing starts produced an expected demand driven response of the lumber sector. The study also found that exchange rate changes had little effect on lumber production. A comparable result was found between the interest rates and the lumber sector, a negligible effect of interest rates on lumber production.

B Data

The basic data set contains 228 monthly observations for the period January 1971 through December 1989. The data could be viewed as being in two blocks: a macroeconomic block containing important macroeconomic variables (exchange rate, EXCH; money supply, M1; interest rate, TBI; and price level, CPI) and an agricultural block containing variables more specific to the agricultural sector (farm output prices, FOPI; farm input prices, FIPI; and agricultural exports, EXPORT). One could view our choice of variables as allowing for the specification of an exchange rate equation, money supply and demand equations (through the money supply and interest rate variables), a price level equation, output supply and demand equations (through the farm output price and export vari-

ables) and an input demand equation (through the farm input price variable). The input demand equation is seldom considered in other studies of the linkages between the macroeconomy and the agricultural sector.

These seven variables were chosen because it was felt that they would capture the important relationships using as few variables as possible. We also allowed for some exogenous influences in the system: eleven monthly dummy variables to account for seasonal fluctuations, a constant, and a linear trend variable to account for drift.

All of these data were obtained from Statistics Canada: most through the CANSIM computer database (farm output prices were taken from Statistics Canada catalogue 62-003). All data except farm input prices are monthly. Farm input prices were quarterly in their basic form and interpolation was used to create monthly data.[4] The variables used are described in Appendix C.

All non-rate variables (M1, CPI, FIPI, FOPI, and EXPORT) in the data set were transformed to first differences (e.g. $\Delta M1_t = M1_t - M1_{t-1}$)[5]. For convenience, all further references to these non-rate variables is to their first differences unless specifically stated otherwise. The data were scaled so that the variables used for estimation were of roughly the same order of magnitude[6].

C Methodology

For the recursive models examined, the principal ordering of variables was exchange rate, money supply, interest rate, the general price level, the farm input price level, the farm output price level, and, finally, agricultural exports. This ordering makes some sense, in that it can be thought of

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4 The months in the middle of a quarter (February, May, August, November) were assigned the quarterly FIPI value. The rate of increase between quarters, r_q, was calculated as $r_q = (FIPI_{q+1} - FIPI_q)/FIPI_q$. The monthly rate of increase r_m, between quarters was calculated as $r_m = (1+r_q)^{1/3} - 1$. Monthly FIPI values for months not in the middle of a quarter were calculated using r_m. The first value in the monthly series (January 1971) was assigned the value of the first quarter in the actual series, and the last value in the monthly series was given the value of the last quarter in the series (December 1989).

5 A number of different variables and transformations of variables were considered and examined before this set of variables was chosen. Some work was done examining the effect of replacing the EXPORT variable with a "pseudo-quantity" variable (EXPORT/FOPI), but the initial indications are that the differences between the two models is not great. A number of different logarithmic and differencing transformations on the variables were done in order to identify and avoid problems associated with unit roots and non-stationarity. There has been some suggestion that a trade-weighted exchange rate may be the more appropriate exchange rate to use (Bluck 1989). We have obtained U.S. agricultural trade weighted exchange rate data, but have not fully explored the effects of including this information in the model.

6 M1 was divided by 100; TBI was divided by 10; CPI, FOPI, and FIPI were multiplied by 10; and EXPORT was divided by 100.

as corresponding to an ordering of "increasing endogeneity". Agricultural decision makers are more likely to have a large impact on agricultural exports than on the exchange rate. The ordering is similar to that used by other researchers (Taylor and Spriggs, 1989; Bluck, 1989). This recursive ordering means that a variable will have a contemporaneous effect on itself and all variables following it in the ordering, but will have no contemporaneous effect on variables preceding it. A shock to exchange rate will have some contemporaneous effect on all variables in the system; a shock to agricultural exports will only have a contemporaneous effect on agricultural exports.

The lag length for all the models estimated in this study was selected using Sims' (1980) likelihood ratio test using the principal recursive structure. A critical level of 1% was used to determine whether differences were significant. Based on the results of these tests, a lag length of seven months was used for all the estimations in this study. The results of the lag length determination are summarized in Table 1.

Model estimation was done using GAUSS routines developed by Fackler (1988a and 1988b). Essentially, the estimation proceeds as follows. VAR coefficients are estimated using OLS regression and the moving average representation of the system is calculated from the VAR coefficients. Given a model identification supplied by the user, and the covariance matrix resulting from the VAR estimation, the routines determine the parameters of the $A(0)^{-1}$ matrix that have the maximum likelihood of producing the estimated VAR coefficients.

Because we have seven endogenous variables in our model, we need 21 (K(K-1)/2) restrictions on our $A(0)^{-1}$ matrix in order to exactly identify our model. This leaves us with 28 free parameters to estimate. Normalization (scaling) of the structural models will reduce this number to 21 free parameters, as the diagonal elements of the $A(0)^{-1}$ will be restricted to one.

We will confine our discussion to four estimated models: two of the models are recursive; two are structural. The free parameters in the $A(0)^{-1}$ matrix for the recursive model A (model RA) are shown in Table 2. The rows in the table can be thought of as causal variables, and columns can be thought of as referring to affected variables. In model RA, the exchange rate is permitted to have a contemporaneous effect on itself and all other variables in the equation. M1 is not permitted to have any contemporaneous effect on exchange rate, but is permitted to have a contemporaneous effect on all other variables. The interpretation of the remaining rows is similar. The only contemporaneous effect agricultural exports is permitted to show is on itself.

Recursive model B (model RB) is the reverse of model RA. Agricultural exports are permitted to have a contemporaneous effect on all variables, and the Canada-U.S.A. exchange rate is permitted to have a contemporaneous effect only on itself. This model was created following the common practice of VAR modelers demonstrating the robustness of structural models by changing the recursive ordering of the variables. This is about as drastic a reordering as is possible (Table 3).

Structural model A (model SA) allows for direct contemporaneous interaction between all the macro variables (exchange rate, money supply, interest rates, and consumer price index), with the exception that exchange rate is not permitted to have a direct contemporaneous effect on money supply. The treasury bill rate is permitted to have a direct contemporaneous effect on all variables. The agricultural variables also form a block of contemporaneous interactions, with the exception that exports are not permitted to affect farm output price directly (Table 4).

Structural model B (model SB) is somewhat different from model A. Exchange rates are given more importance in that they directly contemporaneously affect all variables except money supply. Interest rates are less important, as they no longer directly contemporaneously affect farm input prices and exports. Farm input prices are directly influenced by all variables (Table 5).

D Results

In keeping with the traditional VAR approach, we will not interpret individual coefficients in our estimated $A(0)^{-1}$ matrix. We will focus instead on the dynamic paths of the variables in our system. The decomposition of forecast error variance provides a concise summary of the dynamic inter-relationships in an economic system and will be the focus of the discussion here. We will show some striking differences between the recursive and structural views of the world.

The decompositions of forecast error variance for model RA are presented in Figure 6. Details of the forecast error decompositions for model RA are presented in Table 6[7]. The results can be characterized as follows.

- Variation in the exchange rate is almost entirely explained by itself: 100% of the variance in exchange rates in month 1 can be attributed to exchange rate variation. This

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7 Standard errors for the forecast error decompositions in Tables 6 and 7 are presented in parentheses. The standard errors were estimated by assuming a normal distribution for the errors in the VAR model. The results of a 100 draw Monte Carlo simulation were used to generate the standard errors.

decreases to 87% by month 5, and stays fairly constant until month 24. The standard deviation of this effect increases over the time horizon but is never more than 15% of the mean.

- The forecast error variance in money supply can also be attributed to its own shocks, but not to the same extent as in exchange rates. From month 1 to month 10, the proportion of variance attributable to variation in money supply drops from nearly 100% to about 65%. Exchange rate and the treasury bill rate account for about 9% each from months 10 through 24 although the standard errors for these variables are larger relative to their means than is the standard error of money supply.

- The forecast error variance for the treasury bill rate is interesting. In period 1, 80% of the variance is attributable to the treasury bill rate and 20% to exchange rate. By month 24, treasury bills account for only 20%, the consumer price index accounts for 17%, the farm output price index accounts for 11%, and the farm input price index accounts for 42% of the forecast error variance. The price level variables seem to be quite important in explaining changes in the treasury bill rate but the variance of the decomposition numbers are larger, in relative terms, for the price variables.

- The FEV of consumer price index is attributable mostly to itself. The proportion of FEV that is self explained drops to 69% by month 24. The farm input price index accounts for 15% of the FEV by this time.

- Farm output price is mostly self-explained. By month 24, 69% of the FEV is attributable to farm output price index, and about 7% is attributable to each of exchange rate, treasury bill rate, and farm input prices.

- The FEV of farm input price is mostly self-explained (90% in month 1, 56% in month 24). The treasury bill rate, consumer price index, and farm output price index become somewhat important starting at about month 6.

- Agricultural exports are mostly self-explained (93% in month 1 to 78% in month 24).

Figure 7 presents the forecast error variance decomposition for model RB, the reverse recursive model. The most striking thing about the forecast error variance decomposition for this model is how similar it is to that determined for model RA. This is surprising as the models suggest very

different views of the interrelationships in the economic system. There is somewhat less self-explanation in the exchange rate FEV. This should be expected as this time the other variables are permitted to have some contemporaneous effect on exchange rates.

The overall results here show that, in the recursive models, most of the observed variance in a variable is a result of own effects. Also, the standard errors of the own effects are small relative to the standard errors of the other variables' effects. This general result remains unchanged over two vastly different recursive models. Exchange rates appear to be unimportant except for explaining exchange rates.

Figure 8 presents the FEV decomposition for model SA, the first structural model. Details of the forecast error decompositions for model SA are presented in Table 7. The results can be characterized as follows.

- Variation in the exchange rate is almost entirely attributable to the treasury bill rate (100% in month 1 to 92% by month 24). The standard error on this effect is relatively small and the variability of the other effects is quite large.

- Money supply is self explained in month 1 but by month 7, 37% is attributable to exchange rate, 41% to money supply, and 16% to the treasury bill rate. All of these effects appear to be "significant" in that the means are more than twice the standard deviations.

- In the early months, the treasury bill rate is almost entirely explained by exchange rates. By month 24, the proportion drops to 60% and 29% is explained by the farm input price index. However, the standard error on the FIPI effects is relatively large. The fact that FIPI influences TBI could possibly reflect the response of the Bank of Canada to inflation. If so, this would suggest that the elements that make up the farm input price index may be correlated with the inflation indicators to which the Bank of Canada responds.

- The consumer price index is mostly self-explained (92% in month 1; 62% in month 24), although exchange rates (5%-11%) and farm input prices (1%-19%) are also somewhat important. Exchange rate effects have a relatively high standard deviation while CPI and FIPI standard errors are relatively low.

- Farm output price variations are explained by exchange rates (30-48%), treasury bill rates (40-36%), and farm input prices (20-10%). The most noticeable aspect of the FOPI decomposition is the relatively high standard error on all effects. Only the exchange rate appears to be a significant factor in the decomposition.

- Farm input prices are largely self-explained (78%-39%), but exchange rates (21-33%), and treasury bill rates (0-20)% are also important. Farm input prices are characterized by much less own effect uncertainty than FOPI, as indicated by the standard errors.

- Exports of agricultural commodities are explained mostly by exchange rates (97-56%) and treasury bill rates (0-20%). Surprisingly, farm output prices appear to have no noticeable effect. Again, the variances of these effects are relatively large and only the exchange rate appears to provide a significant effect.

Figure 9 presents the FEV decomposition for model SB, the second structural model. The results are very similar to those for model SA. A slightly larger self-influence of exchange rates is seen towards the end. The FEV decomposition for farm output prices is slightly different initially, with a larger influence of self and the treasury bill rate, but the differences disappear starting at period 2. The FEV decomposition for agricultural exports is more different than the others. Agricultural exports and farm input prices have a large effect in month 1, that was not seen in model SA. Exchange rates account for less towards the end (43% vs. 56%), but are still very important.

The FEV decomposition of the structural models is strikingly different from that for the recursive models. Perhaps the most noticeable differences are that own effects are not nearly as important in the structural models as in the recursive models and that exchange rates exert a strong and important effect on the FEV decomposition of all variables except itself. It is also interesting to note that the "agricultural" variables seem to have higher variances in the FEV decomposition than the macroeconomic variables. The forecast error decompositions are not as definitive for the agricultural variables.

Table 1. χ^2 values for Sim's likelihood ratio test for lag length. Degrees of freedom in parentheses. Tests significant at 1% indicated by an asterisk. Blank entries in the table were not tested.

Lag Length Restricted	Unrestricted										
	2	3	4	5	6	7	8	9	10	11	12
1	127 (49)					423 (294)*					
2		72.1 (49)									
3			65.7 (49)	132 (98)*							
4				76.2 (49)*							
5					46.6 (49)	132 (98)*					
6						87.1 (49)*					
7							46.1 (49)	121 (98)	172 (147)	208 (196)	240 (245)
8								78.0 (49)*			
9									56.6 (49)		
10										45.0 (49)	
11											44.0 (49)

Table 2. General form of $A(0)^{-1}$ matrix for model RA. The elements identified by the Greek letter, π, are free parameters. Zero elements are restricted to the value zero.

	EXCH	M1	TBI	CPI	FOPI	FIPI	EXPORT
EXCH	π_{11}	π_{12}	π_{13}	π_{14}	π_{15}	π_{16}	π_{17}
M1	0	π_{22}	π_{23}	π_{24}	π_{25}	π_{26}	π_{27}
TBI	0	0	π_{33}	π_{34}	π_{35}	π_{36}	π_{37}
CPI	0	0	0	π_{44}	π_{45}	π_{46}	π_{47}
FOPI	0	0	0	0	π_{55}	π_{56}	π_{57}
FIPI	0	0	0	0	0	π_{66}	π_{67}
EXPORT	0	0	0	0	0	0	π_{77}

Table 3. General form of $A(0)^{-1}$ matrix for model RB. The elements identified by the Greek letter, π, are free parameters. Zero elements are restricted to the value zero.

	EXCH	M1	TBI	CPI	FOPI	FIPI	EXPORT
EXCH	π_{11}	0	0	0	0	0	0
M1	π_{21}	π_{22}	0	0	0	0	0
TBI	π_{31}	π_{32}	π_{33}	0	0	0	0
CPI	π_{41}	π_{42}	π_{43}	π_{44}	0	0	0
FOPI	π_{51}	π_{52}	π_{53}	π_{54}	π_{55}	0	0
FIPI	π_{61}	π_{62}	π_{63}	π_{64}	π_{65}	π_{66}	0
EXPORT	π_{71}	π_{72}	π_{73}	π_{74}	π_{75}	π_{76}	π_{77}

Table 4. General form of $A(0)^{-1}$ matrix for model SA. The elements identified by the Greek letter, π, are free parameters. Zero elements are restricted to the value zero, and elements containing 1 are restricted to unity. The diagonal elements are normalized as is traditional in simultaneous equation modeling.

	EXCH	M1	TBI	CPI	FOPI	FIPI	EXPORT
EXCH	1	0	π_{13}	π_{14}	π_{15}	0	0
M1	π_{21}	1	π_{23}	π_{24}	0	0	0
TBI	π_{31}	π_{32}	1	π_{34}	π_{35}	π_{36}	π_{37}
CPI	0	π_{42}	π_{43}	1	0	π_{46}	0
FOPI	0	0	0	0	1	π_{56}	π_{57}
FIPI	0	0	0	π_{64}	π_{65}	1	π_{67}
EXPORT	0	0	0	0	π_{75}	0	1

Table 5. General form of $A(0)^{-1}$ matrix for model SB. The elements identified by the Greek letter, π, are free parameters. Zero elements are restricted to the value zero, and elements containing 1 are restricted to unity.

	EXCH	M1	TBI	CPI	FOPI	FIPI	EXPORT
EXCH	1	0	π_{13}	π_{14}	π_{15}	π_{16}	π_{17}
M1	π_{21}	1	π_{23}	π_{24}	0	π_{26}	0
TBI	π_{31}	π_{32}	1	π_{34}	0	π_{36}	0
CPI	π_{41}	0	π_{43}	1	0	π_{46}	0
FOPI	0	0	0	0	1	π_{56}	π_{57}
FIPI	0	0	0	0	0	1	π_{67}
EXPORT	0	0	0	0	π_{75}	π_{76}	1

Table 6.

Table 6a. Forecast error decomposition for exchange rate. Model RA.

Time	C$/US$	M1(d)	T-bill	CPI(d)	FOPI(d)	FIPI(d)	AgExp(d)
1	100.0	0.0	0.0	0.0	0.0	0.0	0.0
	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)
3	93.0	4.3	0.2	1.1	0.2	1.2	0.0
	(3.5)	(2.4)	(0.8)	(1.5)	(0.8)	(1.4)	(0.5)
6	87.2	6.5	0.5	1.7	0.9	2.2	1.1
	(6.7)	(4.3)	(1.4)	(2.6)	(1.7)	(2.6)	(1.7)
12	89.2	6.4	0.6	1.1	0.5	1.0	1.3
	(8.2)	(6.2)	(2.0)	(2.4)	(1.8)	(2.1)	(2.6)
24	86.2	6.4	4.0	0.9	0.5	0.7	1.2
	(10.1)	(7.8)	(4.8)	(3.6)	(2.6)	(3.5)	(3.1)

Table 6b. Forecast error decomposition for money supply. Model RA.

Time	C$/US$	M1(d)	T-bill	CPI(d)	FOPI(d)	FIPI(d)	AgExp(d)
1	0.1	99.9	0.0	0.0	0.0	0.0	0.0
	(0.9)	(0.9)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)
3	8.4	81.2	6.6	0.6	0.5	1.3	1.3
	(3.8)	(4.6)	(2.6)	(1.4)	(1.0)	(1.2)	(1.3)
6	8.3	69.6	8.6	3.5	3.4	2.9	3.6
	(3.1)	(4.8)	(2.7)	(2.4)	(2.5)	(2.1)	(2.1)
12	9.2	64.0	8.7	4.0	3.9	3.9	6.2
	(3.0)	(5.0)	(2.7)	(2.6)	(2.6)	(2.3)	(3.2)
24	9.4	62.7	8.8	4.3	4.1	4.6	6.2
	(3.0)	(5.2)	(2.7)	(2.6)	(2.7)	(2.6)	(3.1)

Table 6c. Forecast error decomposition for treasury bill rate. Model RA.

Time	C$/US$	M1(d)	T-bill	CPI(d)	FOPI(d)	FIPI(d)	AgExp(d)
1	18.6	0.0	81.4	0.0	0.0	0.0	0.0
	(5.8)	(0.8)	(5.9)	(0.0)	(0.0)	(0.0)	(0.0)
3	18.3	5.2	69.0	1.2	2.1	4.2	0.1
	(6.7)	(3.8)	(7.3)	(1.2)	(1.8)	(1.9)	(0.4)
6	11.5	7.4	49.7	3.3	7.9	19.8	0.4
	(6.2)	(5.3)	(8.3)	(3.5)	(4.8)	(6.2)	(1.3)
12	7.1	7.1	33.7	9.9	9.9	31.5	0.8
	(5.0)	(5.1)	(8.1)	(7.9)	(6.4)	(8.3)	(2.5)
24	4.1	5.9	20.3	16.4	10.7	41.5	1.1
	(5.6)	(5.0)	(6.4)	(10.0)	(7.1)	(9.5)	(3.2)

Table 6d. Forecast error decomposition for CPI. Model RA.

Time	C$/US$	M1(d)	T-bill	CPI(d)	FOPI(d)	FIPI(d)	AgExp(d)
1	0.0	0.0	0.9	99.1	0.0	0.0	0.0
	(0.9)	(1.1)	(1.4)	(2.1)	(0.0)	(0.0)	(0.0)
3	0.6	0.7	1.7	90.2	1.6	3.4	1.8
	(1.4)	(1.5)	(1.6)	(4.0)	(1.7)	(2.0)	(2.3)
6	1.2	3.0	1.7	81.1	1.8	7.1	4.0
	(2.1)	(2.1)	(1.8)	(4.6)	(1.9)	(2.6)	(2.5)
12	1.3	3.8	1.9	76.2	2.8	9.4	4.5
	(2.3)	(2.1)	(2.0)	(5.1)	(2.2)	(3.0)	(2.6)
24	1.2	4.1	1.9	69.3	4.1	15.2	4.3
	(2.7)	(2.3)	(2.1)	(6.4)	(2.9)	(4.6)	(2.6)

Table 6e. Forecast error decomposition for FOPI. Model RA.

Time	C$/US$	M1(d)	T-bill	CPI(d)	FOPI(d)	FIPI(d)	AgExp(d)
1	0.5	0.0	0.7	3.6	95.1	0.0	0.0
	(1.2)	(0.9)	(1.9)	(3.0)	(3.9)	(0.0)	(0.0)
3	3.1	0.1	1.7	3.4	83.4	7.2	1.1
	(2.3)	(1.2)	(1.9)	(2.7)	(4.6)	(2.6)	(1.4)
6	5.5	0.7	5.7	3.7	75.8	6.9	1.6
	(2.4)	(1.9)	(3.0)	(2.8)	(4.9)	(2.4)	(2.0)
12	6.5	1.3	7.3	4.4	69.9	6.8	3.9
	(2.5)	(1.8)	(3.0)	(2.6)	(4.9)	(2.3)	(2.4)
24	6.6	1.8	7.5	4.6	68.7	6.9	3.9
	(2.5)	(1.8)	(3.0)	(2.6)	(4.9)	(2.3)	(2.3)

Table 6f. Forecast error decomposition for FIPI. Model RA.

Time	C$/US$	M1(d)	T-bill	CPI(d)	FOPI(d)	FIPI(d)	AgExp(d)
1	1.4	0.0	4.9	2.1	2.2	89.4	0.0
	(1.8)	(1.1)	(3.1)	(2.3)	(2.4)	(4.9)	(0.0)
3	4.3	0.5	1.9	9.9	4.3	79.0	0.1
	(3.6)	(1.4)	(1.6)	(4.7)	(3.3)	(6.3)	(0.8)
6	4.6	2.9	5.3	10.7	10.4	65.7	0.3
	(3.9)	(2.5)	(3.3)	(5.0)	(4.8)	(7.4)	(1.6)
12	4.9	2.6	8.6	11.7	12.4	59.3	0.6
	(3.8)	(2.0)	(4.5)	(5.3)	(4.5)	(7.1)	(1.8)
24	5.4	3.4	9.5	11.6	13.0	56.3	0.7
	(4.4)	(2.3)	(4.7)	(5.1)	(4.7)	(7.2)	(1.9)

Table 6g. Forecast error decomposition for agricultural exports. Model RA.

Time	C$/US$	M1(d)	T-bill	CPI(d)	FOPI(d)	FIPI(d)	AgExp(d)
1	0.0	3.8	1.8	0.4	0.6	0.0	93.3
	(0.8)	(2.7)	(2.1)	(1.2)	(1.3)	(0.7)	(4.1)
3	0.3	5.8	2.5	1.6	2.5	1.1	86.3
	(1.0)	(3.3)	(2.3)	(1.9)	(2.1)	(1.4)	(5.0)
6	0.8	5.8	3.4	2.2	3.3	2.5	82.0
	(1.8)	(3.1)	(2.3)	(2.2)	(2.5)	(1.6)	(5.6)
12	0.9	6.7	3.6	3.6	4.0	3.2	77.9
	(1.8)	(3.1)	(2.4)	(2.7)	(2.7)	(1.9)	(5.8)
24	0.9	6.7	3.7	3.8	4.2	3.3	77.4
	(1.9)	(3.0)	(2.4)	(2.8)	(2.8)	(2.0)	(6.1)

Table 7.

Table 7a. Forecast error decomposition for EXCH. Model SA.

Time	EXCH	M1(d)	TBI	CPI(d)	FOPI(d)	FIPI(d)	EXPORT(d)
1	0.1	0.0	99.8	0.1	0.0	0.0	0.0
	(0.0)	(0.2)	(0.5)	(0.5)	(0.0)	(0.0)	(0.0)
3	0.1	1.2	98.3	0.1	0.0	0.3	0.0
	(0.8)	(1.2)	(1.9)	(0.5)	(0.0)	(0.5)	(0.0)
6	0.9	1.5	96.8	0.1	0.0	0.7	0.0
	(1.8)	(1.8)	(2.8)	(0.7)	(0.0)	(1.0)	(0.0)
12	0.9	1.5	97.1	0.2	0.0	0.3	0.0
	(2.9)	(2.4)	(4.4)	(1.3)	(0.0)	(1.1)	(0.0)
24	5.4	1.7	92.3	0.4	0.0	0.2	0.0
	(10.3)	(3.1)	(11.5)	(2.5)	(0.0)	(2.4)	(0.0)

Table 7b. Forecast error decomposition for M1. Model SA.

Time	EXCH	M1(d)	TBI	CPI(d)	FOPI(d)	FIPI(d)	EXPORT(d)
1	0.2	99.8	0.0	0.0	0.0	0.0	0.0
	(0.2)	(1.0)	(0.0)	(1.0)	(0.0)	(0.0)	(0.0)
3	31.1	57.9	9.3	0.5	0.0	1.2	0.0
	(8.3)	(6.7)	(5.1)	(1.1)	(0.0)	(1.2)	(0.0)
6	38.6	46.8	8.9	3.4	0.0	2.3	0.0
	(7.5)	(6.2)	(4.6)	(2.2)	(0.0)	(1.6)	(0.0)
12	36.9	40.0	16.5	3.7	0.0	2.9	0.0
	(7.0)	(5.5)	(5.8)	(2.0)	(0.0)	(1.6)	(0.0)
24	36.7	38.9	17.1	3.8	0.0	3.5	0.0
	(6.9)	(5.4)	(5.7)	(1.9)	(0.0)	(1.8)	(0.0)

Table 7c. Forecast error decomposition for TBI. Model SA.

Time	EXCH	M1(d)	TBI	CPI(d)	FOPI(d)	FIPI(d)	EXPORT(d)
1	100.0	0.0	0.0	0.0	0.0	0.0	0.0
	(0.3)	(0.3)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)
3	97.1	1.2	0.2	0.1	0.0	1.4	0.0
	(2.0)	(1.3)	(0.8)	(0.4)	(0.0)	(0.9)	(0.0)
6	88.9	2.2	0.1	0.5	0.0	8.2	0.0
	(5.5)	(2.3)	(1.5)	(1.0)	(0.0)	(4.2)	(0.0)
12	76.1	2.8	1.9	2.5	0.1	16.7	0.0
	(9.0)	(2.8)	(4.6)	(3.4)	(0.1)	(7.7)	(0.0)
24	60.2	3.2	1.8	5.8	0.1	29.0	0.0
	(11.8)	(3.3)	(6.9)	(5.5)	(0.1)	(10.3)	(0.0)

Table 7d. Forecast error decomposition for CPI. Model SA.

Time	EXCH	M1(d)	TBI	CPI(d)	FOPI(d)	FIPI(d)	EXPORT(d)
1	5.4	0.0	1.1	92.0	0.0	1.6	0.0
	(5.3)	(0.8)	(3.3)	(6.6)	(0.0)	(1.7)	(0.0)
3	10.0	0.3	2.0	82.5	0.0	5.1	0.0
	(6.8)	(1.0)	(4.4)	(7.7)	(0.0)	(2.3)	(0.0)
6	9.9	2.6	4.1	73.8	0.0	9.5	0.0
	(6.8)	(1.7)	(4.7)	(7.1)	(0.0)	(3.3)	(0.0)
12	11.2	3.5	4.4	68.8	0.0	12.2	0.0
	(6.4)	(2.0)	(5.0)	(6.5)	(0.0)	(3.8)	(0.0)
24	10.7	3.8	4.2	62.1	0.1	19.2	0.0
	(6.8)	(2.3)	(5.3)	(6.9)	(0.0)	(5.8)	(0.0)

Table 7e. Forecast error decomposition for FOPI. Model SA.

Time	EXCH	M1(d)	TBI	CPI(d)	FOPI(d)	FIPI(d)	EXPORT(d)
1	30.0	0.0	40.5	0.1	9.7	19.7	0.0
	(22.5)	(0.1)	(22.5)	(0.5)	(8.2)	(20.9)	(0.0)
3	22.0	0.3	55.8	0.3	2.7	18.8	0.0
	(12.3)	(1.9)	(13.4)	(3.0)	(1.0)	(11.2)	(0.0)
6	43.6	0.9	40.7	1.3	1.6	11.9	0.0
	(11.4)	(2.2)	(12.2)	(2.7)	(0.4)	(5.8)	(0.0)
12	48.6	1.5	36.0	2.2	1.4	10.3	0.0
	(10.0)	(2.3)	(10.3)	(2.8)	(0.3)	(4.6)	(0.0)
24	48.3	1.9	36.1	2.3	1.3	10.1	0.0
	(9.7)	(2.3)	(9.6)	(2.6)	(0.3)	(4.2)	(0.0)

Table 7f. Forecast error decomposition for FIPI. Model SA.

Time	EXCH	M1(d)	TBI	CPI(d)	FOPI(d)	FIPI(d)	EXPORT(d)
1	21.5	0.0	0.2	0.8	0.0	77.6	0.0
	(8.3)	(0.1)	(0.2)	(1.1)	(0.0)	(8.0)	(0.0)
3	8.2	0.4	14.1	4.9	0.0	72.4	0.0
	(4.3)	(0.4)	(6.8)	(3.1)	(0.0)	(6.9)	(0.0)
6	21.0	2.0	20.4	4.3	0.1	52.3	0.0
	(8.5)	(1.6)	(8.9)	(3.7)	(0.1)	(9.6)	(0.0)
12	31.6	1.7	17.8	4.8	0.1	43.9	0.0
	(9.9)	(1.5)	(7.6)	(3.5)	(0.1)	(8.8)	(0.0)
24	33.4	2.0	20.6	4.6	0.1	39.3	0.0
	(10.4)	(1.7)	(8.3)	(3.4)	(0.1)	(8.2)	(0.0)

Table 7g. Forecast error decomposition for EXPORT. Model SA.

Time	EXCH	M1(d)	TBI	CPI(d)	FOPI(d)	FIPI(d)	EXPORT(d)
1	96.6	0.0	0.9	0.0	0.2	0.7	1.6
	(26.2)	(0.3)	(8.3)	(0.6)	(2.0)	(19.6)	(7.7)
3	69.5	6.5	13.7	5.9	0.3	3.4	0.8
	(20.1)	(8.8)	(14.1)	(9.6)	(0.4)	(8.8)	(0.3)
6	60.9	4.4	22.7	5.0	0.2	6.5	0.4
	(14.3)	(6.0)	(12.1)	(6.0)	(0.2)	(6.0)	(0.1)
12	56.7	6.6	19.5	7.9	0.2	8.7	0.3
	(12.1)	(5.5)	(10.3)	(4.9)	(0.1)	(5.4)	(0.1)
24	55.8	6.7	19.9	8.2	0.2	8.8	0.3
	(11.7)	(5.1)	(10.0)	(4.7)	(0.1)	(5.0)	(0.1)

Figure 6. Forecast error variance decompositions for Model RA

g) Agricultural exports (d)

Figure: FEV Decomposition vs Time (months), with legend: CS/US$, M1 (d), T-Bill rate, CPI (d), FOPI (d), FIPI (d), Ag Exports (d)
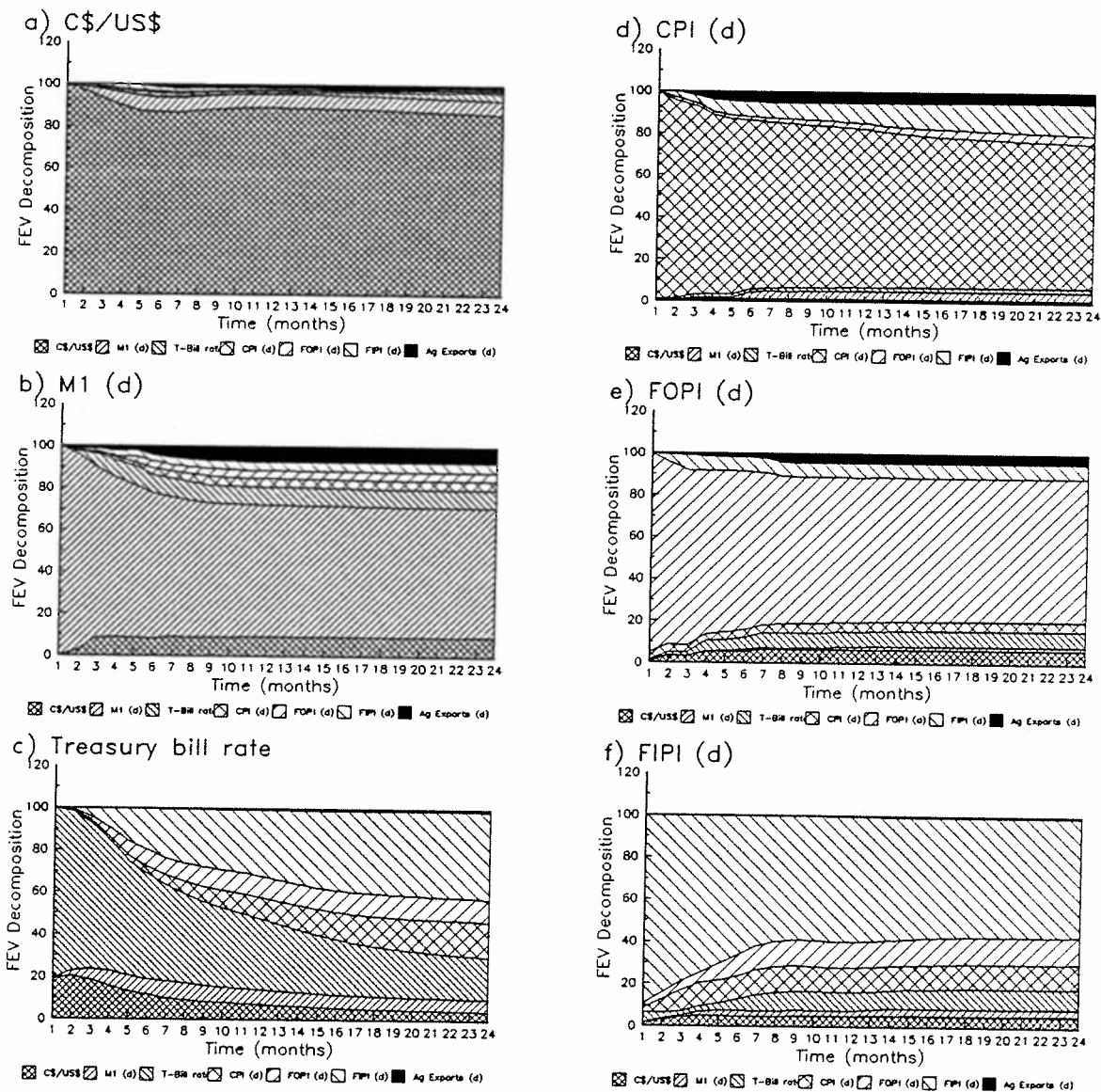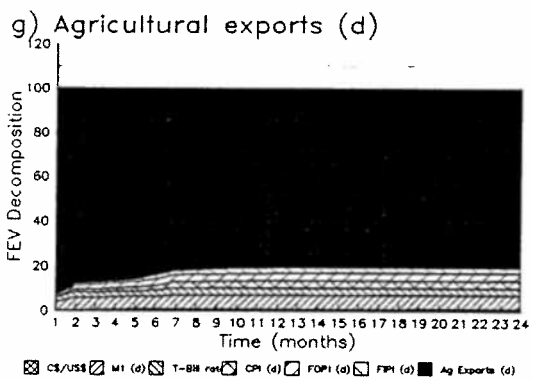
Figure 7. Forecast error variance decompositions for Model RB

a) C$/US$

b) M1 (d)

c) Treasury bill rate

d) CPI (d)

e) FOPI (d)

f) FIPI (d)

40
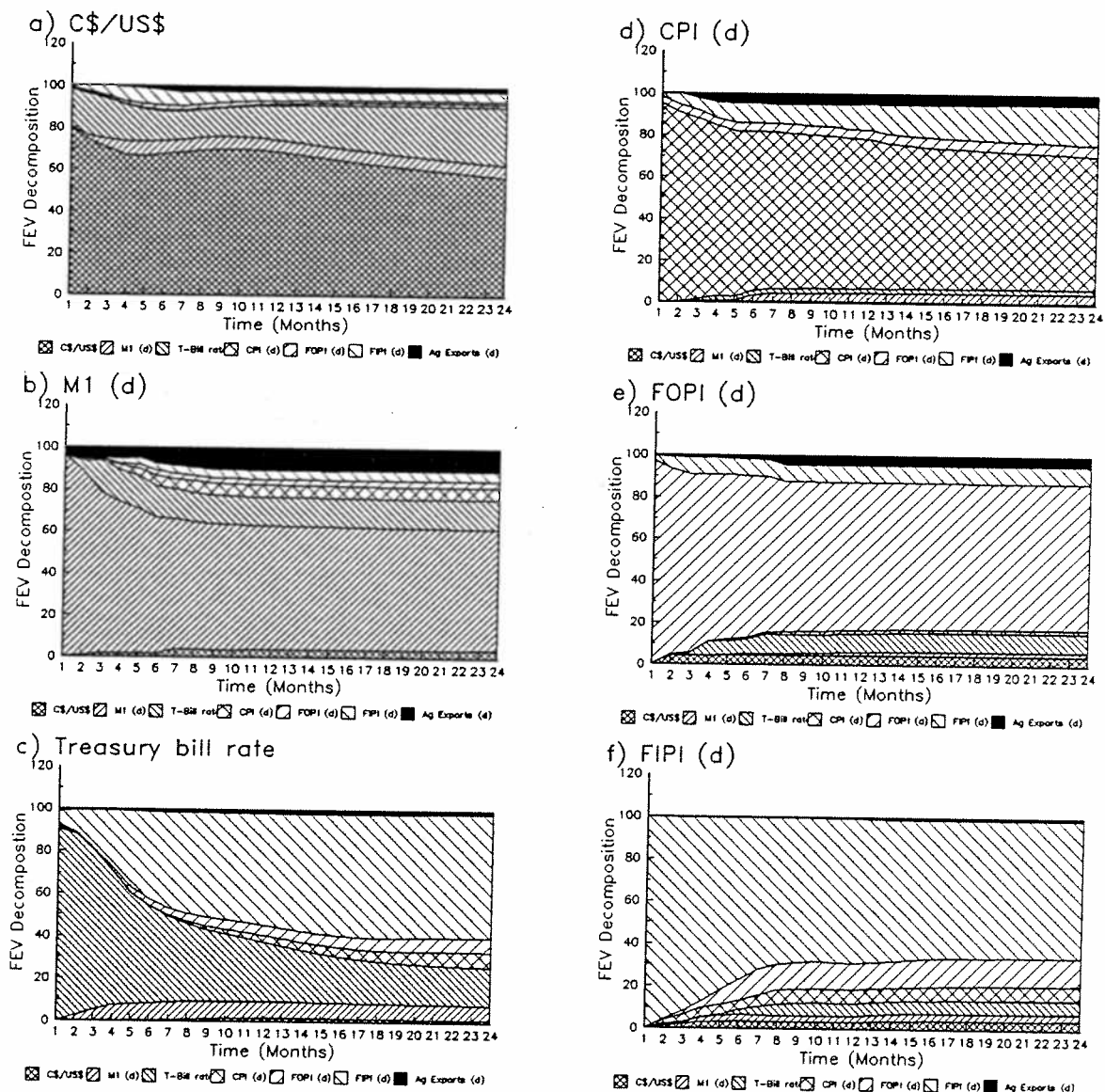
g) Agricultural Exports (d)
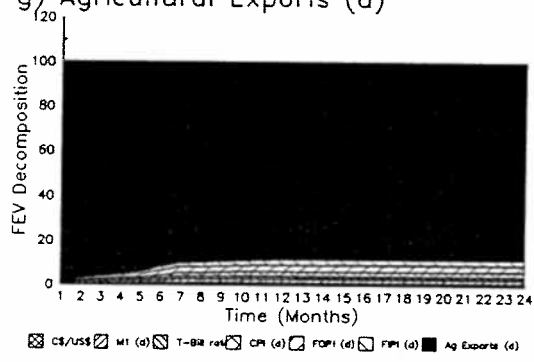
Figure 8. Forecast error variance decompositions for Model SA

a) C$/US$

b) M1 (d)

c) Treasury bill rate

d) CPI (d)

e) FOPI (d)

f) FIPI (d)
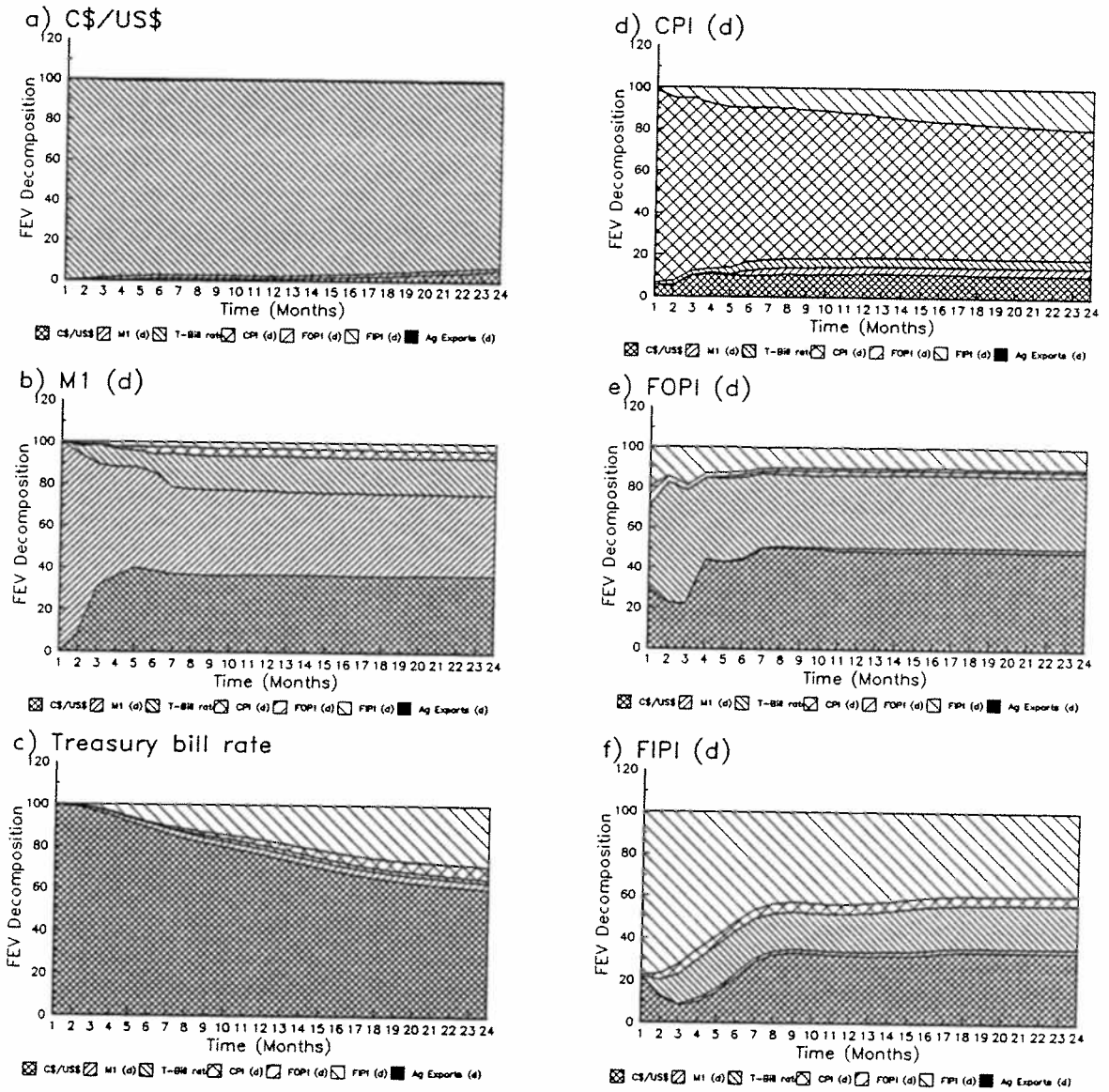
g) Agricultural exports (d)
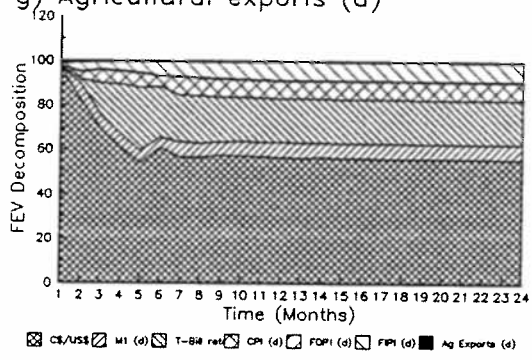
Figure 9. Forecast error variance decompositions for Model SB

a) C$/US$

b) M1 (d)

c) Treasury bill rate

d) CPI (d)

e) FOPI (d)

f) FIPI (d)
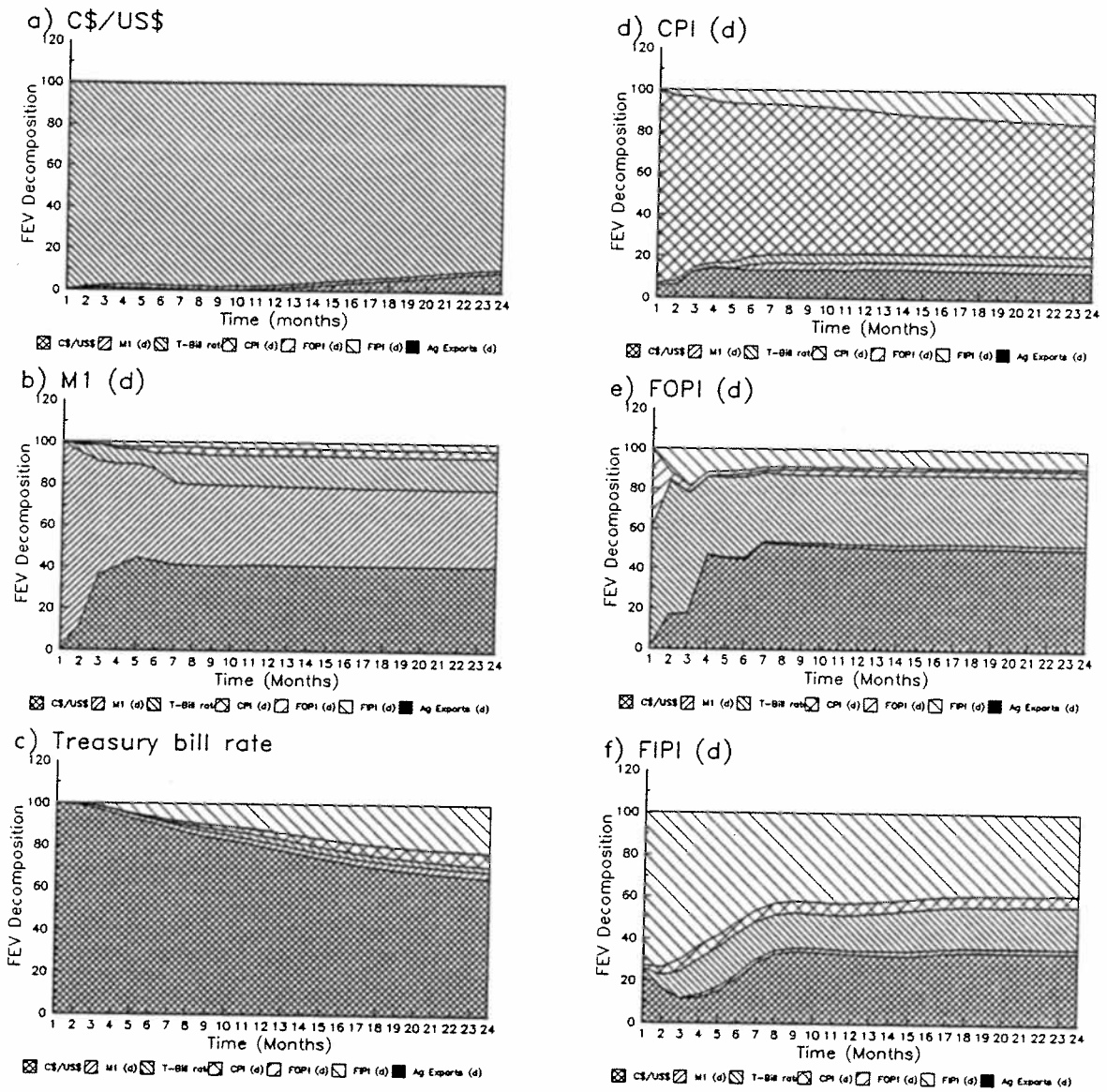
g) Agricultural exports (d)
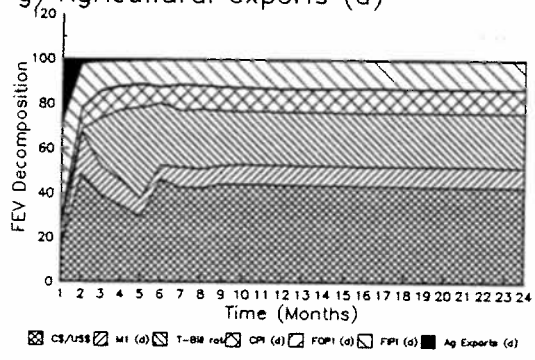
E VAR Models Conclusions

Two types of conclusions arise from this portion of the study. The first type relates to the more technical aspects of identification in VAR models and dramatic difference between structural and non-structural VARs. The second category of conclusions is the empirical evidence on macroeconomic effects on agriculture.

Turning to the more technical conclusions first, the use of non-recursive identification structures in a VAR framework allows modeling without the imposition of the rather tenuous assumption of recursive ordering. Most VAR models use the recursive model assumption and examine the effect of changing the recursive order as a method of investigating the robustness of the model. Our results suggest that the recursive model produces results that are strikingly different from those of non-recursive structures, even in cases where the recursive model is robust over alternate orderings. The major difference between the non-recursive models and their recursive counterparts is the lack of interaction between variables (or structural equations) in the recursive VAR. The structural VAR produces a very different set of results which downplay own effects and emphasize interactions. Although we have only shown a large qualitative difference between alternative identification structures for one particular data series, it should lead one to question the inferences from recursive models. The emphasis on own effects produces a very different view of the world.

The view of the macroeconomy-agriculture work provided by the two non-recursive models we present suggests a pattern that is quite different from those found in the current VAR literature on macro-ag interactions. In many respects, the results are more similar to those produced by traditional structural models. Three issues emerge.

First, macroeconomic influences on agricultural output prices are relatively large. Exchange rate and interest rate influences appear larger than input price or output price effects. However, the macroeconomic impacts on the agricultural economy appear to be more variable than the impacts of macroeconomic variables on themselves. The "macro-ag" linkage seems to be weaker than the linkage between macroeconomic factors. Also, the forecast error decompositions of all factors affecting FOPI have relatively high standard errors.

Second, the impact of macroeconomic factors on agricultural input prices is evident but less dominant than the effects on output prices. Input prices are also affected by exchange rates and interest rates although the impact of these variables on FIPI is smaller than their effect on FOPI. Our results suggest, however, that the impact of these two macroeconomic factors on input prices is more certain (lower relative standard errors) than is the impact on output prices. The relationship between these two price effects somewhat confirms the findings of Carter *et al.* (1990). Both input and output prices are affected by macroeconomic factors: the exchange rate and interest rate, in particular.

Finally, agricultural exports are significantly affected by exchange rate and interest rate fluctuations. The difference between the recursive and non-recursive models could not be more conspicuous on this point. While this result will not be surprising to most structural modelers, this finding is considerably different from many results presented by the proponents of VAR modeling. In contrast to Bessler and Babula (1987) perhaps exchange rates do matter.

V Conclusions

There are a number of significant conclusions from the empirical analysis performed in this study. First, there appear to be significant macroeconomic impacts on the Canadian agricultural sector. Other studies of macroeconomic-sectoral linkage have found limited impact of macroeconomic factors. This study, however, using a relatively new methodology, has discovered a stronger integration. The strongest linkage appears to be between interest and exchange rates and agricultural output prices. There is little impact from inflation directly. Such a result is not surprising given the international nature of Canadian agriculture. Input prices, however, do not appear to be as significantly affected by macroeconomic shocks. Such a result may be interpreted as further evidence of the "fixed-price flex-price" phenomenon. The fixed-price good in this case is the set of agricultural inputs. These inputs are typically manufactured goods and may be insulated from price shocks because of their durable nature and the more oligopolistic structure of markets. Agricultural goods, however, may be flex-price goods and as such are susceptible to more variable fluctuations in price levels. The fact that macroeconomic effects on output prices are significant, and more variable, than input prices may be interpreted as further evidence of the fixed-price flex-price phenomenon.

There are a number of limitations in this study. First, the models used aggregate over commodities and regions. There may be commodity specific reactions to macroeconomic effects as well as regional specific reactions. In particular, it may be interesting to examine the macroeconomic impacts on commodities with different levels of "insulation" from world markets. Commodities which are associated with supply control marketing boards, for example, may react differently to changes in macroeconomic conditions than will those commodities with no marketing boards. These are areas for future research. Second, there is no integration of external policies (US export enhancement programs, EC policy regimes) with the current model. Incorporating these policy rules in the econometric analysis will be a challenging extension of this area of research.

The methods used in this study are relatively new and they provide a flexible approach to modeling economic time series. It is apparent that the "identification conditions" assumed by the researcher significantly affect the empirical results. In this study we have modified existing techniques to provide more plausible identification restrictions on the model. The results indicate that the agricultural sector, in particular agricultural output prices, are sensitive to exchange rate and interest rate variation. Moreover, there is considerable variation in these impacts relative to impacts on input

prices. The techniques used here may be applied in future research to investigate the impact of macroeconomic variables on specific commodities and on regions of the country. The primary conclusion revealed in this analysis is that Canadian macroeconomic policy can have major impacts on the agricultural sector. Macroeconomic policy analysts should be sensitive to these impacts. Further, agricultural producers may benefit from monitoring macroeconomic variables for the potential effects these may have on output prices.

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Appendix A

Tabular Analysis of the Estimation of Terms of Trade for Agriculture in Canada

TABLE 8.

INDICES OF OUTPUT AND INPUT PRICES AND OF TERMS OF TRADE IN THE CANADIAN FARM SECTOR:1971-1989

YEAR	OUTPUT PRICE INDEX	INPUT PRICE INDEX	TERMS OF TRADE INDEX
1971	33.56	34.21	98.11
1972	38.11	36.23	105.17
1973	55.05	43.29	127.17
1974	65.65	50.51	129.96
1975	66.37	55.56	119.44
1976	65.25	59.11	110.38
1977	63.62	61.57	103.34
1978	73.05	68.82	106.15
1979	85.86	80.35	106.87
1980	92.91	88.07	105.50
1981	100.00	100.00	100.00
1982	99.35	103.18	96.28
1983	98.80	103.93	95.06
1984	103.45	106.58	97.07
1985	97.29	106.55	91.31
1986	93.25	108.45	85.98
1987	92.43	110.08	83.96
1988	96.84	113.25	85.51
1989	100.23	116.50	86.03

Annual Compound Growth Rates:

1971-1980	11.98	11.08	0.81
1981-1989	0.03	1.93	-1.86
1971-1989	6.27	7.04	-0.73

TABLE 9.

INDICES OF OUTPUT AND INPUT PRICES AND OF TERMS OF TRADE IN THE CANADIAN GRAIN SECTOR:1971-1984

YEAR	OUTPUT PRICE INDEX	INPUT PRICE INDEX	TERMS OF TRADE INDEX
1971	29.29	29.4	99.63
1972	44.70	29.4	152.04
1973	96.25	35.0	275.00
1974	91.72	61.0	150.36
1975	81.91	76.6	106.93
1976	68.00	68.9	98.69
1977	64.53	65.4	98.67
1978	77.43	64.5	120.05
1979	94.30	65.1	144.85
1980	111.01	87.0	127.60
1981	100.00	100.0	100.00
1982	88.89	102.0	87.15
1983	99.79	99.0	100.80
1984	97.81	102.0	95.89

Annual Compound Growth Rates:

1971-1980	15.96	12.81	2.79
1981-1984	-0.73	0.66	-1.39
1971-1984	9.72	10.04	-0.29

TABLE 10.

INDICES OF OUTPUT AND INPUT PRICES AND OF TERMS OF TRADE IN THE CANADIAN

BEEF SECTOR:1971-1985

YEAR	OUTPUT PRICE INDEX	INPUT PRICE INDEX	TERMS OF TRADE INDEX
1971	49.17	42.8	114.89
1972	55.02	48.9	112.52
1973	65.83	64.4	102.22
1974	60.84	56.9	106.92
1975	48.23	46.6	103.50
1976	47.89	49.1	97.53
1977	50.69	54.1	93.69
1978	78.64	84.8	92.74
1979	112.25	120.6	93.08
1980	105.12	110.8	94.87
1981	100.00	100.0	100.00
1982	93.91	99.8	94.10
1983	95.63	103.0	92.85
1984	100.00	105.7	94.61
1985	97.08	107.4	90.39

Annual Compound Growth Rates:

1971-1980	8.81	11.15	-2.10
1981-1985	-0.74	1.80	-2.49
1971-1985	4.98	6.79	-1.70

TABLE 11.

INDICES OF OUTPUT AND INPUT PRICES AND OF TERMS OF TRADE IN THE CANADIAN
HOG SECTOR:1975-1985

YEAR	OUTPUT PRICE INDEX	INPUT PRICE INDEX	TERMS OF TRADE INDEX
1975	94.44	98.3	96.07
1976	90.05	101.1	89.07
1977	81.62	92.3	88.43
1978	100.22	113.1	88.61
1979	94.30	104.2	90.50
1980	84.14	82.1	102.49
1981	100.00	100.0	100.00
1982	119.97	123.0	97.53
1983	101.94	107.4	94.91
1984	103.16	99.1	104.09
1985	97.50	96.7	100.83
Annual Compound Growth Rates:			
1975-1980	-2.28	-3.54	1.30
1981-1985	-0.63	-0.83	0.21
1975-1985	0.32	-0.16	0.48

TABLE 12.

INDICES OF OUTPUT AND INPUT PRICES AND OF TERMS OF TRADE IN THE CANADIAN
CHICKEN SECTOR:1971-1985

YEAR	OUTPUT PRICE INDEX	INPUT PRICE INDEX	TERMS OF TRADE INDEX
1971	41.28	49.8	82.90
1972	44.69	50.2	89.02
1973	61.52	57.0	107.94
1974	69.94	62.1	112.62
1975	70.94	66.1	107.33
1976	71.34	69.3	102.95
1977	71.54	70.4	101.62
1978	75.55	75.0	100.73
1979	81.56	79.6	102.47
1980	85.77	83.9	102.23
1981	100.00	100.0	100.00
1982	221.24	107.7	205.42
1983	219.24	109.2	200.77
1984	239.88	121.0	198.25
1985	221.44	124.0	178.58
Annual Compound Growth Rates:			
1971-1980	8.46	5.97	2.35
1981-1985	21.99	5.52	15.60
1971-1985	12.75	6.73	5.63

Appendix B

Test of the Homogeneity Property in the Demand for Beef, Pork and Chicken

In this appendix two functional forms for food commodity demand equations are examined for their consistency with the homogeneity property. This property, based on economic theory, suggests that if prices and income rise by the same amount, consumers choices of products are unaffected. This property is also called a "no money illusion" property. The relationship between homogeneity and macroeconomic impacts on agricultural prices is that if there is money illusion, the demand for agricultural products will be significantly affected by inflation. Any type of macroeconomic shock which gives rise to inflation (increases in the money supply for example) will have an impact on the demand for products.

A Double-Logarithmic Function

A double-logarithmic function which is presented in equation (1) is used to test the presence of homogeneity (or no money illusion) in the demand function of beef, pork and chicken.

$$(1) \qquad lnQ_i = \beta_0 + \sum_i \beta_i lnP_i + \beta_y lnY + u$$

where Q_i = Per capita consumption of the i-th commodity,

P_i = Consumer price of the i-th commodity,

Y = Per capita personal disposable income,

u = error term, and

i = Beef, pork and chicken.

Data on consumer prices, per capita consumption and per capita personal disposable income were obtained from the **Handbook of Food Expenditures, Prices and Consumption, 1990,** which is published by Agriculture Canada. The published data on per capita consumption and per capita disposable income which were in kilograms and current dollars were converted into index series by considering the value in 1986 as 100. Moreover, data on the consumer prices of pork were not available for the period of 1971 to 1978. Therefore, the data for that period were extrapolated using data from the period of 1979 to 1989. Indices of the consumer prices and per capita consumption of beef, pork and chicken and the index of the per capita disposable income are presented in Table 13.

TABLE 13.

INDICES OF CONSUMER PRICES AND PER CAPITA CONSUMPTION OF BEEF, PORK AND CHICKEN AND THE INDEX OF PER CAPITA DISPOSABLE INCOME: CANADA, 1971- 1989

Year	Consumer Price Index of			Per Capita Consumption Index of			Per Capita Income Index
	Beef	Pork	Chicken	Beef	Pork	Chicken	
1971	30.40	41.40	27.20	101.65	111.76	64.47	21.26
1972	33.20	43.80	31.20	108.25	107.91	67.89	24.03
1973	40.20	46.30	41.00	106.43	101.53	71.21	27.81
1974	44.30	49.00	46.40	110.53	105.73	68.03	32.33
1975	42.00	49.00	51.50	122.83	90.56	64.52	37.44
1976	39.30	54.70	51.30	129.99	95.39	71.40	41.82
1977	41.80	57.90	51.60	123.64	95.59	74.77	45.56
1978	61.10	61.20	59.90	115.74	97.43	77.94	50.85
1979	80.30	63.70	66.00	100.99	107.81	86.09	56.80
1980	87.20	62.20	71.00	100.05	114.95	83.89	63.52
1981	89.50	72.30	84.50	102.78	110.17	83.16	73.22
1982	88.90	85.30	86.70	102.10	100.97	84.38	80.19
1983	89.50	84.30	89.90	101.70	104.30	84.48	83.50
1984	95.50	83.90	95.80	97.17	101.35	89.31	90.17
1985	97.90	86.10	91.80	98.56	103.19	96.73	95.76
1986	100.00	100.00	100.00	100.00	100.00	100.00	100.0
1987	109.10	108.90	106.10	96.61	99.48	105.81	106.07
1988	110.80	103.60	107.60	96.91	101.60	110.79	114.76
1989	113.20	105.30	120.00	95.04	101.80	107.66	124.93

The data in Table 13 were used to estimate demand equations (1) for beef, pork and chicken in order to test the homogeneity property of the demand function. The null hypothesis which is used to test the homogeneity property is formulated as:

$$(2) \qquad \sum_i \beta_i + \beta_y = 0$$

Results of the estimated demand equations and homogeneity tests are presented in Table 14. According to the estimated values of t and F of the homogeneity tests, the homogeneity property holds only in the case of the pork demand function. The property does not hold in the beef and chicken demand functions. In other words, money illusion appears to exist in the case of beef and chicken demand but not in pork demand.

However, the homogeneity tests under the single equation estimation method may not present a true picture regarding the presence of homogeneity in the demand equations because the single equation estimation methods do not take the correlation of the disturbances across equations into account. As a result, the method leads to estimates that are consistent but, in general, not asymptotically efficient. This problem is overcome in the system estimation method which allows one to estimate all equations of the system simultaneously or as seemingly unrelated regression equations. One of the most appropriate methods of estimating a system of seemingly unrelated regression equation is Zellner's estimation method. Therefore, the method is used below to estimate the system of share equations (3) to (5) in order to test the homogeneity property of the demand functions.

TABLE 14.
RESULTS OF THE ESTIMATED DEMAND EQUATIONS AND HOMOGENEITY TESTS

	Dependent Variable in the Demand Equation					
	Beef (n = 19)		Pork (n = 19)		Chicken (n = 19)	
Coefficients:						
β_0	5.918^{***}	(14.709)	4.956^{***}	(14.560)	2.819^{***}	(6.684)
β_b	-0.513^{***}	(-6.271)	0.402^{***}	(5.802)	0.239^{**}	(2.219)
β_p	-0.414^{***}	(-2.661)	-0.089	(-0.672)	0.286^{*}	(1.658)
β_c	0.385^{**}	(2.110)	-0.464^{***}	(-3.005)	-0.408^{**}	(-2.106)
β_y	0.253^{*}	(1.345)	0.076	(0.479)	0.271	$(1.489)^{*}$
Estimated Values of:						
R^2	0.85		0.73		0.96	
Adjusted R^2	0.80		0.65		0.95	
Durbin Watson	1.178		2.212		1.687	
Homogeneity Test Statistics:						
t with 14 df	-3.233^{***}		-0.982		4.059^{***}	
F with 1,14 df	10.452^{***}		0.964		16.479^{***}	

Figure in the parenthesis represents t-value.

*   Significant at 0.10 level ($t^{*}_{14} = 1.345$)

**   Significant at 0.05 level ($t^{*}_{14} = 1.761$, $F^{*}_{1}, 14 = 4.60$)

***   Significant at 0.01 level ($t^{*}_{14} = 2.624$, $F^{*}_{1}, 14 = 8.86$)

B A System of Share Equations

The homogeneity property of the demand functions of beef, pork and chicken is tested by using the set of share equations (3), (4) and (5).

(3) $S_1 = \beta_1 + \gamma_{11} lnP_1 + \gamma_{12} lnP_2 + \gamma_{13} lnP_3 + \alpha_1 lnY + \theta_1 T + u_1$

(4) $S_2 = \beta_2 + \gamma_{21} lnP_1 + \gamma_{22} lnP_2 + \gamma_{23} lnP_3 + \alpha_2 lnY + \theta_2 T + u_2$

(5) $S_3 = \beta_3 + \gamma_{31} lnP_1 + \gamma_{32} lnP_2 + \gamma_{33} lnP_3 + \alpha_3 lnY + \theta_3 T + u_3$

where number 1, 2 and 3 respectively represent beef, pork and chicken; S_i implies the share of the i-th commodity in total cost; Y and P_i are the indices respectively of per capita disposable income and prices of the i-th commodity; T is a time variable; and u is an error term.

In the estimation of the share equations, the adding-up condition which implies that the cost shares must be equal to one is imposed so that one of the share equations must be dropped in the estimation process in order to overcome the problem of over-identification in the model. The chicken share equation (5) is dropped from the estimation process and the remaining two share equations (3) and (4) are estimated as a system of seemingly unrelated regression equations.

While estimating the system of share equations, several statistical tests were carried out to detect problems of heteroskedasticity, autocorrelation and multicollinearity. The Breusch-Pagan (BP) test is used to detect heteroskedasticity in the system of share equations. The calculated BP test statistics are presented in Table 15 in which BP1 represents the BP test statistic when explanatory variables in share equations are in their original form such as in equations (3) to (5), whereas BP2 is the BP test statistic when explanatory variables in share equations are in their square form. The BP2 statistic is calculated as an alternative form of heteroskedasticity. The results presented in Table 15 indicate that heteroskedasticity does not exist in the system of share equations.

The Durbin-Watson (D-W) test statistic, presented in Table 16, indicates that autocorrelation exists only in the chicken share equation. However, the Durbin-Watson test is not an appropriate test, especially for testing higher order autocorrelation. Therefore, autocorrelation is further tested by using the Breusch-Godfrey (BG) test which is a general test and allows tests of autocorrelation of any order. The calculated BG test statistics presented in Table 17 confirm the absence of autocorrelation in the system of share equations of beef, pork and chicken.

TABLE 15.

RESULTS OF BREUSCH-PAGAN HETEROSKEDASTICITY TEST

Dependent Variable in Share Equations	Calculated Test Statistic		Degree of Freedom	Critical Value of Chi-square[1]	Presence of Heteroskedasticity
	BP1	BP2			
Share of Beef	1.019	1.140	5	15.086	No
Share of Pork	1.625	1.611	5	15.086	No
Share of Chicken	3.963	3.814	5	15.086	No

1. At one percent level of significance.

In addition to the heteroskedasticity and autocorrelation tests, collinearity tests were carried out to detect the presence of multicollinearity in the system of share equations. Collinearity is tested by using the correlation coefficient method and the auxiliary regression method. According to the coefficient of correlation method, an extremely high value of correlation coefficient between two individual variables implies the presence of collinearity between those two variables; whereas the collinearity problem under the auxiliary regression method is confirmed if the estimated value of R^2 is extremely high and the estimated value of F is greater than its critical value. Results of collinearity tests under the correlation coefficient method and the auxiliary regression method which are presented in Tables 18 and 19 respectively indicate collinearity in the system of share equations mainly between the chicken price and income variables. Collinearity can be addressed by dropping out the income variable in the system of share equations. The system of share equations without the income variable is estimated and then estimated parameters were used to test the homogeneity and symmetry restrictions in the system of share equations.

TABLE 16.

RESULTS OF DURBIN-WATSON AUTOCORRELATION TEST[1]

Dependent Variable in Share Equation	Calculated d^*	Critical Value at 0.01 Level				Presence of Autocorrelation
		d_L	d_U	$4\text{-}d_L$	$4\text{-}d_U$	
Share of Beef	1.586	0.561	1.767	3.439	2.233	No
Share of Pork	1.328	0.561	1.767	3.439	2.233	No
Share of Chicken	2.631	0.561	1.767	3.439	2.233	Yes

1. Test is inconclusive if $d_L < d^* < d_U$ or if $(4\text{-}d_U) < d^* < (4\text{-}d_L)$; whereas the null hypothesis of no autocorrelation is not rejected if $d_U < d^* < (4\text{-}d_U)$.

TABLE 17.

RESULTS OF BREUSCH-GODFREY AUTOCORRELATION TEST

Dependent Variable in Share Equations	Calculated Value of BG	Degree of Freedom	Critical Value of Chi-square[1]	Presence of Autocorrelation
First Order Autocorrelation Test:				
Share of Beef	0.489	1	6.635	No
Share of Pork	1.669	1	6.635	No
Share of Chicken	2.285	1	6.635	No
Second Order Autocorrelation Test:				
Share of Beef	0.986	2	9.210	No
Share of Pork	2.074	2	9.210	No
Share of Chicken	6.514	2	9.210	No
Third Order Autocorrelation Test:				
Share of Beef	1.008	3	11.345	No
Share of Pork	2.078	3	11.345	No
Share of Chicken	6.579	3	11.345	No
Fourth Order Autocorrelation Test:				
Share of Beef	4.520	4	13.277	No
Share of Pork	7.737	4	13.277	No
Share of Chicken	6.936	4	13.277	No

1. At one percent level of significance.

TABLE 18.

ESTIMATED VALUES OF CORRELATION COEFFICIENTS BETWEEN INPUT PRICES

Explanatory Variables in Share Equations	Correlation Coefficient	Presence of Collinearity
Beef Price and Pork Price	0.94	No
Beef Price and Chicken Price	0.96	No
Beef Price and Income	0.96	No
Pork Price and Chicken Price	0.96	No
Pork Price and Income	0.98	Yes
Chicken Price and Income	0.99	Yes

TABLE 19.

ESTIMATED VALUES OF R^2 AND F UNDER THE AUXILIARY REGRESSION METHOD

Dependent Variable in Regression Equation	Estimated Value		Critical Value[1] of $F_{3,15}$	Presence of Collinearity
	R^2	$F_{3,15}$		
Price of Beef	0.93	70.845	5.42	No
Price of Pork	0.96	126.907	5.42	No
Price of Chicken	0.98	326.575	5.42	Yes
Income	0.99	569.209	5.42	Yes

1. At one percent level of significance.

The homogeneity and symmetry restrictions are tested in this model by using the Likelihood Ratio (LR) test. According to the LR test, the LR-statistic which has a Chi-square distribution with p degrees of freedom is calculated as:

$$(6) \qquad LR = 2[lnL(\hat{\theta}_1) - lnL(\hat{\theta}_0)] \quad \sim \quad \chi_p^2$$

where $lnL(\hat{\theta}_1)$ and $lnL(\hat{\theta}_0)$ are the log likelihood values, respectively, in the unrestricted and restricted model and p is the number of restrictions imposed in the model. After dropping the share equation (5), the unrestricted model to be estimated as a system is represented by equations (3) and

(4), whereas the same model becomes restricted when the homogeneity and symmetry restriction shown in Table 20 are imposed into the system of share equations. The estimated LR-statistics presented in Table 14 indicate that the homogeneity and symmetry restrictions do hold in the system of share equations when these restrictions are tested individually, but they do not hold when they are tested jointly.

TABLE 20.

RESULTS OF LR TESTS RELATING TO HOMOGENEITY AND SYMMETRY RESTRICTIONS: WITHOUT INCOME VARIABLE IN THE SYSTEM OF SHARE EQUATIONS

Restrictions	Calculated LR Value	Degree of Freedom	Critical Value of Chi-square[1]	H_0: Restrictions Hold
Homogeneity Restrictions: $Y_{11} + Y_{12} + Y_{13} Y_{21} + Y_{22} + Y_{23}$	2.696	2	9.210	Accept
Symmetry Restrictions: $Y_{12} = Y_{21}$	6.760	1	6.635	Reject
Homogeneity and Symmetry Restrictions Imposed Jointly	49.286	3	11.345	Reject

1. At one percent level of significance.

The exclusion of the income variable in the system of equations may not provide a true test of money illusion in the demand functions. Therefore, the system of share equations was re-estimated including the income variable. Then, the estimated parameters were used to test homogeneity and symmetry restrictions in the system of share equations. Results of the test which are presented in Table 21 imply that the homogeneity restriction holds in the system of share equations when the restriction is tested individually, but it does not hold when it is tested jointly with the symmetry restriction. Moreover, the symmetry restriction does not hold whether the restriction is tested individually or jointly.

TABLE 21.

RESULTS OF LR TESTS RELATING TO HOMOGENEITY AND SYMMETRY RESTRICTIONS:

WITH INCOME VARIABLE IN THE SYSTEM OF SHARE EQUATIONS

Restrictions	Calculated LR Value	Degree of Freedom	Critical Value of Chi-square[1]	H_0: Restric- tions Hold
Homogeneity Restrictions: $\gamma_{11} + \gamma_{12} + \gamma_{13}\gamma_{21} + \gamma_{22} + \gamma_{23}$	2.026	2	9.210	Accept
Symmetry Restrictions: $\gamma_{12} = \gamma_{21}$	12.670	1	6.635	Reject
Homogeneity and Symmetry Restrictions Imposed Jointly	21.370	3	11.345	Reject

1. At one percent level of significance.

Summarizing this section of the study, there appears to be little evidence of money illusion operating in the beef, chicken and pork markets. This result leads us to consider other traditional economic factors in the analysis of macroeconomic impacts, namely demand and supply shifts, exports and imports and the influence of exchange rates, interest rates and price levels on the these markets.

Appendix C

Description of Data Used in the VAR Analysis

APPENDIX: DATA SOURCES AND DESCRIPTION

EXCH	The exchange rate between Canadian and U.S. currency (expressed as Canadian dollars/U.S. dollar). Noon spot rate. Unadjusted. CANSIM series number B 3400.
M1	Canadian money supply (billions of dollars). Currency and demand deposits (M1) less dollar float (cheques and other items in transit). Seasonally adjusted. CANSIM series number B 1627.
TBI	Interest rate on Canadian 91 day treasury bills. CANSIM series number B 14001.
CPI	Consumer price index (1981=100) used as a measure of general price level. CANSIM series number D 484000.
FOPI	Total farm output price index (1981=100). From Statistics Canada catalogue 62-003.
FIPI	Total farm input price index (1981=100). CANSIM series number D 600000.
EXPORT	The value of exports (thousands of dollars) of wheat, barley, other cereal grains, oilseeds, and live animals (CANSIM series numbers D 402128, D 402119, D 402116, D 402053, and D 402053, respectively). The values in these series were added in order to provide a measure of agricultural exports.