THE UNIVERSITY OF CALGARY

THE EX ANTE REAL INTEREST RATE IMPLICATIONS OF FOREIGN EXCHANGE MARKET INTERVENTION: EVIDENCE FROM A VECTOR AUTOREGRESSION

by

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies for acceptance, a thesis entitled "The Ex Ante Real Interest Rate Implications of Foreign Exchange Market Intervention: Evidence From a Vector Autoregression," submitted by David Fife Peever in partial fulfillment of the requirements for the degree of Master of Arts.

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Abstract

This thesis investigates the premise that policy measures designed to influence movements in the foreign exchange value of the Canadian dollar can also influence the domestic ex ante real rate of interest. The premise is founded on three assumptions: a) to the extent that currency depreciation is related to domestic price inflation, causality runs from inflation to depreciation; b) the monetary authorities resist currency depreciation in part by increasing domestic nominal interest rates in order to encourage capital flows; c) ceteris paribus, agents do not revise upward their estimates of future price inflation. As a consequence, the expected real interest rate rises.

In the discussion of both economic theory and results obtained by other researchers, an equilibrium macroeconomic approach to the real interest rate parity theorem is emphasized. In this context, movements in the real interest rate attributable to policy measures are termed distortions, in that the real interest rate is displaced from its equilibrium value. Empirical testing for the existence of distortions is two-part. First, a time series of inflation expectations is estimated for both Canada and the United States, and used to derive values of the ex ante real interest rate for both countries. In the second step, a six variable vector autoregression is estimated. Included are the nominal and real interest rates for Canada and the United States, as well as the exchange rate and official Canadian reserves of U.S. dollars. The results are presented in an "innovation accounting" framework. The conclusion reached is that the data are indeed consistent with the hypothesis that policy measures can influence the ex ante real interest rate.

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Dedication

For Mom. I couldn't have done it without you.

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Chapter One

I) Introduction

The ex ante real rate of interest plays an important role in neo-classical economic theory. Through its intimate relationship with investment, changes in the real interest rate can be expected to strongly influence income and employment. A significant body of economic theory holds that, except for periods of very short duration, monetary policy cannot impact upon real variables. That position is a logical implication of the classical dichotomy which implies that nominal policy instruments impact directly only upon nominal magnitudes. An alternative hypothesis is that rigidities within the Canadian economy are such that the "short run", during which the classical dichotomy may not hold, is sufficiently long for policy to have a significant real impact. Under the latter hypothesis, the specific question the present research will seek to address is whether the central bank, by manipulating the nominal interest rate for the purposes of influencing nominal exchange rate movements, can also manipulate the ex ante real rate of interest. Are empirical movements in real rates correlated with exchange rate movements and intervention activity?

The remainder of this chapter will describe the economic environment within which recent Canadian economic policy has been formulated. In that context, the theoretical justification for the expectation of a policy impact on the real interest rate will be outlined.

II) The Policy Environment

Perhaps the most pervasive policy concern since the early 1970s has been that of inflation. As an indication of how volatile the price level has been, consider the following: for the twelve months prior to December 31, 1970, the Consumer Price Index (C.P.I.) rose 1.46% [1]. The corresponding number for 1974 was 10.97%. For the year ending July 31, 1981, the inflation rate was 11.41%.

It has frequently been argued that much of the responsibility for Canada's poor price performance prior to 1982 lay with the growth of the nominal money stock. The M1 aggregate grew by 15% in the twelve months prior to December 31, 1971. Annualized M1 growth exceeded 10% for every month between April 1971 and January 1974. The increase from December 1974 to November 1975 was an impressive 19.24%. The response of the central bank to the resulting inflationary environment was the institution of a policy of "Monetary Gradualism" in 1975.

The essential theoretical justification for Monetary Gradualism as a means of reducing price inflation is the Quantity Theory of Money. The Quantity Theory indicates that, given stable velocity of circulation, monetary growth in excess of real output growth yields inflation. Hence Monetary Gradualism was a policy of manipulating short term interest rates and thereby restricting the growth of the M1 aggregate to certain

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[1] All statistics quoted in this chapter are derived from the Cansim University Base.

target ranges[2]. The bounds of the target ranges were gradually reduced, in an attempt to minimize the costs of the transition to lower inflation.

An important requirement for the effectiveness of such a policy is a stable money demand function. The velocity of M1 proved unstable, however, due perhaps to technological innovation in the financial sector, or perhaps to agents responding rationally to the announced policy. The velocity shocks meant that the specified target ranges were inappropriate, and their attainment irrelevant to the goal of reducing inflation. In any event, Monetary Gradualism was abandoned not so much because it had failed as that it precluded foreign exchange market intervention.

The well known principle of pairing targets with instruments dictates that a central bank can control only one of the nominal interest rate, the nominal exchange rate or the nominal money supply. By targeting the money stock, the bank had to be content to let the market determine the exchange rate. Until 1978, events in the rest of the world were apparently such that the interest rate could be set without significant exchange rate repercussions. In 1978, however, the Canadian dollar began to encounter significant depreciation pressure.

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[2] It was by no means a foregone conclusion that control over M1 via short-term interest rate manipulation was the optimal policy. Considerable discussion centred upon the choice of target (M1 or a broader aggregate) as well as the choice of instrument (interest rate manipulation or active control of the monetary base). See, for example, Courchene et. al. "Monetary Policy in Canada: a Symposium", Canadian Journal of Economics. XII No. 4, November 1979, pp. 590-646.

For much of 1977, the exchange rate ($C/$1 U.S.) was below par[3]. By November 1978, the exchange value of the dollar had depreciated to almost $1.11. The Bank's response was to begin to intervene more actively to resist depreciation pressure. Although Gradualism was not officially abandoned until 1982, it has been argued that concern over the dollar led to de facto abandonment in 1978 or 1979[4].

With the advent of highly restrictive monetary policy in the United States, Canadian exchange rate intervention translated into importation of American monetary policy. The result was previously unheard of levels for nominal interest rates. In January 1979, the Bank Rate was 7.5%. One year later it was 11.25%. By August of 1982, the Bank Rate stood at 21.03%. Monetary growth, as defined by the M1 aggregate, fell accordingly. The conventional explanation for this decline is that the components of M1 are non-interest bearing. Higher nominal interest rates increase the opportunity cost of holding such assets, and thereby reduce demand. And, at any given moment, the

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[3] Discussion of exchange rates can be confusing, given the tendency of the media to quote the value of the Canadian dollar in terms of U.S. currency. In this, the popular usage, the exchange rate was above par for much of 1977, peaking at nearly $1.03 U.S. in July 1977, and falling to 90.16 cents U.S. in November 1978. The convention followed in this thesis shall be to cite the Canadian dollar price of foreign currency. Hence a depreciation of the Canadian dollar is equivalent to an increase in the exchange rate, and vice versa. Unless otherwise stated, discussion throughout will refer to the exchange rate vis-a-vis the U.S. dollar. This latter convention is in keeping with the apparent bias of policymakers, who arguably overemphasize the U.S. dollar rate given Canada's overall trade patterns.

[4] See Courchene, 1981, chapter 4.

supply of money is demand determined[5]. Hence, for example, in the twelve months prior to November 30, 1981, M1 fell by 7.47%.

These statistics help illustrate how markedly unstable the economic environment has been in recent years. Inflation is currently in the neighbourhood of 4 to 4.5%, which is considered a more reasonable level. The foreign exchange markets, however, have remained volatile. The central bank has therefore been careful to try to maintain what it believes to be a suitably large nominal interest rate differential vis-a-vis the United States.

To see how such a policy might affect the real interest rate, consider a scenario in which the exchange value of the Canadian dollar comes under depreciation pressure as a result of a recent history of higher inflation in Canada than in the United States. The monetary authorities are not prepared to allow a depreciation commensurate with the realized inflation differential. One method of countering an incipient depreciation is to attract short-term capital flows by offering a higher nominal interest rate. One means by which the Bank of Canada can raise short-term interest rates is to set chartered bank reserves at a sufficiently low level that financing is "tight". Alternatively, the authorities may use foreign currency reserves to purchase Canadian dollars in the foreign exchange market. Such a purchase ultimately has interest rate implications since, ceteris paribus, it represents a decrease in the rate of growth of the nominal money stock.

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[5] Courchene, 1979, p. 605.

In this context, consider Fisher's identity:

$$i_t = r_t + E_{t-1}(\pi_t)$$

where i_t is the nominal interest rate at time t,
r_t is the real interest rate, and
$E_{t-1}(\pi_t)$ is the expected rate of inflation.

The identity can be rewritten as :

$$r_t = i_t - E_{t-1}(\pi_t).$$

These identities show that, in calculating the real interest rate, it is future rather than past inflation which is relevant. An increase in the nominal interest rate designed to attract capital flows will, in the absence of any change in expected future inflation, raise the real interest rate. If, in the context of the above scenario, expected inflation is less than the past inflation which led to the depreciation pressure, intervention by the authorities distorts the real interest rate[6].

It is the objective of this thesis to determine whether the data are consistent with the hypothesized existence of such distortions. First, however, it is necessary to define a point of reference. In chapter two, the theoretical basis for the real interest parity theorem will be detailed.

Clearly, some method is required for estimating the expected rate of inflation. In chapter three, an autoregressive structure conditioned upon an information set will be described. The resulting estimates will be used to calculate the ex ante real rate of interest. A vector autoregressive system will then be constructed. This system will include

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[6] Distort in the sense that the real rate diverges from the real interest parity condition, discussed in chapter two.

Canadian and U.S. real and nominal interest rates, Canadian reserves of U.S. dollars, and the Canadian dollar price of U.S. currency. The results of the system, as shown by its response to imposed shocks, will then be discussed. In chapter four, conclusions and policy implications will be presented.

Chapter Two

I) Introduction

The objective of this chapter is to familiarize the reader with the theoretical framework, as well as the relevant literature, within which the question above is to be considered. The second section discusses in general terms the characteristics of "classical", or equilibrium macroeconomic models, as well as disequilibrium adjustment. Emphasis is on the role of the real interest rate in both a closed and open economy environment.

The third section provides a review of the relevant literature. Topics examined include the covered and uncovered interest parity theorems. Further, within the context of equilibrium macroeconomic analysis, the reasons for anticipating real interest rate parity between Canada and the United States are discussed. The section concludes with a discussion of the Dornbusch exchange rate model.

In the fourth and final section, the attitude of the Bank of Canada toward foreign exchange market intervention is outlined. The focal point of the discussion is the question of the causal relationship between exchange rate depreciation and inflation.

II) Equilibrium Macroeconomic Analysis and Disequilibrium Adjustment

A) General

What are commonly referred to as "classical" economic models may be more accurately termed "equilibrium" models. This form of analysis emphasizes what is usually called the long run - that is, the period after which all equilibrating adjustments have been achieved. Equilibrium-oriented analysts stress the strength and effectiveness of the self-correcting forces in a market economy.

Faith in the effectiveness of market adjustments is seen in the standard equilibrium assumption that markets clear. This is a short-hand expression for the paradigm attributed to Walras. Specifically, it is assumed that prices adjust infinitely quickly in order to eliminate excess demand or supply in any market, such that there are no "false trades". As quantity adjustment is relatively slower than price adjustment, it is considered to be unimportant. It is further assumed that no impediments to market clearing are present - that is, all prices are fully flexible both upward and downward.

A further defining characteristic of equilibrium analysis is the view of aggregate output and price determination. The level of real output is determined by the conditions of aggregate supply. In the short run, given a fixed capital stock, output is uniquely determined by equilibrium in the labour market. Demand for workers is a function of the marginal product of labour. Workers will be hired to the point where the real value of the marginal physical product equals the real

wage rate. Labour supply is a function of a trade-off between income and leisure. Incremental units of labour time will be supplied up to the point where the marginal utility of leisure equals the real wage rate. It is assumed that there exists, at least conceptually, an aggregate production function for the economy:

$$Y_t = f(K_t, L_t)$$

where Y_t is real output at time t,
K is the capital stock, and
L is the labour stock.

At any moment in time, the capital stock is assumed fixed, hence

$$Y_t = f(L_t \mid \bar{K}).$$

Real national output, then, is uniquely determined by the level of employment.

Since the assumption of perfect markets ensures that output will always tend toward its full employment level, aggregate demand has no role in output or real income determination in an equilibrium model. Rather, aggregate demand determines the price level, and thus the level of nominal income. In equilibrium, production provides sufficient income for agents to clear the output market (by Walras' law). Money has no Keynesian "speculative demand" role. Its purpose is solely to facilitate transactions so as to circumvent the inefficiency inherent in the required dual coincidence of wants under a barter system. Classical theory further assumes that agents will always prefer an asset yielding a positive return over one yielding no return. Given a constant price level, money by definition yields zero return; the holding of idle cash balances is therefore in contradiction to rational optimising behaviour. With a given velocity of circulation, the price level is the variable

which adjusts to equilibrate the existing nominal stock of money with transactions demand determined by the given level of output.

The response of a classical model to a shock to the nominal money supply is indicated by the Quantity Theory of Money. Humphrey[1] describes five major postulates upon which the Quantity theory rests. Briefly they are as follows. First, the price level varies in exact proportion to the nominal stock of money. Second, the direction of causation runs from the nominal money stock to the price level. Third, except for transitional adjustment periods, changes in the nominal money stock do not influence real economic variables. Fourth, the price level itself is influenced predominantly by changes in the quantity of money. Fifth, the nominal money stock is not demand determined, but rather is exogenous.

A variety of disequilibrium adjustment mechanisms can be inferred. Humphrey notes what he calls a "direct expenditure" and an "indirect interest rate" mechanism. The first describes the process by which real cash balances are raised above their predetermined desired level, leading to upward pressure on prices. The second describes a process by which the real interest rate is depressed, increasing investment.[2] However, the disequilibrium adjustment process is not an explicit component of the Quantity Theory. Rather, the Quantity Theory is a comparative statics proposition which indicates that a given percentage increase in the money stock will, ceteris paribus, result in a new

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1 Humphrey, 1974, pp. 1-5.

2 Ibid., p. 3.

equilibrium which differs only in that the price level is higher by the same given percentage.

B) The Role of the Interest Rate

Assume a constant price level, defined such that a change in a nominal magnitude is equivalent to a change in a real magnitude. Assume further, for the time being, that no changes are anticipated in the price level over the relevant period. A potential investor will undertake additions to his stock of capital to the point where the value of the marginal product of the capital purchased equals the marginal cost of the investment. An important element of the cost of his investment is the opportunity cost of the funds used. Given a well developed capital market, those funds could be used to purchase an interest bearing security. If the return on a security of risk equivalent to the intended investment exceeds the return anticipated for the investment, the proposed addition to the capital stock is not optimal. In the same manner, if the investment funds are to be borrowed, optimality requires the anticipated return on investment to equal or exceed the rate of interest on the loan. To the firm, then, the market rate of interest is one variable by which they must evaluate investment opportunities.

The source of funds for investment is foregone consumption from past periods, ie. saving. An agent will save in order to attain higher levels of consumption in the future. That is, saving behaviour is an intertemporal optimization process in which the agent seeks to maximize his utility, which is a function of consumption. It is assumed that a

given unit of consumption is valued more highly today than in the future, due to fundamental uncertainty. Funds saved must therefore earn a premium over the individual's rate of time preference, or his implicit discount rate. For any positive discount rate, a positive rate of interest must be offered; otherwise, the agent's future consumption opportunities cannot be enhanced. It is therefore assumed that savings respond positively to increases in the rate of interest.[3]

The role of the interest rate in an equilibrium model is thus to coordinate the intended actions of savers and investors. If the market rate is too low, the number of projects undertaken will exceed the equilibrium value. The demand for funds by investors will therefore exceed the supply of funds offered by savers. It will be in the interest of a given firm to continue to offer a higher premium on funds so long as a positive differential exists between the (disequilibrium) market interest rate and the expected yield of the prospective investment. This higher interest rate will call forth a greater abstention from current consumption, decreasing the excess demand for loanable funds. At the same time, as the market interest rate rises, fewer investment projects will be profitable, which also acts to decrease excess demand. Equilibrium is attained when, at the market rate of interest, savers are content to just supply the funds required by firms.

Conversely, if the initial interest rate is too high, few projects will be profitable, and demand for loanable funds will be relatively low.

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[3] Strictly speaking, this statement is not correct unless we further assume that the income effect does not outweigh the substitution effect, ie. what might be termed the non-perverse case.

The supply, however, will be relatively high. It will then be in the interest of some savers to offer their funds at a lower premium, so long as they continue to perceive an adequate enhancement of their consumption possibilities in the next period. This acts both to remove some funds from the market as the terms of the intertemporal trade-off worsen, and to stimulate demand for funds as more projects become profitable. In this manner, the market for loanable funds is cleared by a freely moving rate of interest. It is this equilibrium interest rate to which Wicksell referred as the "natural" rate[4].

At this point, it is useful to note the distinction between ex ante and ex post equality between savings and investment. Ex post equality is an accounting identity. It is a tautology by virtue of the methods of national income accounting[5]. What is of interest, and is the postulated role of the real interest rate in equilibrium macroeconomics, is the coordination of intended saving and investment. Economic decisions are assumed to depend upon what is expected to happen, in as much as agents are unable to influence history. Given the assumption of a constant price level, the importance of this distinction may not be clear. This assumption is therefore relaxed in the following example.

Assume that the market is in equilibrium with a 5% interest rate, and that over the next period no agent anticipates a change in the price level. At the beginning of the period, the money stock is unexpectedly increased by 5%. By the Quantity Theory, the price level at the end of the period will have risen by 5%. Agents who lent funds

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4 Ackley, p.149.

5 Ibid., p. 35.

to investors at the 5% nominal rate receive, at the end of the period, repayment which commands precisely the same quantity of real resources as could have been consumed at the beginning of the period. Savers expected to be able to command 5% more real resources, and thus provided the loanable funds. They in fact realized no increase, frustrating their intertemporal maximization process. If the money stock is expected to continue growing at 5% per period, savers will demand a higher nominal interest rate, in order to enhance their resource endowment over time. The size of the "inflation premium" can be computed using the Fisher identity:

$$[1+i_t] = [1+r_t][1+\{E_{t-1}(\pi_t)|I_{t-1}\}]$$

where i_t is the nominal interest rate at time t,
r is the required real return, and
$E_{t-1}(\pi_t)|I_{t-1}$ is the expected change in the price level conditioned on the information set available at time t-1.

(In chapter one, the Fisher identity was introduced omitting the second order term. Solving the equation above yields:

$$i_t = r_t + E_{t-1}(\pi_t)|I_{t-1} + r_t[E_{t-1}(\pi_t)|I_{t-1}].$$

In some cases, such of the German hyperinflation of the 1920s or contemporary Argentine experience, the second order term $r_t[E_{t-1}(\pi_t)|I_{t-1}]$ can be significant. Within the historical experience of both Canada and the United States however, the second order term has been relatively small. Henceforth, it will be disregarded.)

By the quantity theory, expected inflation is 5%. To earn the required real return of 5%, then, savers will demand a nominal return of 10.25%. Investors, who have the same information set, will be

prepared to pay this nominal rate since their receipts will increase by the rate of inflation, and they were prepared to pay a 5% real rate in the absence of inflation.

Clearly, information in this context is valuable. If the quantity of funds provided for saving is contingent upon a given expected real rate of return, it is optimal for the saver to acquire all information useful in determining the likelihood of attaining that return. More specifically, he will acquire information up to the point where the cost of incremental information equals the expected cost of incorrect/inaccurate expectations. Information is a scarce resource; the rational optimising agent will not waste it.

The above implies a particular method of expectation formation. For the purposes of this thesis, it will be assumed that agents understand the manner in which certain economic variables impinge upon the rate of inflation[6]. The assumption can be summarized as a form of the rational expectations hypothesis. This hypothesis asserts that the market's subjective probability distribution of any variable is identical to the objective probability distribution of that variable, conditional on all available past information[7]. In its least controversial form, the Rational Expectations Hypothesis states simply that agents will not be consistently incorrect in their predictions.

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6 These variables will be discussed in chapter three.

7 Mishkin, 1983, p. 9.

C) Extension to Open Economy and Exchange Rate Determination

A substantial portion of Canadian output is traded on world markets. Canadians are relatively free to purchase foreign financial instruments, as are foreigners in the market for Canadian securities. It is therefore necessary to consider the changes required to the framework when extending the model to include trade.

Consider first the rather idealized view of the nineteenth century industrializing world. Most countries followed the gold standard, under which any currency could be freely converted to its gold equivalent. Governments stood ready to back any such currency exchange at the announced parity, implicitly maintaining a fixed exchange rate regime. Under either full or fractional reserve banking, a given national money was a multiple of the stock of gold. An increase in foreign demand for domestic goods would cause an inflow of gold, and hence an increase in the money supply. This would then increase the relative price of domestic to foreign goods, thereby choking off the excess foreign demand. This is the familiar Price Specie Flow Mechanism. In the face of shifting trade flows, and given a fixed exchange rate, the domestic price level must adjust to return markets to equilibrium.

Given perfect national and international markets, equilibrium theory would imply that the value of a given good expressed in a common currency would be equal in all countries except for transportation costs. This is referred to as the law of one price. Extension of the 'law' to all goods is referred to as the Purchasing Power Parity theorem (PPP)[8]. Violation of PPP was expected to lead to

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[8] Roll, p. 135.

arbitrage, since failure to arbitrage a relative price differential would represent an unexploited opportunity for economic profit, and hence violate the assumption of rationality. It is of value to enumerate some of the specific assumptions involved in the "perfect markets" postulate. First, the goods in question must be homogeneous. Second, neither production nor consumption of the good can face differential taxation treatment in the two countries. Third, there must be neither export restrictions nor import quotas or tariffs on the good in question. Fourth, markets in both countries must be in equilibrium.[9] Finally, there must be no non-traded goods.

International goods market arbitrage requires the physical movement of commodities, and thus is by necessity an intertemporal process. An arbitraging agent will face several forms of risk. In the absence of a forward market, he faces exchange risk. While the good is in transit, an appreciation of the domestic currency or a devaluation of the export market currency will result in a lower return. Such risks need not necessarily be borne in the case of a financial asset, since its physical movement is not always necessary[10].

PPP implies a formula for the real exchange rate which can be expressed as:

$$\theta = eP^*/P$$

where θ is the real exchange rate,
e is the nominal exchange rate,
P^* is the foreign price level, and
P is the domestic price level.

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[9] Ibid.

[10] Ibid., p. 137.

PPP clearly has implications for nominal exchange rate determination. If markets behave in a manner such that deviations from PPP are expected to be quickly arbitraged, then assumptions about causality yield conclusions about exchange rate movements. If causality runs from prices to exchange rates, then inflation in the home country will imply depreciation, as will deflation abroad. Ceteris paribus, the nominal exchange rate will move to maintain the constancy of relative prices.

To this point, we have introduced the role of the real interest rate and the nominal exchange rate in a theoretical equilibrium macroeconomic environment. We now turn to the empirical research on related topics.

III) Review of Pertinent Literature

The purpose of this section is to establish a frame of reference with which to interpret the empirical results presented in chapter 3. We begin in section A with the relatively non-controversial theorem of covered interest rate parity. Next is discussed the relatively more stringent condition of uncovered interest parity. In section C, the real interest rate parity theorem is detailed. Finally, exchange rate determination is discussed. In this manner, the reader is shown the assumptions required to interpret movements in the ex ante real rate of interest as "distortions" from the real interest rate parity condition.

A) Covered Interest Arbitrage

In a situation where no impediments exist to flows of investment funds across borders, theory suggests that yields should be equalized. Assume a costless environment with perfectly elastic supplies of, and demand for, securities and foreign exchange. Assume further that an individual seeks to avoid exchange risk. With a well developed forward market, the individual seeking to purchase a foreign security can purchase foreign exchange on the spot market and simultaneously sell it on the forward market. The covered interest parity theorem states that the equilibrium relationship between exchange rates and nominal interest differentials is given by:

$$(F_t - S_t)/S_t = (i_t - i_t^*)/(1+i_t^*),$$

or, alternatively,

$$F_t/S_t = (1+i_t)/(1+i_t^*)$$

where F is the forward exchange rate,
S is the spot exchange rate,
i is the domestic nominal interest rate, and
i* is the foreign nominal interest rate.

The securities to which i and i* pertain are identical in all respects except the currency of denomination, and are perfect substitutes. In a "perfect" world, a divergence from covered parity would represent an unexploited opportunity for arbitrage. In fact, a number of distortions are possible which could create a "neutral band" about the parity condition, within which deviations from parity do not represent unexploited profit opportunities.

i) Transaction costs

Frenkel and Levich list four separate transactions in an outflow of covered funds: a) sale of domestic securities; b) purchase of foreign currency; c) purchase of foreign securities; d) sale of foreign currency (forward)[11]. With each transaction is associated a cost which may be expressed as a percentage of the total value. It is intuitively obvious that a covered interest rate differential which is exceeded by transaction costs will not provoke transactions. Should the arbitrager's initial position be in cash rather than securities, step (a) is omitted, and transactions costs are correspondingly lower.

Frenkel and Levich estimated the cost of transactions by examining triangular arbitrage, as in:

$$(\$U.S./\#)_t = (\$U.S./DM)_t(DM/\#)_t, \text{ or}$$

$$(\$U.S./\#)_t = (\$U.S./\$Can)_t(\$Can/\#)_t.$$

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[11] Frenkel and Levich, 1975, p. 327.

The first equation refers to the U.S. dollar price of one pound sterling, using Deutsche Marks as the intermediate currency. The second equation uses Canadian dollars as the intermediary. If the cross exchange rates are to be consistent then, "...the upper limit of the absolute discrepancy between the two sides of [the equation] should correspond to the cost of transacting" [12].

Having calculated the width of the neutral band about the covered parity line, Frenkel and Levich examine transactions in $U.S. and sterling-denominated 90 day securities. For the period January 1962 to November 1967, they found that transaction costs accounted for approximately 85% of the apparent arbitrage opportunities [13].

ii) Political Risk

Political risk is a factor for the investor considering securities issued in different jurisdictions. It is a function of the, "...probability that the authority of the state will be interposed between investors in one country and investment opportunities in other countries"[14]. An example is the imposition of exchange controls.

One method of accounting for political risk is to examine securities denominated in given currencies issued in a foreign country. For example, U.S. dollar and U.K. sterling-denominated securities issued in the Euromarket should bear the same risk[15]. When political risk was

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12 Ibid., p. 328.

13 Ibid., p. 333.

14 Aliber, p. 1453.

15 Frenkel and Levich, 1975, p. 332.

taken into account in this manner it was found that, with transaction costs, 99% of the deviations from covered parity were accounted for.

iii) Elasticities

If the interest elasticities of supply of or demand for funds for arbitrage are less than infinite, then another explanation of the neutral band about (Ft-St)/St is manifest. Frenkel (1973) examined the question, without accounting for either transaction costs or differential risk. For the period 1959 to 1970, he calculated the elasticities required to account for all deviations from covered parity on U.S. and U.K. three-month treasury bills. He found that, "[e]ven when the periods 1960-61 and 1967-70 are excluded as highly speculative, it is seen ... that the elasticities are lower than 10 in most cases. When the less stringent requirement is imposed (that only 49 weeks per year are bounded), the elasticities are estimated to be between 1.7 (1969) and 20.0 (in 1965)"[16]. Such estimates imply that the relevant markets are substantially less competitive than is normally assumed.

Frenkel and Levich (1975) also discuss the question of elasticities, but account for transaction costs and political risk. Given that their estimates of transaction costs and risk account for the vast majority of seemingly profitable arbitrage opportunities, it should not be surprising to find that their estimates of the elasticities required to account for the remaining deviations are quite high. "...[T]he values of the elasticities needed to account for all the deviations from the interest parity line are very high, reaching many hundreds in all cases. These

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[16] Frenkel, 1973, pp. 745-46.

high values are not inconceivable given the highly competitive organization of the markets in question"[17].

Finally, Pippenger (1978) investigates the elasticity of supply for arbitrage funds. He uses the techniques of cross spectral analysis on forward exchange rates and interest rate differentials between Canada and the U.S. The data are weekly, over the period 1959 through 1975. Pippenger finds that the supply elasticity of funds rises from zero in the short run (in this case, periods shorter than approximately four weeks) to infinite in the long run.[18] The most plausible explanation he offers for this result is that central bank intervention behaviour can temporarily isolate a domestic short term money market.[19]

This brief review of the literature permits us to conclude that the data are not inconsistent with the covered parity hypothesis. We therefore take the next step toward real interest parity by examining the uncovered interest parity theorem.

B) Uncovered Interest Parity

A stronger condition than covered parity, uncovered parity requires that the forward rate be an unbiased predictor of the future spot rate:

$$E_t(S_{t+1}) = F_t.$$

This can be analogously expressed as:

$$E_t(dS_{t+1}) = FP_t$$

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17 Frenkel and Levich, 1975, p. 335.

18 Pippenger, p. 187.

19 Ibid., p. 190.

where $dS_{t+1}=S_t-S_{t+1}$,
S_t is the spot rate, and
FP_t is the forward premium (or discount) at time t[20].

In other words, the forward premium/discount should reflect only anticipated depreciation/appreciation of the spot exchange rate. The null hypothesis to be tested is therefore that of rational expectations and no risk premium[21].

Longworth, Boothe and Clinton (1983) discuss a series of tests on what they refer to as the joint hypothesis that foreign exchange markets are "efficient" and that the risk premium is either zero or constant. By efficient, they mean that forecast errors are uncorrelated with information available to traders at the time of the transaction. They find that, "... the forward rate is inferior to other predictors of the future spot rate".[22] Not only did they find that information such as interest rate differentials and lagged spot rates improved forecast performance, they presented evidence that certain simple trading rules would have been profitable, in an ex ante sense, over the period June 1970 to December 1981. One such rule involved buying forward the currency of the country with the highest nominal interest rate.

None of the tests Longworth et. al. applied were adequate, in principle, to determine whether rejection of the joint hypothesis was the result of market inefficiency or the existence of a time varying risk premium. Their results were consistent with either or both. They

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[20] Gregory and McCurdy, p. 4.

[21] Ibid., p. 2.

[22] Longworth et. al., p. 4.

were inclined, however, to agree with previous research which implied rejection of the efficiency hypothesis. Such previous research includes Hansen and Hodrick (1980) and Cumby and Obstfeld (1981)[23]. Gregory and McCurdy (1984) obtain results consistent with the conclusion of market inefficiency and/or a time varying risk premium.

More recent research has centred on the question of the risk premium. See, for example, Frankel (1987). It appears now to be generally accepted that the risk premium is in fact not constant over time. Frankel concludes that, "[w]e are ... not yet at the point where we can claim to have found the risk variables that explain the behaviour of the forward discount prediction errors."[24]

C) Real Interest Parity

Real interest parity is the logical outcome of an equilibrium model. Given perfect capital mobility, arbitrage will ensure that the expected real net return on domestic- and foreign-currency denominated bonds of identical default risk will be equal[25]. Goods market arbitrage will ensure that ex ante PPP will hold.

In the following analysis, Roll (1979) implies that the conditions for real interest parity are uncovered interest parity and ex ante PPP. Consider first the law of one price:

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[23] Cumby and Obstfeld actually conclude, "... market efficiency is consistent with the existence of risk premia at equilibrium." (p. 702) In this manner they avoid rejecting the efficiency hypothesis.

[24] Frankel, 1987, p. 17.

[25] Mark, 1985, p. 681.

1) $P^*_{i,t}(S_t) = P_{i,t}$

where $P^*_{i,t}$ is the \$U.S. price of good i at time t,
S_t is the Canadian dollar price of one \$U.S.
P_i is the Canadian dollar price of good i.

Equation (1) implies:

2) $P^*_{i,t}/P^*_{j,t} = P_{i,t}/P_{j,t}$;

that is, the relative prices of goods i and j are the same in Canada and the U.S. Now assume that i can be characterized as either a good whose physical presence is unimportant (ie. an asset), or one which can be transported costlessly between t-1 and t. The good is purchased in Canada at t-1 and is sold at t in the U.S. The Canadian dollar nominal return from the transaction is

3) $X_{i,t} \equiv \ln [P^*_{i,t}(S_t)/P_{i,t-1}]$

where $X_{i,t}$ is the nominal return in time t on the transaction involving good i. Constancy of relative prices in Canada implies an inflation rate of:

$$dP = \ln[P_{i,t}/P_{i,t-1}].$$

This implies a real return from the transaction of

4) $R_{i,i,t} = \ln [P^*_{i,t}(S_t)/P_{i,t}]$.

If PPP is taken in its most rigourous interpretation, ie. the law of one price applied to all goods, then

$$R_{i,i,t} = 0 \text{ for all } i,t.$$

Relaxing the assumption of the constancy of relative prices requires the introduction of some price index, j, such that the return accrued by the Canadian trader in the above transaction is:

5) $R_{i,j,t} = \ln [P^*_{i,t}(S_t)/P_{j,t}] - \ln [P_{i,t-1}/P_{j,t-1}]$.

Should the agent decide to speculate in the U.S. market, that is purchase goods in the U.S. for future delivery there, his real return is given by:

$$6)\ R_{i,j,t} = \ln [P^{*}_{i,t}(S_t)/P_{j,t}] - \ln[P^{*}_{i,t-1}(S_{t-1})/P_{j,t-1}]$$

Classical PPP implies that $R_{i,j,t} = 0$. Modern PPP incorporates uncertainty, accounting for the probability that stochastic processes will cause positive real returns in some periods and negative real returns in others. Roll gives this "efficient markets", or rational expectations, version of PPP as

$$7)\ E[R_{i,j,t} \mid I_{t-1}] = 0,$$

where E is the expectations operator and I_{t-1} is the relevant information set available at t-1. Equation (7) states that the expected real return from such a transaction has an expected value equal to zero, given all relevant and available information. This can be rewritten as:

$$8)\ E\ [\ln(P^{*}_{i,t}(S_t)/P_{j,t}) \mid I_{t-1}] = \ln\ [P^{*}_{i,t-1}(S_{t-1})/P_{j,t-1}]$$

Recalling the definition of inflation allows equation (8) to be rewritten as:

$$9)\ E\ [\ln(S_t + dP^{*}_{i} - dP_t) \mid I_{t-1}] = \ln[S_{t-1}]$$

ie. the spot exchange rate in the last period reflects all information relating to the inflation differential between Canada and the U.S. Real interest parity is seen in equation (7):

> The assumption of equal expected real interest crept in unobtrusively at equation [7], where it was asserted that the real returns to commodity speculation should average algebraically to zero. Actually, they should average

algebraically to the difference in real interest.[26]

Also, "...the strictest interpretation of PPP would also imply equality in real interest rates"[27].

It has now been shown that goods and asset market arbitrage should theoretically yield ex ante real interest parity as an equilibrium condition. Roll, Mishkin (1984) and Mark (1985) all find evidence in the data such that they cannot reject the parity hypothesis for the U.S. - Canada case.

Roll tests two equations. The first is referred to as the "efficient markets version of PPP" (p.147):

$$9') \quad X_t = B_0 + B_1S_{t-1} + B_2X_{t-1} + \ldots + B_7X_{t-6} + U_t$$

where $X_t \equiv S_t - dP_t$
$dP_t \equiv dP_{j,t} - dP^*_{i,t}$ where
j is the price index relevant to Canada
i is the price index relevant to the U.S.
S is the spot exchange rate (Can.$/$1U.S.)
$dP_j \equiv \ln(P_{j,t}/P_{j,t-1})$.

This equation is used to test the null hypothesis $B_1 = 1$ and $B_j = 0$ for all j not equal to 1.

The second equation is referred to as "classic PPP":

$$10) \quad dP_t = B_0 + B_1dS_{t+3} + \ldots + B_4dS_t + \ldots + B_7dS_{t-3} + U_t$$

with the null hypothesis being $B_4 = 1$, $B_i = 0$ for all i not equal to 4. Absence of relative price variation implies $U_t = 0$ for all t. The data set used consists of monthly observations over the period January 1957 through December 1976, for a maximum possible sample size of 240 observations. Roll reports 238 observations for Canada and 239 for the

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[26] Roll, p. 141, note 11.

[27] Ibid., p. 139.

U.S., without specifying which months were excluded. For equation (9'), tested for the flexible exchange rate period April 1971 through December 1976, the Canada - U.S. results reported are as follows:

B1 = 1.38 ; t-statistic: 3.37

B2 = -0.361 ; t-statistic: -0.922

Adjusted R^2 = 0.678.

For equation (10), tested over the same period:

B4 = 0.0281 ; t-statistic: 0.456

B5 = 0.0808 ; t-statistic: 1.30

Adjusted R^2 = 0.00638.

Using justification discussed in chapter three, Mishkin (1984) uses ex post real interest rates as a proxy for ex ante rates. He analyses real rates in the euro-deposit market for the second quarter of 1967 to the second quarter of 1979 for the U.S., Canada, and five other O.E.C.D. countries. Mishkin tests for constancy of real rates, rather than parity. Examination of his figures 1 and 2 on page 292, however, would probably be interpreted as inconsistent, or at best only weakly supporting, the parity hypothesis. That study finds evidence that there is, "... a strong Fisher effect and a weak association of nominal rates with real rates for Canada ..."[28]. By Fisher effect is meant that nominal interest rate movements are associated with changes in inflation expectations rather than real interest rate changes.

Mark performs three tests on ex post real rates. He uses the same assumptions as Mishkin to make inferences about real rates. The data are for the U.S., Canada, and others for the period May 1973 through

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[28] Mishkin, 1984, p. 285.

August 1984. In all three tests, parity is rejected for every country pair except Canada and the U.S.A.

D) Exchange Rate Determination

The standard Keynesian approach of rigid or 'sticky' prices, and the liquidity preference theory of interest rate determination, typify the disequilibrium approach to exchange rate determination. An appreciation of the exchange rate comes about in the asset market from a restrictive monetary policy. With imperfect price adjustment (and a constant level of real wealth), agents respond to the policy by the sale of bonds in order to maintain the desired degree of liquidity. The attendant increase in the nominal interest rate is also an increase in the real rate, provoking inflows of capital from abroad, placing appreciation pressure on the exchange rate. Asset markets are assumed to clear at all times, while the goods market adjusts only slowly.

Frankel (1979) contrasts this approach with what he terms the "Chicago" school, ie. something more akin to an equilibrium approach. An increase in the domestic nominal interest rate is a result of the Fisher effect - it reflects agents' expectations of higher inflation. The currency of the country with the higher inflation rate will depreciate.

These two approaches might more constructively be viewed as the short run and long run responses of the nominal exchange rate to monetary phenomena. In the short run, rigidities cause a violation of the classical dichotomy, while in the long run, the Quantity Theory holds.

i) The Dornbusch Model

The model introduced by Dornbusch in his 1976 J.P.E. article has become the "workhorse" of exchange rate theory, much as was the Mundell-Fleming approach before it. In this model, slow goods market adjustment can combine with rapid asset market adjustment to result in exchange rate "overshooting". The policy relevance of this approach makes it worthwhile to relate in some detail here.

Dornbusch assumes perfect capital mobility, such that uncovered interest parity holds at all times. The domestic asset market and the foreign exchange markets are perfectly flexible; the domestic goods market, however, clears slowly. Perfect capital mobility is represented by :

$$11)\quad r = r^* + x$$

where x is the expected rate of depreciation, r and r* are the domestic and foreign nominal interest rates respectively, and all variables are in natural logarithms.

$$12)\quad x = \theta(z-e)$$

where e is the spot exchange rate, z is the long run exchange rate, and Θ is a parameter. Domestic money demand is given by

$$13)\quad m = p - ar + by$$

where m is the domestic nominal money stock,
y is real national income,
p is the price level, and
a, b are parameters.

Dornbusch then combines 11, 12, and 13 into

$$14)\quad p - m = -by + ar^* + a\theta(z-e).$$

The long run equilibrium price level is then shown as

$$15)\quad \bar{p} = m + (ar^* - by).$$

Equations 14 and 15 together yield the relationship between the price level and the spot exchange rate:

$$16)\quad e = z - (1/a\theta)(p-\bar{p}).$$

Aggregate demand is a function of the relative price of domestic to foreign goods, as well as interest rates and real income. Setting $P^*=1$ such that $\ln(P^*)=0$, aggregate demand is given by:

$$17)\quad d = u + c(e-p) + fy - gr$$

where u is a shift parameter and c, f, and g are parameters. Inflation is taken as a function of excess demand:

$$18)\quad dP/dt = h(d-y) = h[u+c(e-p)+(f-1)y-gr]$$

where h is a parameter. Equation (18) yields the long run equilibrium exchange rate:

$$19)\quad z = \bar{p} + (1/c)[gr^* + (1-f)y - u].$$

Since $r - r^* = \theta(z-e)$,

$$20)\quad dP/dt = -h[(c+g\theta)/\theta a + c](p-\bar{p}) = -v(p-\bar{p})$$

where $v \equiv h[(c+g\theta)/\theta a+c]$. Hence:

$$21)\quad p(t) = \bar{p} + (p_0 - \bar{p})\exp(-vt) \quad \text{and,}$$

$$22)\quad e(t) = z + (e_0 - z)\exp(-vt).$$

It is the response of this model to a positive domestic monetary shock which is of interest. Assume for simplicity that output is at its full employment level. The increase in the nominal money stock in the short run is also an increase in the real money stock, given slow goods market adjustment. Via the standard Keynesian liquidity effect, domestic nominal interest rates fall, which leads, by capital mobility, to an outflow of capital and depreciation pressure on the exchange rate. Short run price inflexibility implies that the depreciation causes a

favourable movement in the terms of trade, such that foreign demand for domestic goods increases and domestic demand for foreign goods falls. This excess demand pressure is accentuated by the fall in the domestic (real) interest rate. Excess demand implies upward pressure on the domestic price level. Classical homogeneity implies a depreciation of the exchange rate and increase in the price level equal to the nominal money expansion. Short run goods market inflexibility, however, implies that the immediate impact of adjustment pressure will fall entirely upon the (perfectly flexible) exchange rate. The spot rate depreciates "excessively", that is, it overshoots its long run equilibrium level. As prices increase over the longer term, thereby absorbing some of the adjustment burden, the exchange rate is free to appreciate toward its equilibrium level. Indeed, given perfect capital mobility, domestic agents must anticipate an appreciation in order to compensate for the lower domestic nominal interest rate (see eqn. 11). The perfect foresight path is such that, "[t]he impact effect of a monetary expansion is ... to induce an immediate depreciation in the spot rate and one that exceeds the long run depreciation, since only under these circumstances will the public be compensated for the reduced interest on domestic assets"[29].

As Dornbusch notes, the theoretical basis for this differential market adjustment speed is lacking[30]. Nevertheless, he excuses its ad hoc nature by its apparent consistency with the data. Depending upon the length of the goods market price adjustment process, an "excessively" low value of the exchange rate may promote real resource

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29 Dornbusch, J.P.E. 1976, p. 1168.

30 Ibid., p. 1171.

shifts within the economy. This movement of resources into the export market is undesirable to the extent that firms' competitiveness is artificially enhanced by the improvement in the terms of trade induced by the depreciation. If the policy maker is aware of the overshooting phenomenon, he may intervene, for example by selling bonds on the open market. That will raise the domestic nominal interest rate, attract capital inflows, and mitigate the depreciation pressure. Such an action may prevent undesirable resource reallocations; it is the aim of this research to determine whether such actions might also introduce distortions in the ex ante real rate of interest.

IV) Comments on Intervention Policy

A) The View of the Bank of Canada[31]

The fundamental question is whether or not exchange market intervention is associated with inflation expectations. In the case of Dornbusch-type overshooting, intervention would not be expected to distort the ex ante real rate of interest. Rather, the authorities would be shortening the period of transition to long run equilibrium. The publication of the overshooting hypothesis was hardly the stimulus for the Bank of Canada to begin intervening in the foreign exchange market. On the contrary, the hypothesis has instead been used to justify actions the Bank was inclined to undertake in any event.

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[31] References for this section include various issues of the Annual Report of the Governor of the Bank of Canada.

The central bank has provided two main arguments for exchange market intervention. The first is that of the inflationary consequences of a depreciation, at a time when the fight against accelerating inflation has just subsided. It is tautologically true that, in as much as imported goods enter into the C.P.I., a given depreciation of the dollar will cause an increase in the C.P.I. This increase does not represent inflation in the proper sense of the word, any more than does an increase in a sales or excise tax. Rather, it represents a once and for all increase in the index which will be reported, and may be perceived, as a positive rate of inflation during the period of transition. The Bank has stated on several occasions that it fears the consequences of such events. It sees the danger of a renewed wage-price spiral, as workers find their purchasing power eroded through inflation. Since the events of the late 1970s and early 1980s have made inflation expectations volatile, an increase in the C.P.I. resulting from a depreciation could spark an expectations-based price spiral.

The second justification is given in response to criticism of high nominal interest rates. To the argument that permitting a lower value for the Canadian dollar would permit lower nominal (and by implication real) interest rates in Canada, the Bank has responded in the following way. Given the volatility of currency markets, permitting depreciation would simply heighten expectations of further depreciation. A higher domestic nominal interest rate premium would then be required to maintain the attractiveness of domestic assets. By implication, the foreign exchange market has been uncertain as to the equilibrium value

of the Canadian dollar. Activist intervention mitigates that uncertainty and discourages speculation.

To the extent that the depreciation pressure is unrelated to inflation *expectations*, a policy of maintaining an artificially high foreign exchange value of the Canadian dollar will also maintain an artificially high nominal interest rate. The result should be deviations from the real interest parity line. The remainder of this paper will be concerned with the evaluation of the correlation, if any, between movements in the nominal exchange rate and the ex ante real rate of interest.

Chapter Three

I) Introduction

This chapter will discuss both methodology and results. The main emphasis will, of course, be upon the tests for exchange rate influence on the (ex ante) real interest rate. To that end, estimation of the Vector Autoregression (V.A.R.) will be discussed, as well as calculated F statistics testing Granger-Sims' causality. The V.A.R. will then be converted into its moving average representation, and the response of the system to shocks will be examined.

Clearly, when speaking of the ex ante real rate of interest, some algorithm for inflation expectations is required. This issue will be addressed in the second section of the chapter. The third section will present the V.A.R., while the fourth will examine the impulse responses of the estimated system. The fifth and final section will comment on the empirical results.

II) Inflation Expectations

A) Methodology

Two basic methods are used to obtain data on unobservable variables such as inflation expectations. The first is to survey agents in order to ascertain their predictions. This method was rejected because of the well-known deficiencies of survey data. The second alternative is to use econometric methods.

Econometric estimation of expectations is generally performed under one of two guiding assumptions. The first, and the one commonly

found in the literature[1], is that of "rational expectations", which permits the assertion that, on average, agents will predict the rate of inflation correctly. If the expected value of the forecast error is zero, and the variance of this error is "small", it follows that the ex post real rate of interest is as good a proxy for the ex ante rate as any other.

An alternative to assuming "rational" expectations, and the strategy followed below, is to utilize an algorithm akin to the "adaptive" approach. If it is assumed that agents understand how inflation is generated within the economy and further do not believe that the process follows a random walk, then it is possible to gather information which would have been available to a given agent at a particular period in the past. This information can be employed to estimate his inflation "expectation". The advantage of this method is that it can be used within the constraint that the equation incorporate no information which would have been unavailable to an agent at the time he wished to make his forecast.

A general question of methodology should be noted. The restriction was imposed that no contemporaneous variables could be used. This constraint was introduced to ensure that the model had no information which would not have been available to an actual agent undertaking an inflation forecast. Such a restriction is violated if, for

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[1] See, for example, Fredric Mishkin, "The real interest rate: a multi-country empirical study", Canadian Journal of Economics, May 1984, particularly pages 285-287. Another example can be found in Nelson Mark's paper, "A Note On International Real Interest Rate Differentials", Review of Economics and Statistics, 1985.

example, the econometrician estimates the relationship over the entire interval, and then uses the estimated coefficients to forecast in-sample. The coefficients so estimated implicitly contain information which no agent could have possessed at the time of the forecast. If one seeks to uncover an ex ante relationship, this is an undesirable defect.

The following technique was used. The relationship was estimated and used to forecast one period ahead. The regression was then "rolled" (that is the first observation was dropped and one more was added at the end[2]), re-estimated, and used to obtain another forecast.

B) Canadian Inflation Forecast

Inflation as defined here refers to the annualized three month symmetric percentage change in the Consumer Price Index, that is

$$\pi_t = ((CPI_t - CPI_{t-3}) / ((CPI_{t-1} + CPI_{t-2})/2)) * 400.$$

The three month interval was chosen so as to provide inflation data consistent with the three month treasury bill series used in the V.A.R. Two estimation techniques were attempted. The first was the Box-Jenkins, or Auto Regressive Integrated Moving Average (A.R.I.M.A.), algorithm. This class of models has proven quite successful in short-term forecasts. A variety of specifications were examined, with the most promising candidates being estimated over the rolling intervals. The results were unsatisfactory: while it was possible to fit an A.R.I.M.A. to a given sub-period, no specification was consistent with

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[2] This is the methodology used by Meese and Rogoff in their 1983 paper "Empirical Exchange Rate Model's of the Seventies - Do They Fit Out of Sample?", in the Journal of International Economics. See also Blanchard and Summers, "Perspectives on High World Real Interest Rates", in the Brookings Papers on Economic Activity, 1984.

the data for more than fourteen sub-periods[3]. Clearly, respecifying the model for each year (or, for that matter, each month) amounts to little more than an exercise in fitting the sample, and implies an excessive loss of generality. It was therefore necessary to explore a more robust estimation technique.

As an alternative to the A.R.I.M.A. methodology, a variety of linear equations incorporating likely explanatory variables for inflation were investigated. Candidate variables included past inflation, monetary growth, unemployment, changes in the index of leading indicators, economic growth, foreign (U.S.) inflation, and foreign monetary growth. The overriding criterion for selection of a given equation for further examination was forecast performance. Similar research was undertaken with American inflation, except that only U.S. variables were included. This restriction is in keeping with the standard assumption that Canada is a "small open economy", while the United States is not.

Given the intention to study implications of intervention under a regime of floating exchange rates, estimates for anticipated inflation were obtained beginning in 1972, roughly coincident with the start of the flexible regime[4]. While initial conditions may overlap with the fixed-rate period, the use of rolling intervals permits the incorporation of learning on the part of agents.

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[3] That is, each specification became invalid within fourteen "rolls", ie. within fourteen months of the original period of estimation.

[4] It has been argued that the *de facto* float began some months after the imposition of the current *de jure* flexible regime. Hence it is difficult to date precisely the end of the fixed rate system.

The equation for Canadian inflation is as follows:

$$\pi_t = a_1 + a_2(\pi_{t-1}) + a_3(\pi_{t-2}) + a_4(\pi_{t-3}) + a_5(\pi_{t-4}) + a_6(\pi^*_{t-3}) + a_7(\pi^*_{t-5}) + a_8(dM2_{t-4})$$

where π_t is inflation at time t,
π^* is U.S. inflation,
$dM2_t$ is growth in the M2 aggregate.

Estimation was performed using ordinary least squares, and the value for $E_{t-1}(\pi_t \mid I_{t-1})$ was obtained by using the forecast command after each regression[5]. Information on forecast performance is presented below.

Table 1

Statistics on Actual and Expected Canadian Inflation
Monthly Data, January 1972 - December 1986

Variable:	π_t	$E_{t-1}(\pi_t)$	$\pi_t - E_{t-1}(\pi_t)$
Mean:	7.61%	7.51%	0.10%
Variance:	10.75	9.35	3.62
T Stat. for Null Hyp. of mean = 0:	31.16	32.94	0.73

On the next two pages are presented graphs of actual and forecast inflation. The following two pages present plots of the forecast error. The data are broken into three roughly equal periods for clarity of exposition.

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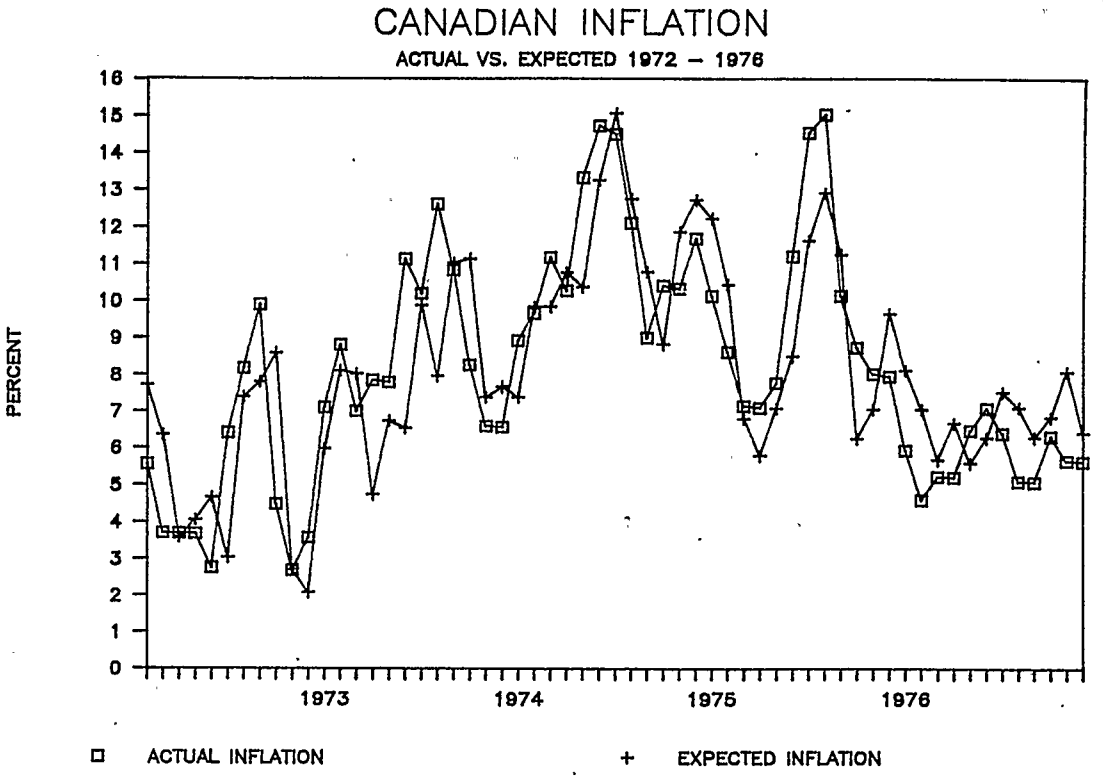
5 Both the inflation series and the V.A.R. were estimated using RATS version 1.20.


CANADIAN INFLATION
ACTUAL VS. EXPECTED 1972 – 1976
PERCENT
16
15
14
13
12
11
10
9
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6
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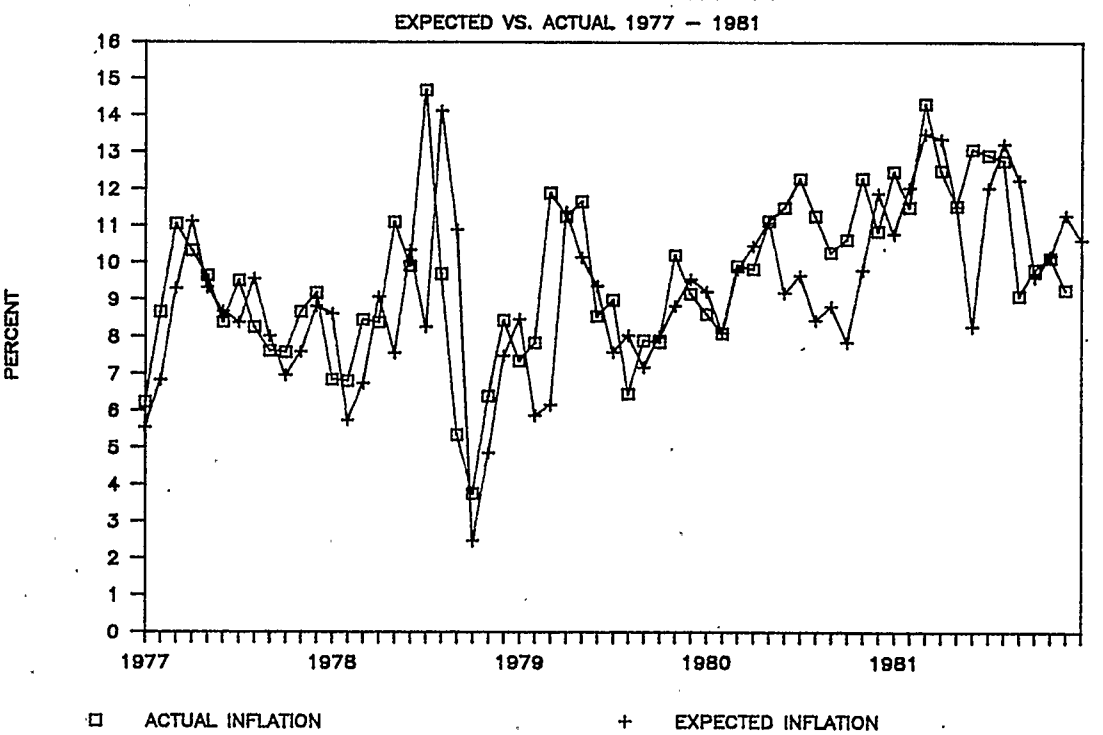
3
2
1
0
1973
1974
1975
1976
ACTUAL INFLATION
EXPECTED INFLATION


CANADIAN INFLATION
EXPECTED VS. ACTUAL 1977 – 1981
PERCENT
16
15
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1977
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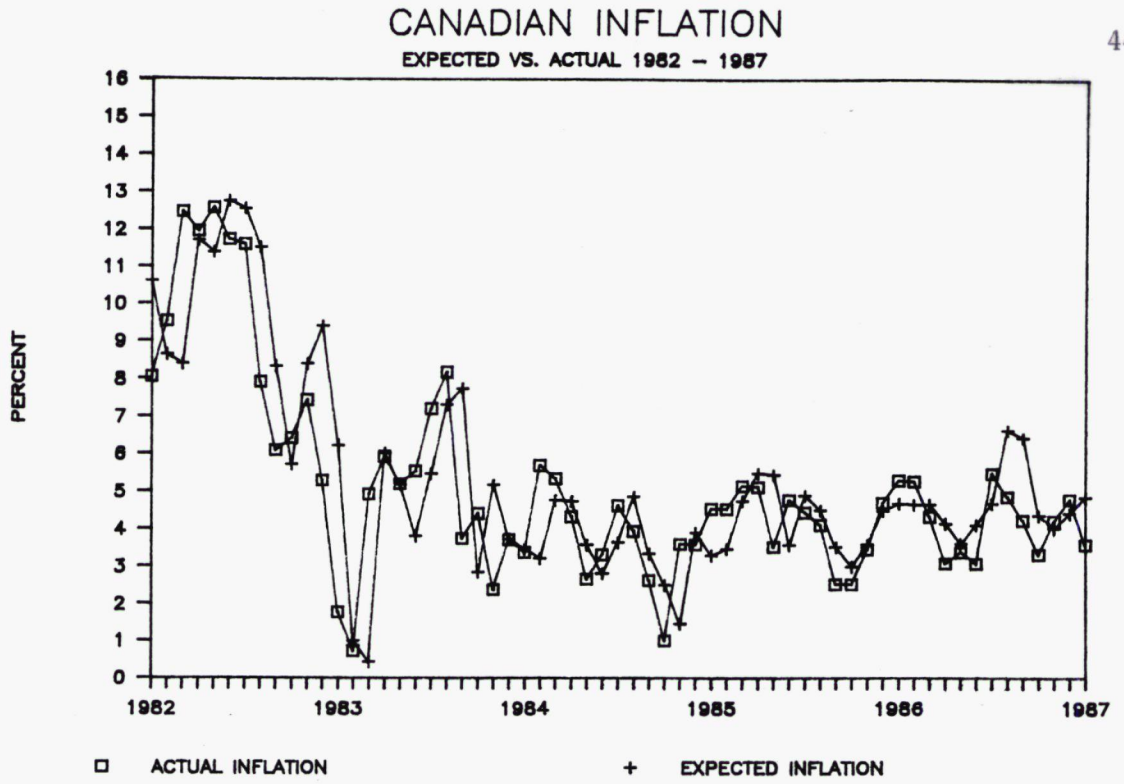
1981
ACTUAL INFLATION
EXPECTED INFLATION


CANADIAN INFLATION
EXPECTED VS. ACTUAL 1982 – 1987
PERCENT
16
15
14
13
12
11
10
9
8
7
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5
4
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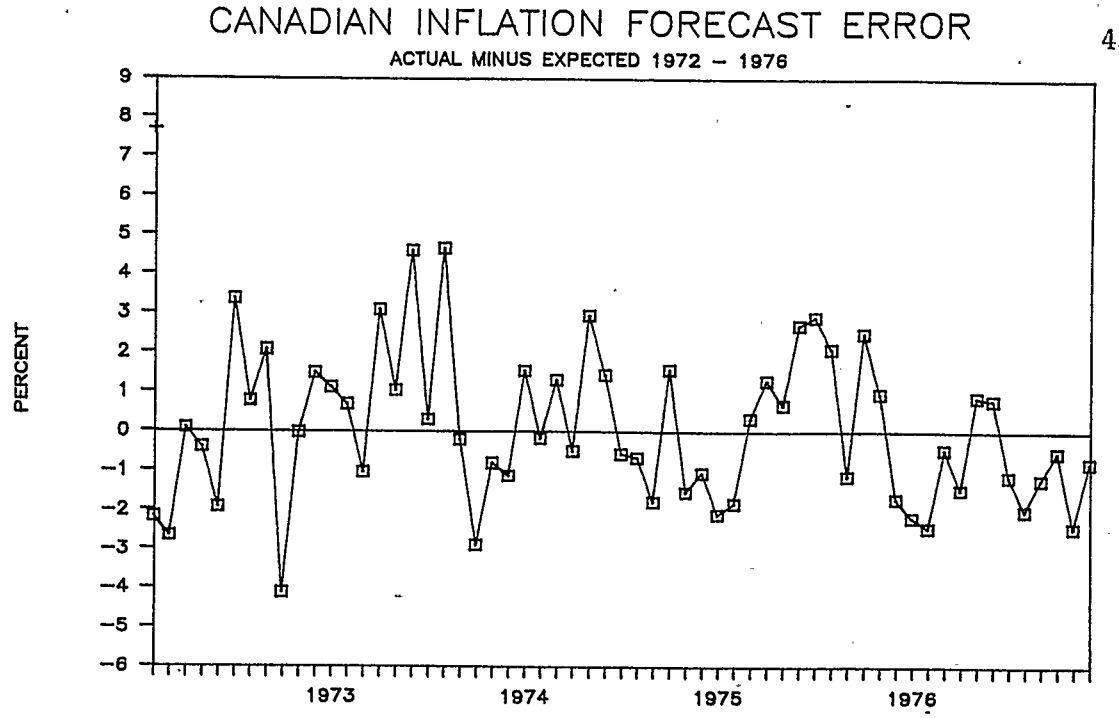
2
1
0
1982
1983
1984
1985
1986
1987
ACTUAL INFLATION
EXPECTED INFLATION


CANADIAN INFLATION FORECAST ERROR
ACTUAL MINUS EXPECTED 1972 – 1976
PERCENT
9
8
7
6
5
4
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2
1
0
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−2
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−4
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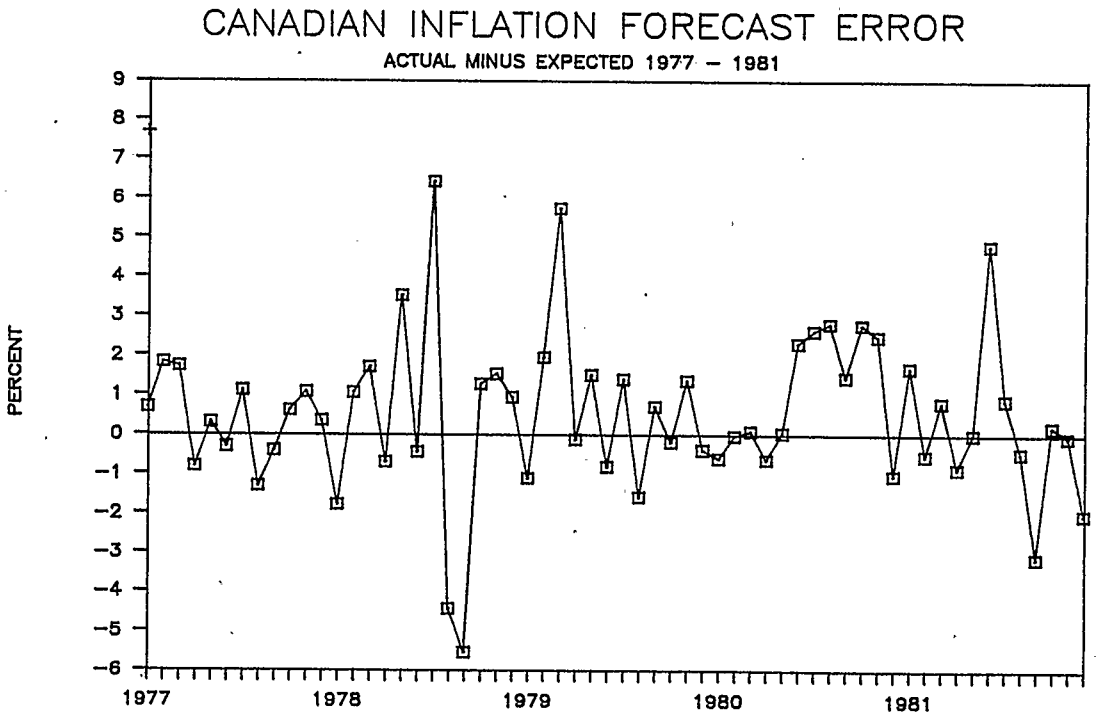
−6
1973
1974
1975
1976


CANADIAN INFLATION FORECAST ERROR
ACTUAL MINUS EXPECTED 1977 – 1981
PERCENT
9
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1977
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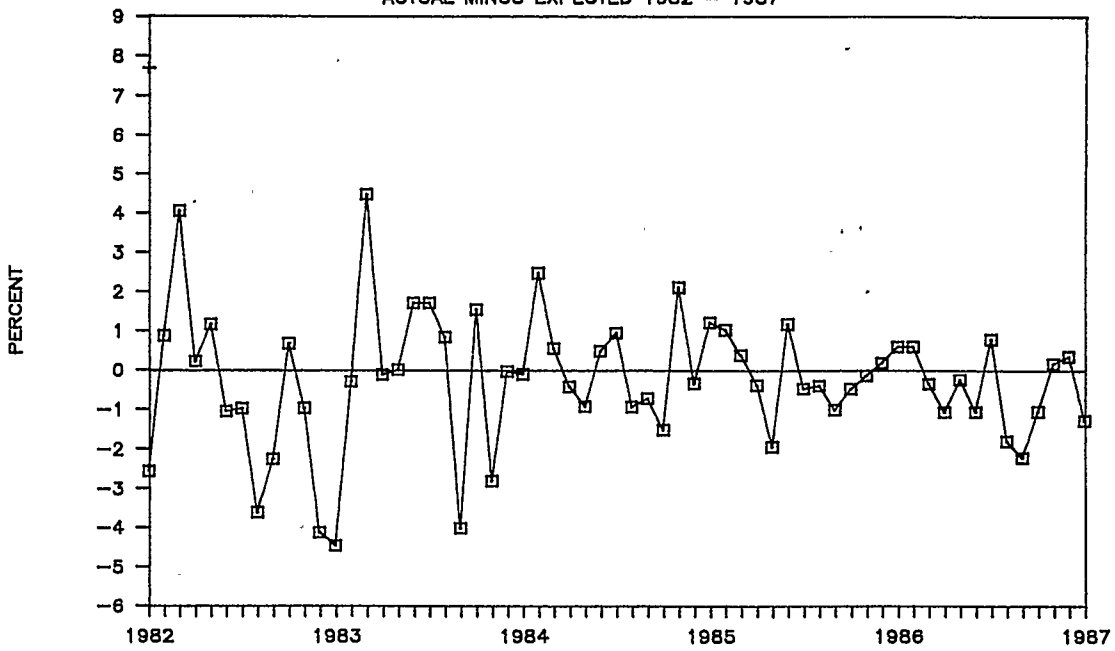
1979
1980
1981

CANADIAN INFLATION FORECAST ERROR

ACTUAL MINUS EXPECTED 1982 – 1987



It is evident that the equation tracks reasonably well. Switchpoints are largely captured, although frequently with a lag of one month. An agent with such a forecasting algorithm might reasonably be expected to consider it as a viable alternative to hunches and intuition.

Use of the "rolling" technique provides a unique opportunity for examining changes in the relationship between the dependant and independent variables over time. The table below presents some information on the coefficients. The interested reader is referred to Appendix A, in which graphs of the coefficients are presented. The debates of the 1970s concerning the structural determinants of inflation, for example demand-side versus supply-side factors, show that shifts over time in the structural relationships cannot be ruled out a priori. Furthermore, the period in question has been marked by significant price volatility. It is therefore not surprising to find considerable variability over time in the estimated coefficients. Of course, not all coefficients are always significant. In fact, only the first lagged dependant variable consistently showed a T statistic greater than two. However, none of the variables could be excluded without impairing the equation's general forecast performance.

Table 2

Summary of Independent Variable Coefficients
Canadian Inflation Forecasting Equation

Coefficient on:	Maximum	Minimum	Mean	# of occurrences less than 0
Constant	6.90	-1.63	1.67	11
π_{t-1}	1.11	0.34	0.79	0
π_{t-2}	0.24	-0.43	-0.10	140
π_{t-3}	0.05	-0.69	-0.29	178
π_{t-4}	0.45	0.06	0.26	0
$dM2_{t-4}$	0.24	-0.09	0.09	12
π^*_{t-3}	0.43	-0.31	0.02	96
π^*_{t-5}	0.15	-0.43	-0.09	141

C) United States Inflation Forecast.

For the United States, the inflation rate was defined in the same manner as in the Canadian case, ie. the annualized three month percentage change. The structure of U.S. inflation proved more complicated. Whereas only seven variables were used in the domestic case, a full twelve are included here. The equation is as follows:

$$\pi^*_t = b_1 + b_2(\pi^*_{t-1}) + b_3(\pi^*_{t-2}) + b_4(\pi^*_{t-3}) + b_5(\pi^*_{t-4}) + b_6(\pi^*_{t-5}) + b_7(M2^*_{t-3}) + b_8(M2^*_{t-4}) + b_9(M2^*_{t-6}) + b_{10}(i^*_{t-3}) + b_{11}(i^*_{t-5}) + b_{12}(U^*_{t-3}) + b_{13}(dM2^*_{t-4}),$$

where * indicates a U.S. variable,
M2 is the monetary aggregate,
dM2 is the three month symmetric percentage change in the M2 aggregate,
i is the three month treasury bill rate, and
U is the unemployment rate.

Information similar to that for the Canadian inflation forecast is presented below: in table 3, statistics on forecast performance

are shown, and in table 4 summaries of the mean, maximum and minimum values of the estimated coefficients in the equation are presented. On subsequent pages will be found the plots of the forecast versus actual inflation, and graphs of the forecast errors. Graphs of the coefficients can be found in Appendix A.

Table 3

Statistics on Actual and Expected U.S. Inflation
Monthly Data, January 1972 - December 1986

Variable:	$\pi\%$	$E_{t-1}(\pi\%)$	$\pi\% - E_{t-1}(\pi\%)$
Mean:	6.60%	6.68%	-0.08%
Variance:	15.21	21.44	3.81
T Stat. for Null Hyp. of mean = 0:	22.70	19.36	-0.56

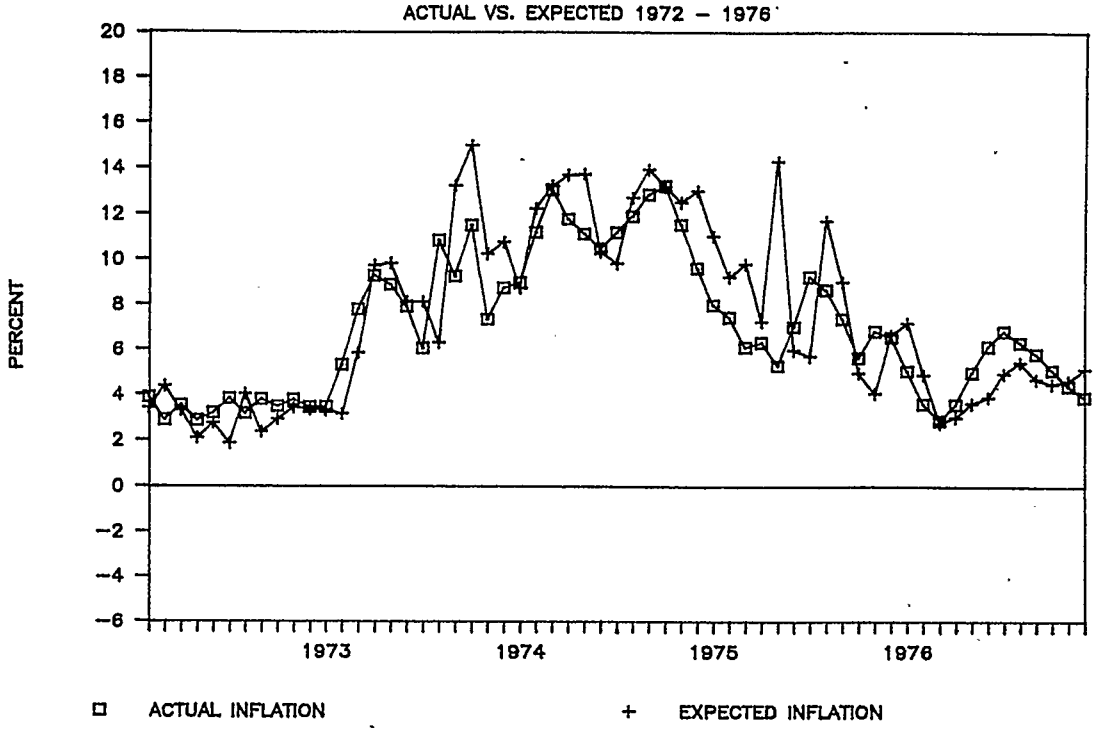
Table 4

Summary of Independent Variable Coefficients
U.S. Inflation Forecasting Equation

Coefficient On:	Maximum	Minimum	Mean	# of occurrences less than 0
Constant	52.40	-42.84	4.13	67
$\pi\%_{-1}$	1.36	0.38	0.99	0
$\pi\%_{-2}$	0.99	-1.00	-0.21	124
$\pi\%_{-3}$	0.12	-0.87	-0.43	173
$\pi\%_{-4}$	0.69	-0.15	0.32	6
$\pi\%_{-5}$	0.73	-0.58	-0.13	125
$M2\%_{-3}$	0.37	-0.12	0.05	53
$M2\%_{-4}$	0.18	-0.55	-0.06	102
$M2\%_{-6}$	0.33	-0.18	0.01	102
$i\%_{-3}$	0.61	-1.09	0.11	51
$i\%_{-5}$	1.10	-1.02	0.13	67
$U\%_{-3}$	0.03	-0.04	0.00	71
$dM2\%_{-4}$	0.75	-0.39	0.00	103

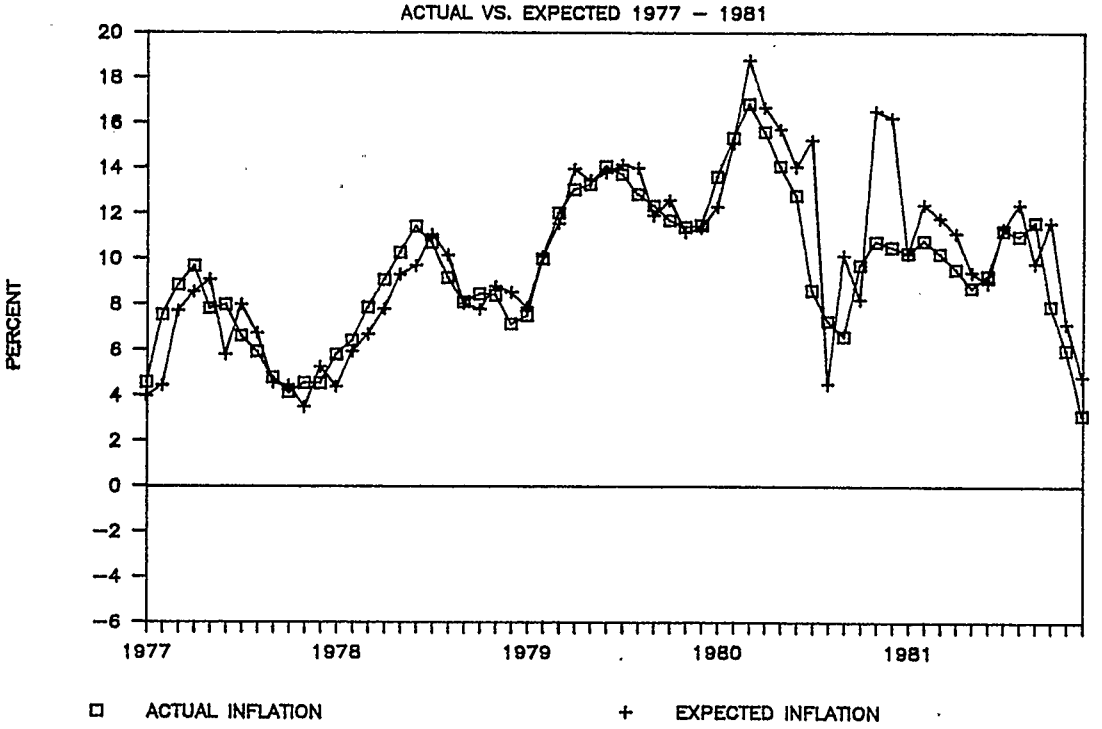
U.S. INFLATION FORECAST

ACTUAL VS. EXPECTED 1972 – 1976



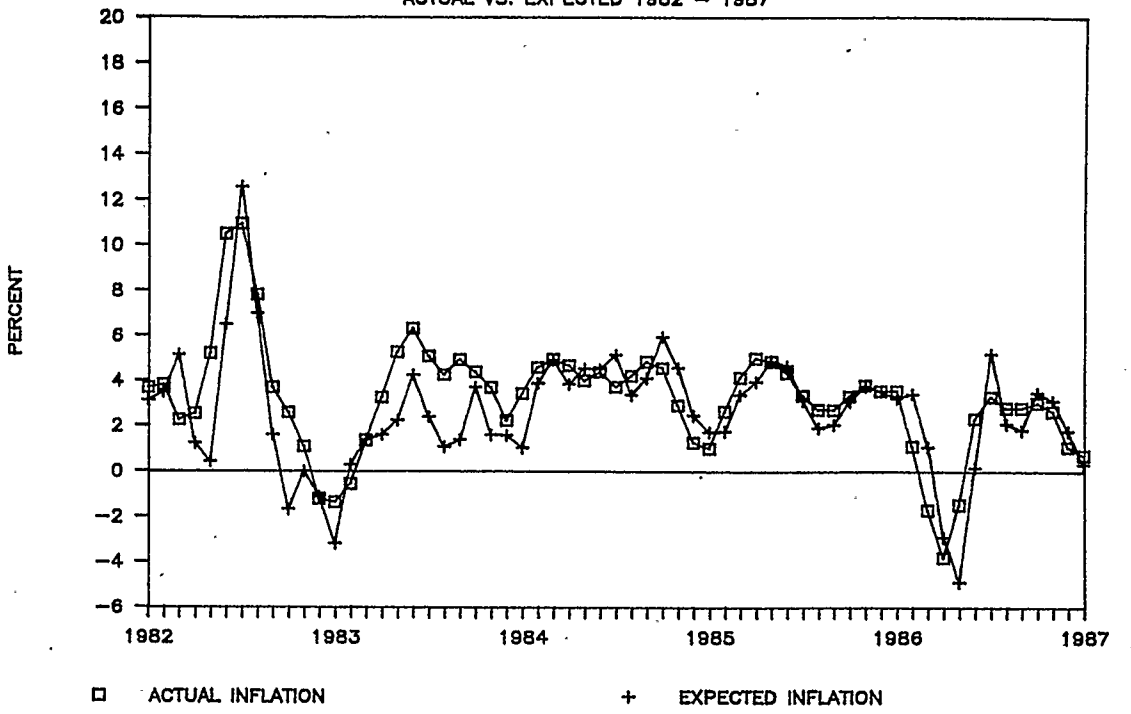
U.S. INFLATION FORECAST

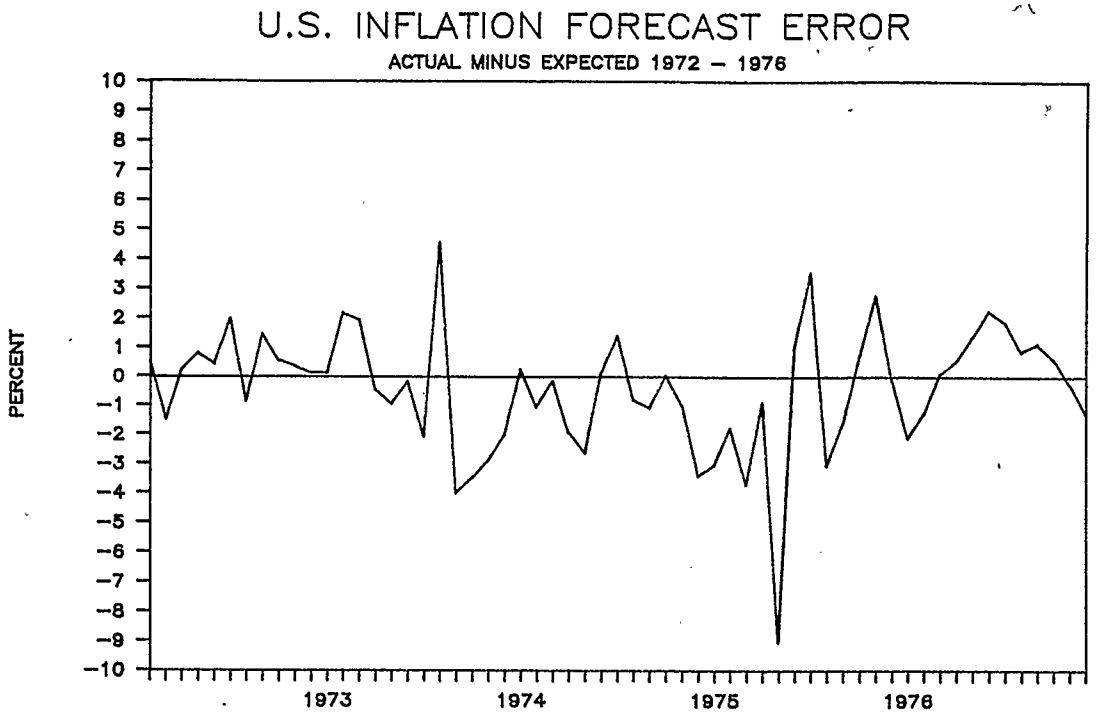
ACTUAL VS. EXPECTED 1977 – 1981



U.S. INFLATION FORECAST

ACTUAL VS. EXPECTED 1982 – 1987




U.S. INFLATION FORECAST ERROR
ACTUAL MINUS EXPECTED 1972 – 1976
PERCENT
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−6
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1973
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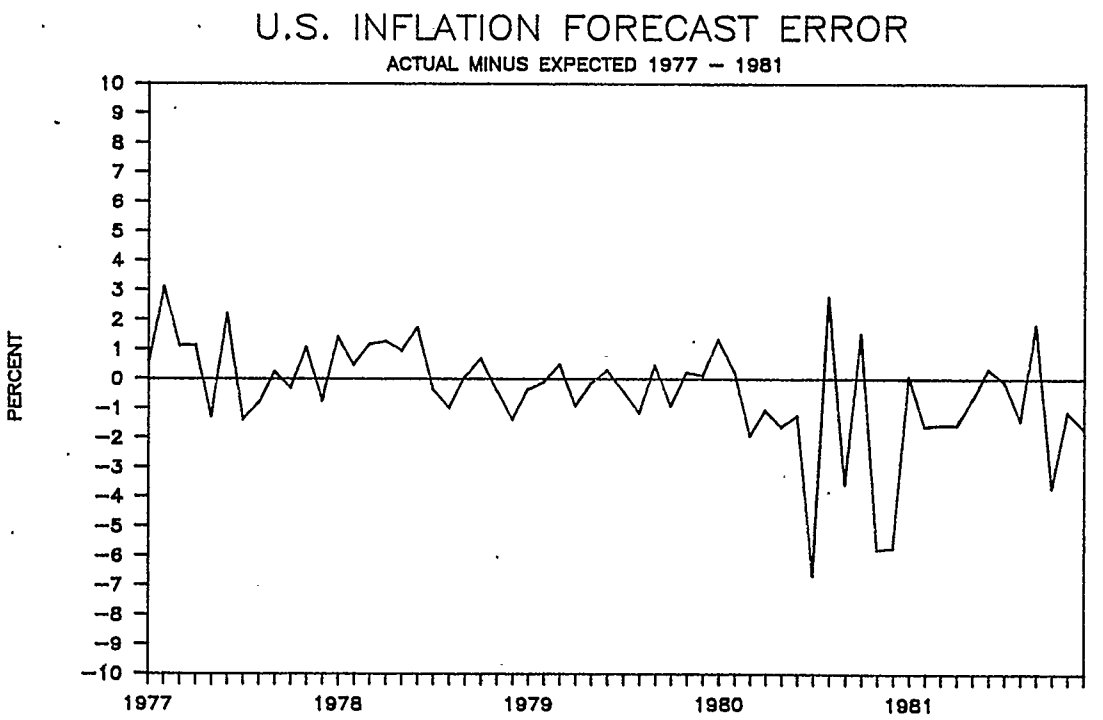
1975
1976


U.S. INFLATION FORECAST ERROR
ACTUAL MINUS EXPECTED 1977 – 1981
PERCENT
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1977
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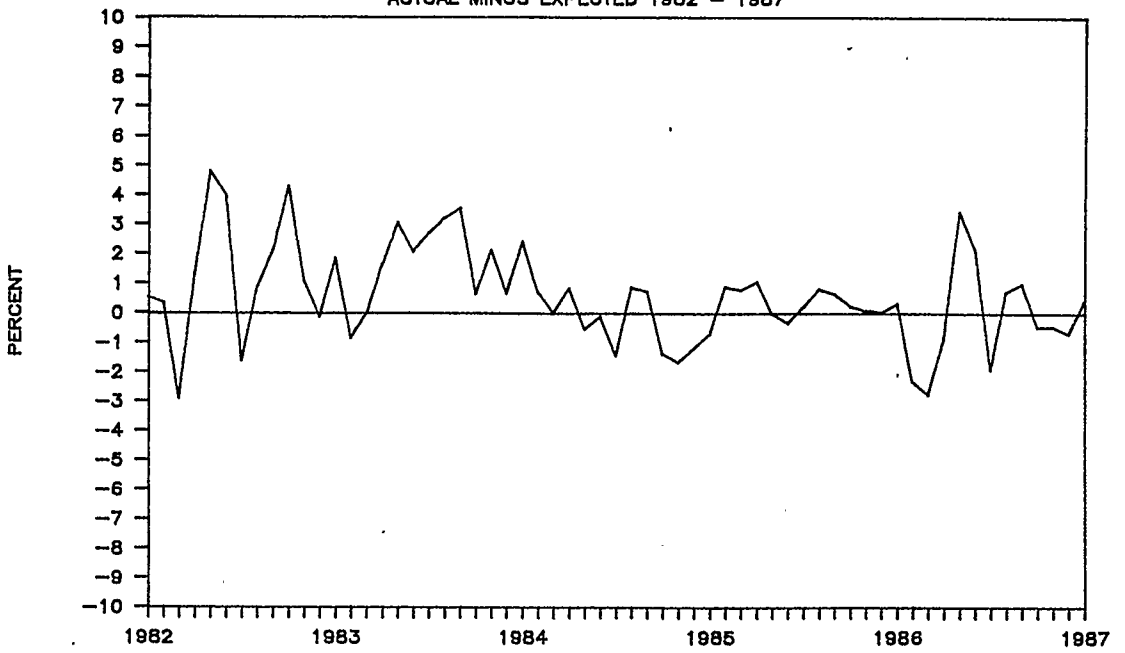
1979
1980
1981

U.S. INFLATION FORECAST ERROR

ACTUAL MINUS EXPECTED 1982 – 1987



III) The Vector Autoregression

A) General[6]

Sims' 1980 article re-asserts a long-known but frequently overlooked caveat in the construction and use of structural macroeconometric models. The caveat is that the restrictions necessary to ensure identification are so extensive as to render claims for identification "incredible"[7]. "In effect, the shrewd restrictions which are useful for partial equilibrium purposes, when concatenated across many categories of demand, yield a bad *system* of restrictions"[8]. Sims proposes that a step back be taken. He introduces a vector time-series technique, vector autoregression, the objective of which is to uncover the relationships within the data which structural models must explain. By this method, he estimates a large-scale macromodel, "... as [an] unrestricted reduced [form], treating all variables as endogenous"[9]. By unrestricted is meant, "... 'without restrictions based on supposed a priori knowledge'"[10].

By vector autoregression then, we refer to a system of equations in which each variable appearing on the left hand side is also found on the right. An appropriate lag length is selected and applied identically to each regressor. More rigourously, the V.A.R. can be written:

---

6 Presentation in section A follows closely the standard treatment in the literature. See, for example, Sims (1980), and Burbidge and Harrison (1985).

7 Sims, 1980, p. 1.

8 Ibid., p. 3.

9 Ibid., p. 15.

10 Ibid.

$$A(B)y_t = e_t$$

where A(B) is an n X n matrix of polynomials in B, the lag operator. N is the number of variables, y_t is the n X 1 vector of endogenous variables and e_t is a n X 1 vector of random variables. Just as in the single equation case, any finite order vector autoregressive process can be written as a vector moving average process of infinite order. The moving average representation can be written as:

$$y_t = A(B)^{-1}e_t = C(B)e_t = \sum_{i=0}^{\infty} C_i e_{t-i}$$

where C_0 is the identity matrix, A(B) being normalized so that the first entry of each polynomial on A's diagonal is unity.

Some of the most interesting characteristics of the system are revealed by its response to shocks, or innovations. In the equation immediately above, consider a shock to the k^{th} component of e_t, such that e_t^k equals unity. The response of y_t^k is also unity, and that of y_{t+j}^k is the k^{th} column of C_j. In this manner one obtains the impulse response of each variable, at times t + j for j = 0, 1 ,..., to a shock introduced at time t.

The model includes six variables: the United States 90 day treasury bill rate (I*), the U.S. ex ante real interest rate ($R_t^* = I_t^* - E_{t-1}(\pi_t^*)$, with expected inflation as discussed above), the exchange rate (E = \$C/\$1U.S.), Canadian reserves of U.S. dollars, the Canadian 90 day treasury bill rate (I), and the Canadian ex ante real interest rate ($R_t = I_t - E_{t-1}(\pi_t)$).

All data are monthly; the exchange rate and reserves are in

natural logarithms, while the interest rates are raw[11]. The deterministic components are a constant and seasonal dummy variables. The period of estimation is February 1973 through January 1987.

While the reasons for the inclusion of the interest rates and exchange rate are obvious, some explanation is in order regarding the inclusion of reserves. Presumably the exchange rate data contain information on central bank intervention in the foreign exchange market. However, given that the exchange rate responds to a very broad spectrum of information, it was thought desirable to include a variable which might act as a proxy for intervention. In the case of a policy of "leaning against the wind", the Bank of Canada might purchase (and of course has purchased) Canadian dollars in the foreign exchange markets in response to an incipient depreciation. On the other hand, a strengthening dollar may be used as an opportunity to replenish these reserves. While no claim is made here that reserves are the ideal proxy for central bank intervention, their inclusion did provide some interesting results, as discussed below.

In order to determine the appropriate order of the polynomials in the lag operator, likelihood ratio tests were performed starting with

---

[11] Note that the question being addressed is the response of interest rates to *changes* in the exchange rate and reserves. Inclusion of the levels of reserves and the exchange rate in the V.A.R. results in the impulse response function revealing the impact of a change in the level. Clearly, then, rates of change of these two series would not be the appropriate variables to include in the V.A.R.

twelve lags and descending by one each time[12]. The results, presented in table 5 below, indicated that a four lag system was appropriate. Note, however, that the results are non-transitive. That is, it was possible to reject ten lags as a restriction on a system of eleven, but accept nine as a restriction on a system of ten. The need for parsimony indicated that it was desirable to take the lowest possible order; hence the four lag system was accepted. Also presented in the table are the marginal significance levels associated with the Chi squared statistics. The marginal significance level is the degree of confidence associated with the null hypothesis that imposition of the restriction has not changed the value of the determinant ratio. Hence the lower the marginal significance level, the greater is the degree of confidence with which one can reject the hypothesis that the imposed restriction is not binding.

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[12] These tests compare the (natural) log determinants of the covariance matrices of the restricted and unrestricted systems. Kuszczak and Murray (1987) cite Sims (1980) as the originator of this test.

Table 5

Likelihood Ratio Test Results on V.A.R. Lag Length

Lag	Chi Squared Statistic	Marginal Significance Level	Conclusion
12 vs. 11	48.36	8.17%	Accept 11
11 vs. 10	54.04	2.72%	Reject 10
10 vs. 9	44.17	16.46%	Accept 9
9 vs. 8	33.70	57.85%	Accept 8
8 vs. 7	42.22	22.00%	Accept 7
7 vs. 6	69.14	7.37%	Accept 6
6 vs. 5	41.41	24.65%	Accept 5
5 vs. 4	24.38	92.96%	Accept 4
4 vs. 3	59.95	0.74%	Reject 3
3 vs. 2	51.93	4.17%	Reject 2
2 vs. 1	79.54	0.00%	Reject 1

Note: Dropping one lag on each variable implies 6*6=36 degrees of freedom associated with the Chi squared statistics.

B) F - Statistics

With respect to the V.A.R. itself, perhaps the most enlightening statistics are the F-tests on the null hypothesis that the coefficients on a given right-hand-side variable's lags are all equal to zero[13]. Table 6 below presents the marginal significance levels for these F-tests.

[13] Regression output showing the coefficients themselves can be found in Appendix B.

Table 6

F - tests on V.A.R. Lags
Marginal Significance Levels, Null Hypothesis that all Lag Coefficients on the Independent Variable are Zero
(%)

Dependant Variable	Independent Variables					
	I*	R*	E	Res	I	R
I*	0.00	7.12	79.23	6.78	21.01	90.19
R*	79.56	0.00	91.42	83.69	21.11	60.93
E	16.28	10.82	0.00	0.01	0.38	51.49
Res	7.05	14.65	31.39	0.00	90.38	97.04
I	0.03	86.91	6.09	0.06	0.00	87.24
R	41.80	52.68	9.47	3.07	49.91	0.00

From the table it is apparent that, at the conventional 5% level, the most important variables associated with the Canadian ex ante real rate of interest are the level of reserves and the real rate itself. At the 10% level, the exchange rate is also significant. These results imply that intervention can influence the real rate, although it is not possible to infer whether the influence is positive or negative. Another result of interest is that the link between real and nominal interest rates in both Canada and the United States is exceedingly weak. That is, we can reject the hypothesis that the lags on the nominal rate are significant in explaining the real rate at the 50% level for Canada and at the 80% level for the U.S. Note also that the real rate in Canada is not directly influenced by U.S. variables, and no feedback from the Canadian to the U.S. real rate is indicated.

For the most part, the results in table 6 are in accord with standard priors. We see evidence of strong unidirectional causality from the U.S. nominal interest rate to the Canadian nominal rate. This,

combined with the links between the Canadian nominal rate and the exchange rate, accords with the usual hypothesis that a higher U.S. nominal rate leads to a higher Canadian rate to help alleviate depreciation pressure. The table also indicates the presence of the Fisher effect in Canada, in that the domestic real rate does not appear to be a significant determinant of the nominal rate. This result is consistent with Mishkin's finding, noted in chapter two. Evidence for a Fisher effect in the U.S. is weak - while the hypothesis would be rejected at the 5% level, it would not be rejected at the 10% level. The only result which appears to conflict with the small-country hypothesis is the 6.78% value for reserves in the equation for the U.S. nominal interest rate.

C) Impulse Responses

The most informative means by which to present the results of shocks to the system, or impulse responses, is pictorial. For that reason, the remainder of this chapter will rely heavily upon the graphs of the responses. The chief advantage is that the qualitative implications are readily apparent. The graphs show the response of each variable in the system to a one standard deviation shock to every variable, over a period of sixty months. Also shown in the graphs are one-standard-error bands about the response[14]. Once the bands consistently include zero, the response cannot be considered statistically significant.

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[14] In fact, what are presented are the standard errors of the posterior distribution of the responses, based upon 125 draws from the distribution. See Doan and Litterman, 1984, chapter 17, and Burbidge and Harrison, 1985, p. 790.

The obvious variable with which to begin is the ex ante real rate of interest. The next six graphs detail its response to one standard deviation shocks to the U.S. nominal interest rate, the U.S. real interest rate, the exchange rate, reserves, the (Canadian) nominal interest rate, and the real rate itself, respectively.

i) Response of the Real Interest Rate to Shocks:

a) Shock to the U.S. Nominal Interest Rate.

The first graph clearly shows the real rate being significantly displaced by a shock to the U.S. nominal rate. The greatest increase, of approximately 45 basis points, is found in the third month. The response is then mixed until a second, lower peak is reached at seven months. The displacement then falls toward the zero axis, becoming insignificantly different from zero by 40 months. The displacement is positive over the entire interval. Given that a shock to I* impacts strongly and unambiguously on I, and that an increase in I increases R, it is quite likely that the I* shock is impacting on R through I.

b) Shock to the U.S. Real Interest Rate.

The second chart shows initial upward displacement of the real interest rate, followed by a period of downward displacement. Displacement is generally positive for the first year. The depression would appear to be statistically significant until the fiftieth month.

c) Shock to the Exchange Rate.

The results of a depreciation shock to the exchange rate are mixed. The real rate responds in the first month with a positive displacement of just under 20 basis points. The second and subsequent months show a downward displacement, which remains statistically significant until

after month 24. The maximum negative displacement is just over 40 basis points.

The first month's response is consistent with the hypothesis that exchange rate depreciation can be associated with increases in the ex ante real rate of interest. The explanation for the behaviour in subsequent months likely involves a question of overshooting in the sense of the Dornbusch model, discussed in chapter two. Agents understand that the exchange rate has depreciated below its long run equilibrium level, and therefore expect it to appreciate in the future. Investment funds are thus in abundant supply in the anticipation of a capital gain, depressing real rates. Alternatively, the decrease in the real rate might be the result of a fairly rapid disequilibrium response on the part of savers who saw the initially higher real rate and increased the supply of loanable funds accordingly.

d) Shock to Reserves.

The increase in reserves is associated with a negative displacement of the real rate lasting approximately 40 months. The maximum decrease is approximately 45 basis points.

This response is particularly interesting if one considers the role of U.S. dollar reserves in foreign exchange market intervention. An increase in reserves may be the result of the purchase in the foreign exchange market of U.S. currency with Canadian dollars[15]. Such a purchase might be undertaken in order to prevent an incipient

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[15] Of course, some other asset such as gold or another currency might be used. Further, the increase in reserves may reflect U.S. dollar borrowing, as happened during a recent period of particularly low confidence in the Canadian dollar.

appreciation of the dollar. The result shown here is consistent with the hypothesis that intervention in either direction can influence the real rate. Here, prevention of an appreciation depresses the real rate; by corollary, then, prevention of a depreciation would increase the real rate.

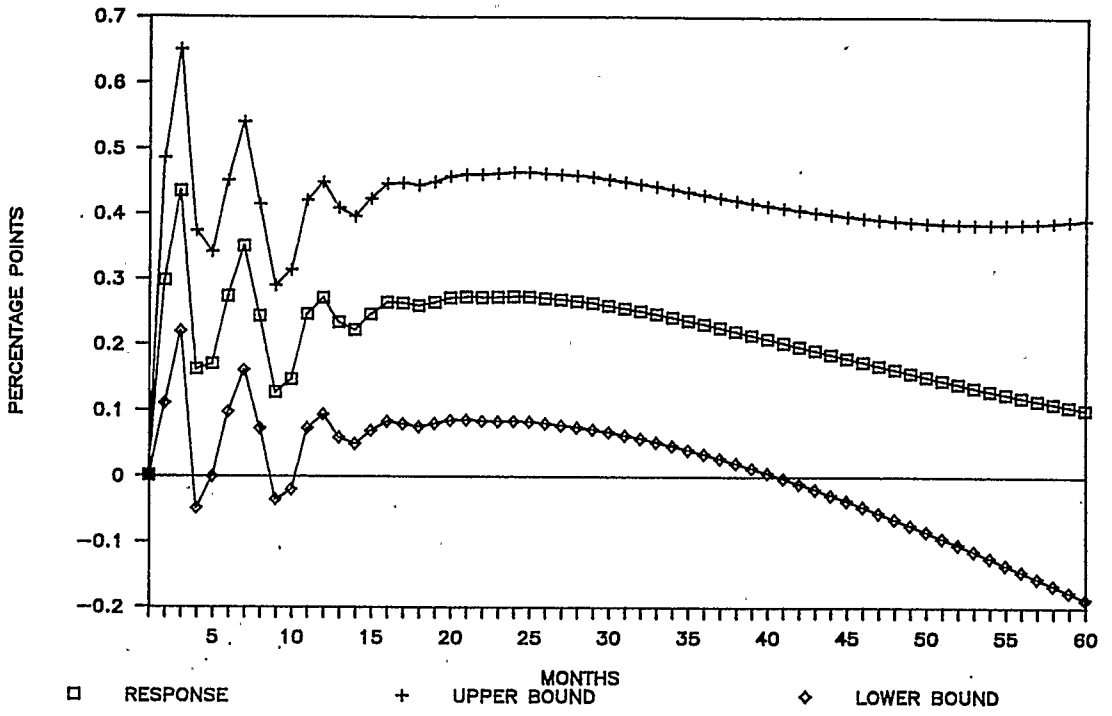
e) Shock to the Canadian Nominal Interest Rate.

A shock to the nominal rate displaces the real rate upward sharply. The response peaks first in month four at more than 35 basis points. A second, higher peak is reached in month six at approximately 40 basis points; the response declines thereafter. The upper bound dips below zero slightly from month 30 to month 45 - the implied depression of the real rate is very likely spurious. These results clearly imply a strong positive relationship between the nominal and real rates in the short run.

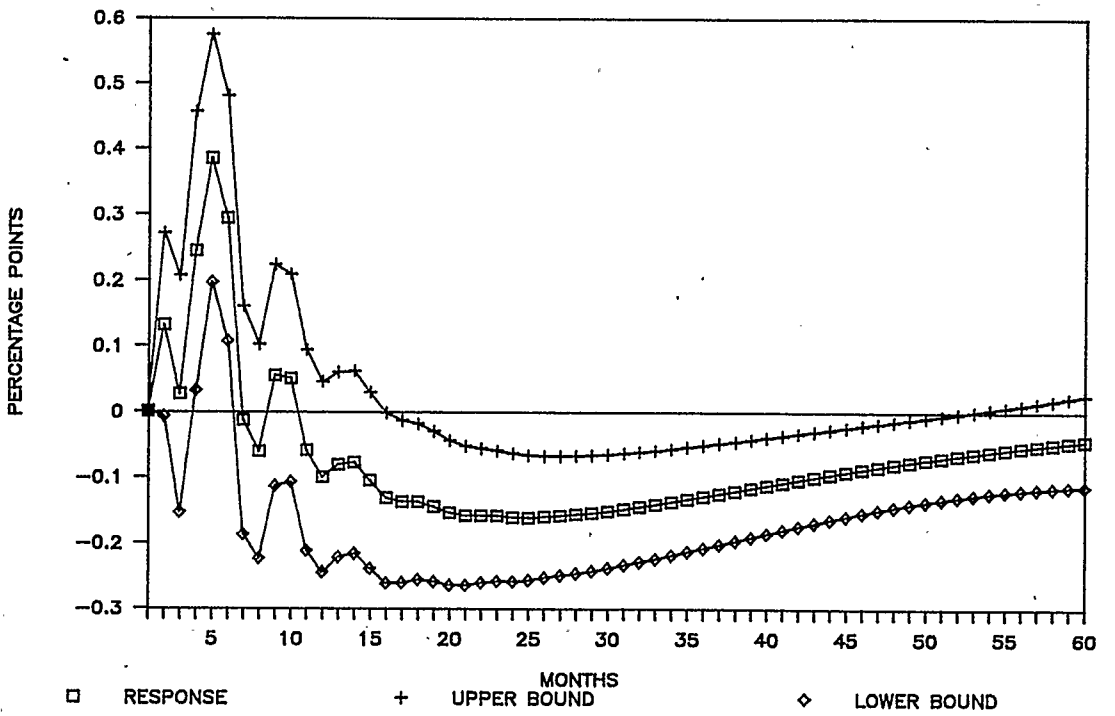
f) Own Response.

The shock to the real rate is a comparatively large one at more than 160 basis points. The responses becomes insignificant very quickly - the shock dies out before the fifth month.

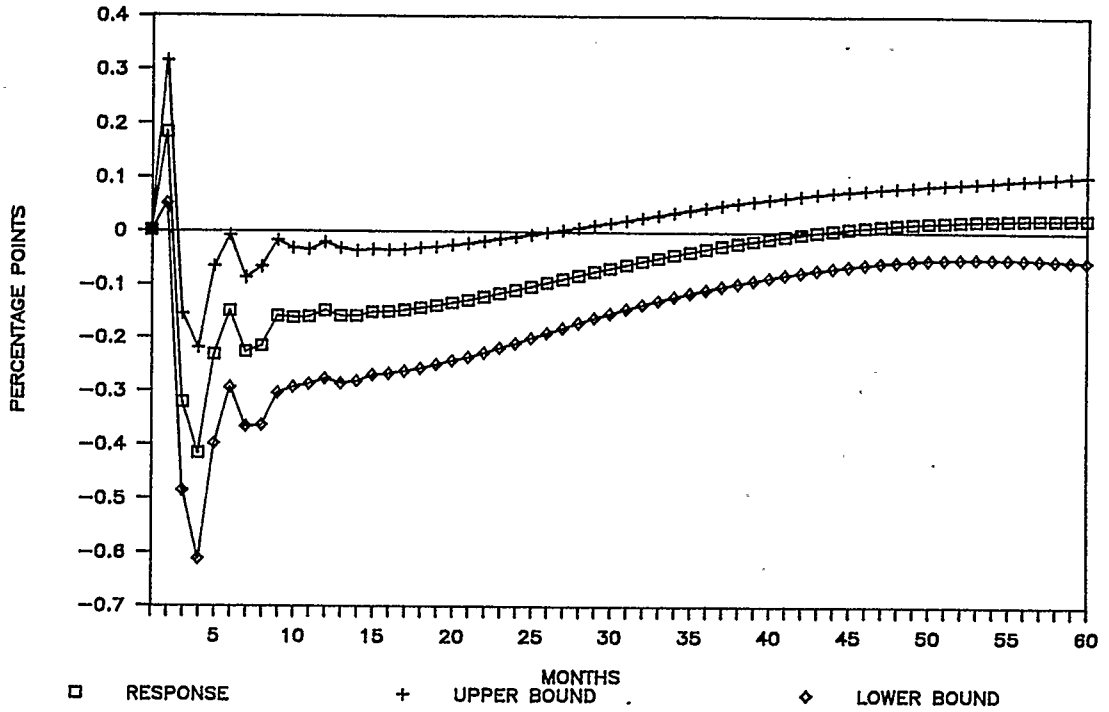
SHOCK TO I* — RESPONSE OF R



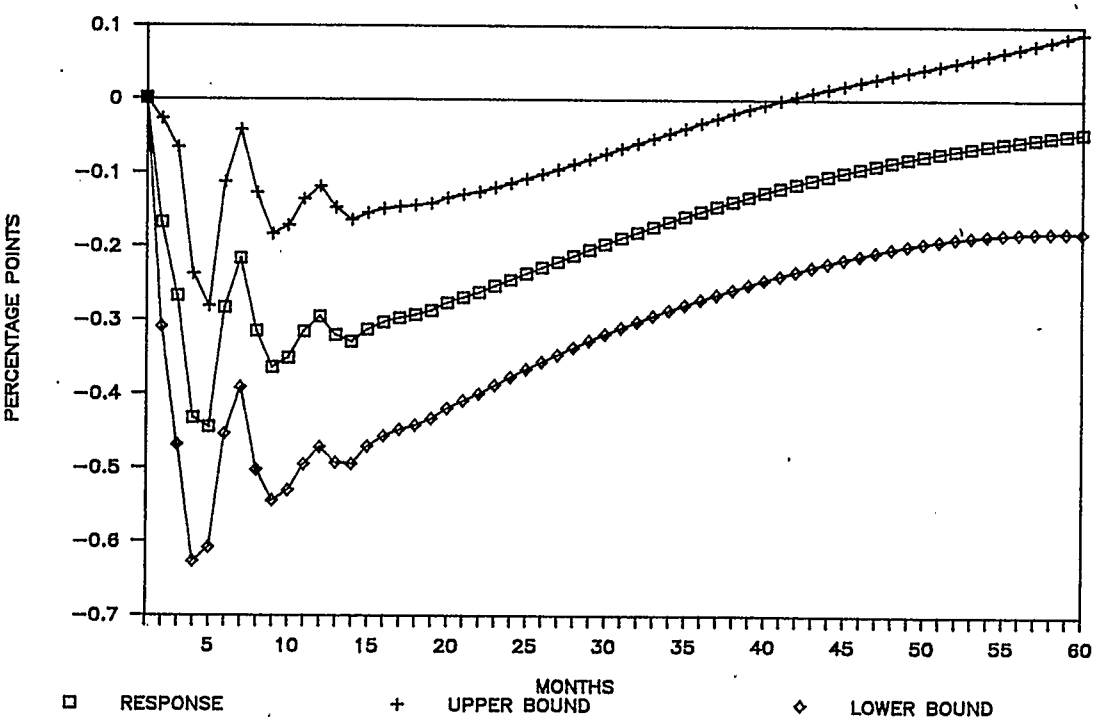
SHOCK TO R* — RESPONSE OF R



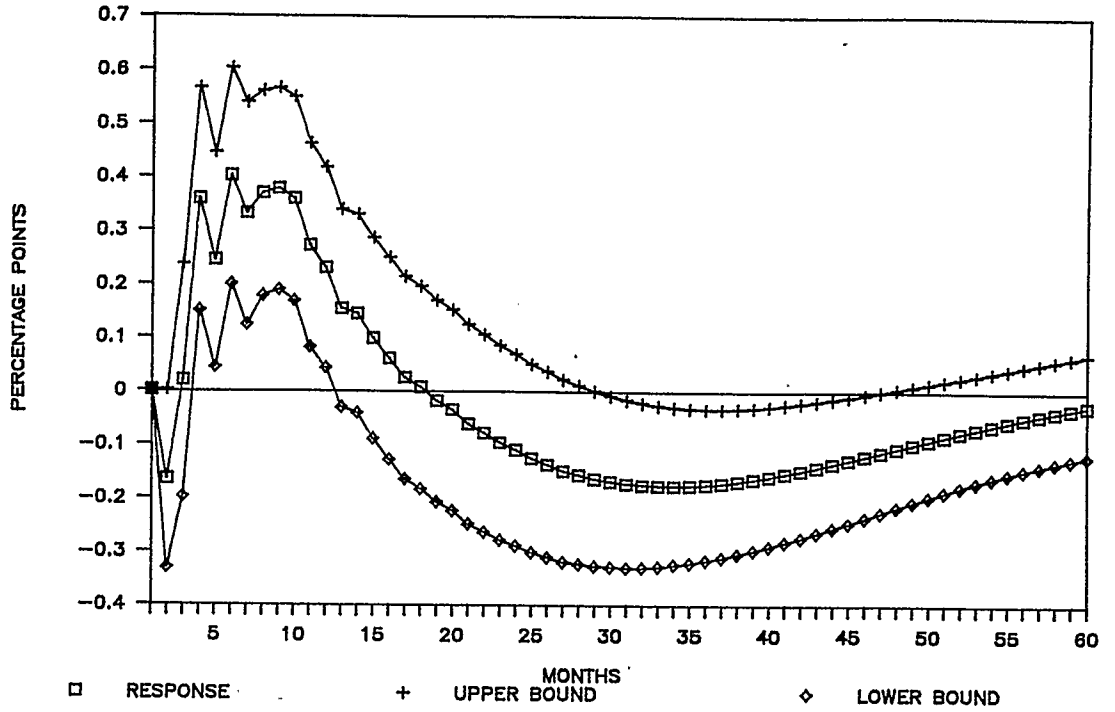
SHOCK TO E — RESPONSE OF R



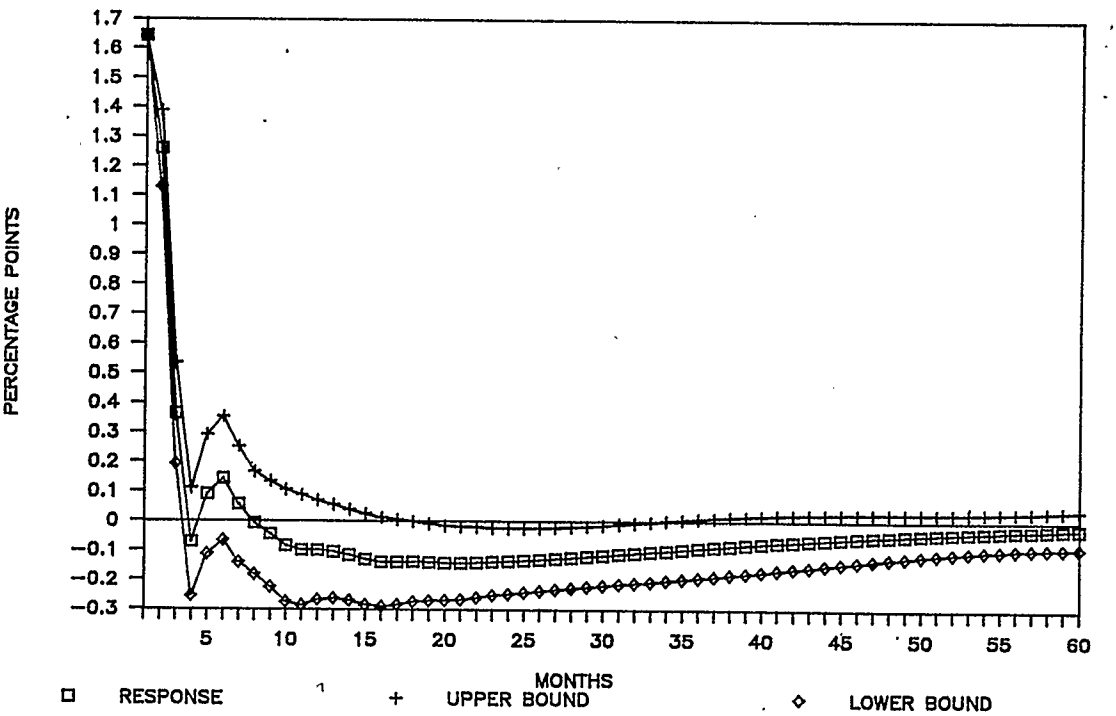
SHOCK TO RESERVES — RESPONSE OF R



SHOCK TO I — RESPONSE OF R



SHOCK TO R — OWN RESPONSE



ii) Response of the Nominal Interest Rate to Shocks:

a) Shock to the U.S. Nominal Interest Rate.

The graph indicates an impressively strong direct relationship between nominal rates in the two countries. The shock to the U.S. rate is approximately 110 basis points. The domestic rate is higher by 40 to 60 basis points until the response ceases to be significant after more than 35 months. Such data are consistent with tighter financing in Canada following an outflow of funds to the United States. They are also consistent with central bank intervention to mitigate depreciation pressure.

b) Shock to the U.S. Real Interest Rate.

The graph indicates an initial positive displacement, to a maximum of about 15 basis points. The nominal rate is then depressed for 34 months, after which the response ceases to be significant. The maximum depression exceeds 30 points.

c) Shock to the Exchange Rate.

The results shown appear at first glance to be at odds with standard priors. A depreciation is shown to be associated with a decrease in the nominal interest rate of almost 35 basis points by the seventh period. The interest rate then returns to its original level, the response becoming insignificant by period 24.

A plausible interpretation of this result is that a large depreciation shock inspires the expectation of an appreciation, permitting the maintenance of a lower domestic nominal rate than would otherwise be the case. Note that we would expect a higher nominal interest rate in response to an incipient depreciation. A large

realized depreciation from the equilibrium exchange rate would be expected to correct itself - it would be interpreted as overshooting. In the anticipation of an appreciating exchange rate, the authorities could permit a lower nominal interest rate to prevail in Canada without encouraging adverse capital flows.

d) Shock to Reserves.

An exogenous increase in reserves is associated with a significant downward displacement in the nominal interest rate. The trough is reached at around period 15, at more than 50 basis points. The displacement then tends back toward zero, becoming insignificant after 40 months. Such a response is consistent with the following series of events. The Canadian dollar is perceived to be relatively strong. The authorities take advantage of the situation to increase reserves of U.S. dollars, purchasing them with Canadian currency. The increase in the domestic money supply so entailed depresses the nominal interest rate.

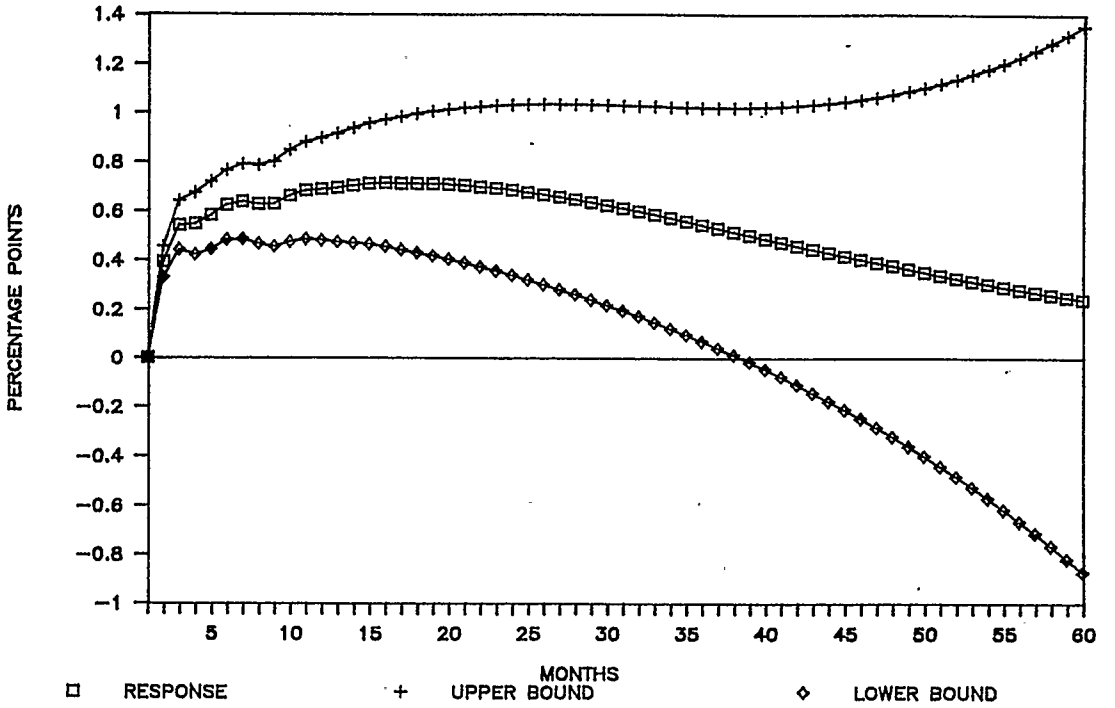
e) Own Response.

The shock to the nominal rate implies an initial increase of approximately 60 basis points. The displacement quickly tends toward zero, crossing the axis after period seven.

f) Response to a Real Interest Shock.

The graph indicates that a domestic real interest rate shock may exert some upward pressure on the nominal rate. While the lower bound is slightly above zero for several periods, the response is most likely spurious.

SHOCK TO I* — RESPONSE OF I



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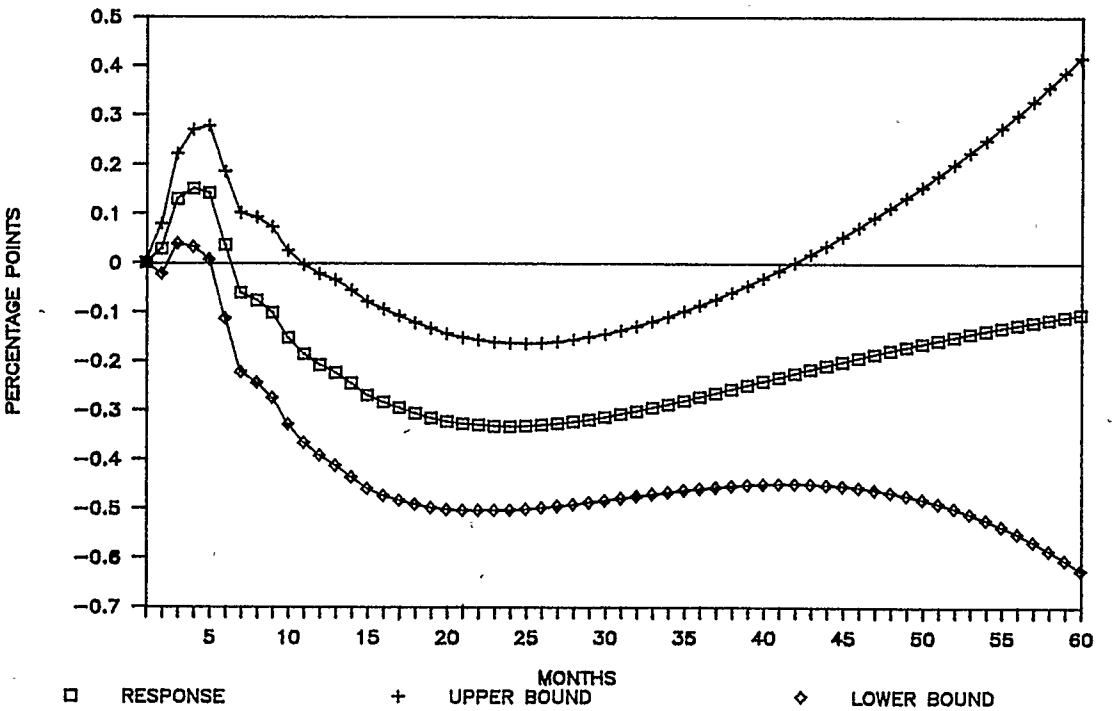
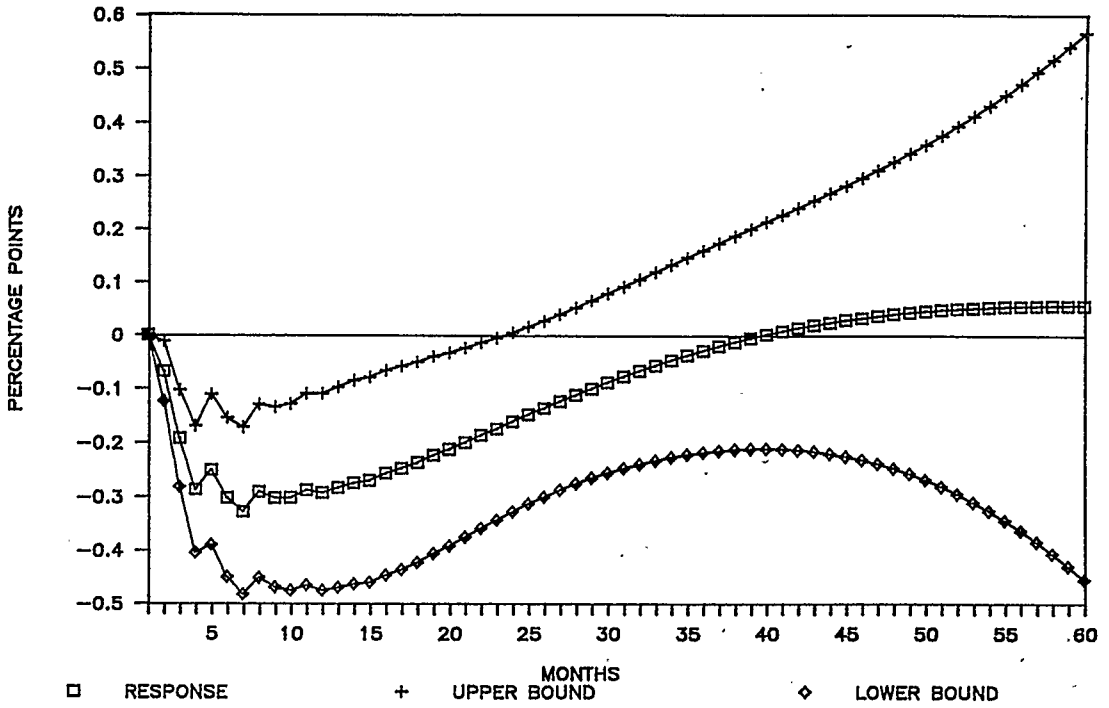
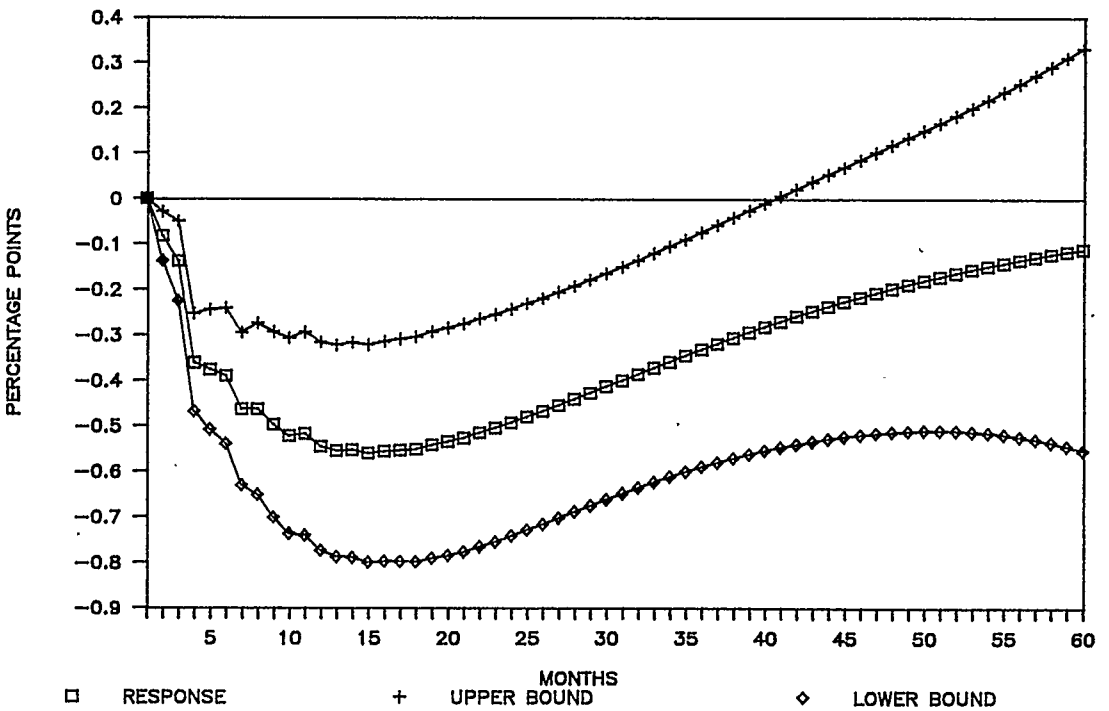


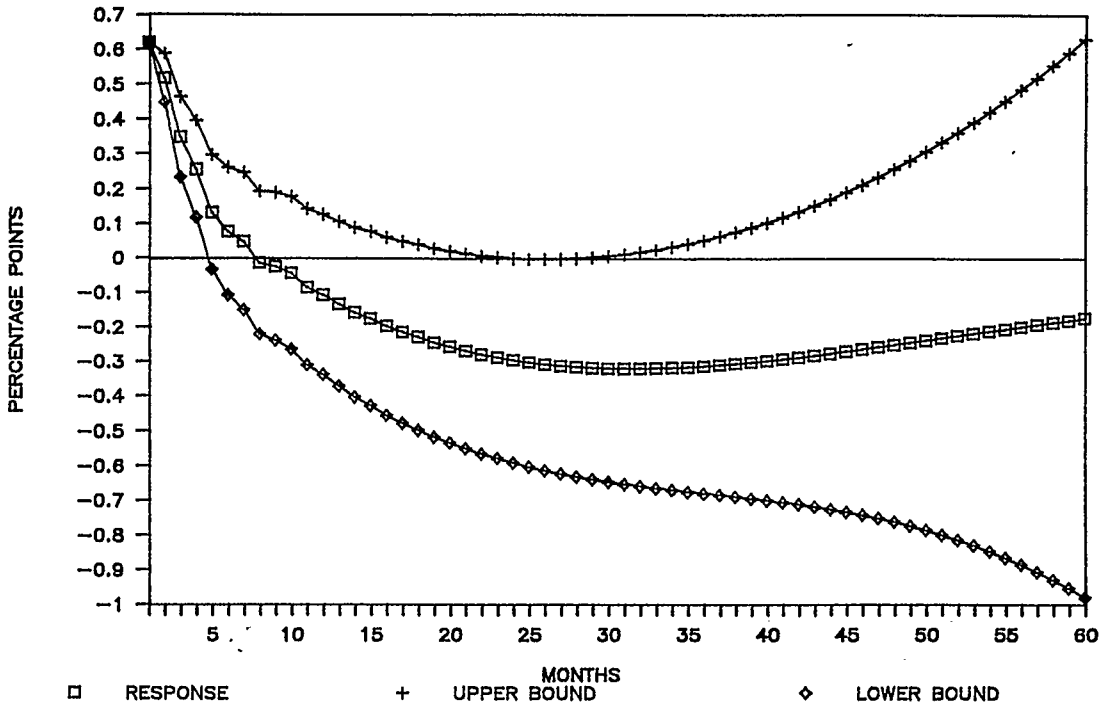
SHOCK TO E — RESPONSE OF I



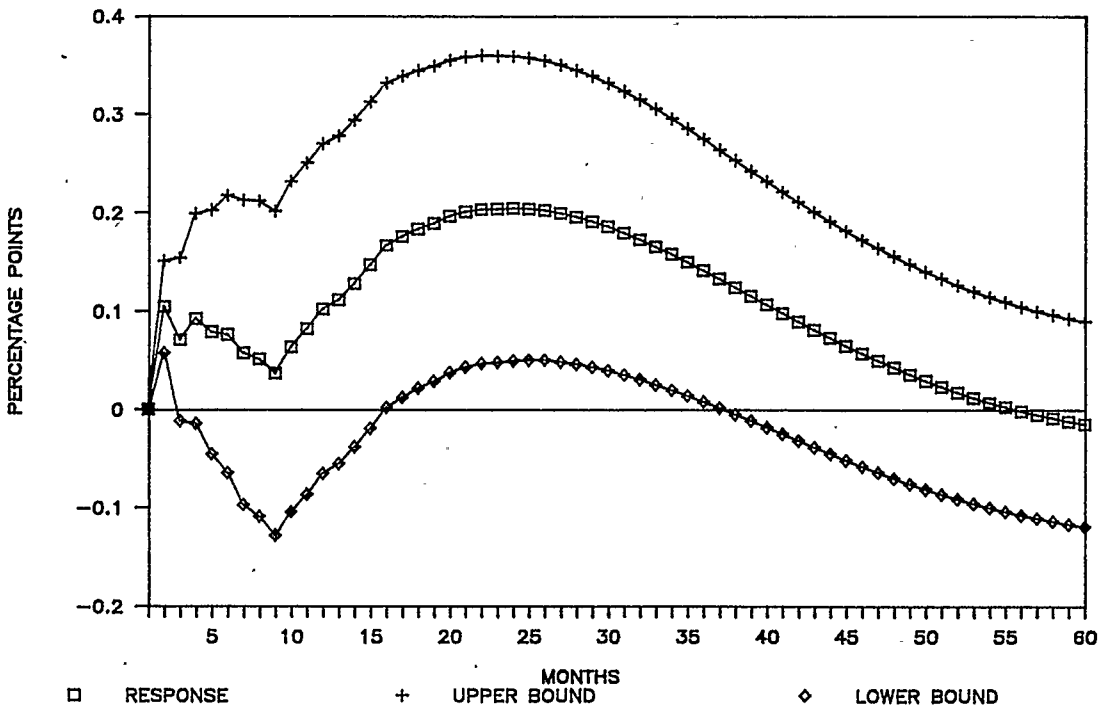
SHOCK TO RESERVES — RESPONSE OF I



SHOCK TO I — OWN RESPONSE



SHOCK TO R — RESPONSE OF I



iii) Response of the Exchange Rate to Shocks

In interpreting the following graphs, note that the variable used in the V.A.R. was the natural log of the exchange rate expressed as Canadian cents per U.S. dollar. A positive response therefore indicates a depreciation of the Canadian currency.

a) Shock to the U.S. Nominal Interest Rate.

An initial-period increase in the U.S. nominal rate of approximately 110 basis points provokes a depreciation of the exchange rate. The dollar is depressed for six periods. The displacement then tends toward zero, ceasing to be statistically significant after one year. This result is consistent with the occurrence of capital outflows to the United States following a narrowing of the nominal interest rate differential.

b) Shock to the U.S. Real Interest Rate.

An increase in the foreign real rate appears to imply a depreciation of the Canadian dollar, peaking in the third period. The positive displacement is not statistically significant after this point. This is not indicative of a strong response.

c) Own Response.

The graph indicates that the depreciation shock lasts for approximately 16 months.

d) Shock to Reserves.

A shock to official reserves of U.S. dollars is followed by an appreciation of the Canadian dollar. Peak displacement occurs in period five. The response remains significant for some twelve periods. A possible interpretation is that an increase in reserves from foreign borrowing on the part of the authorities demonstrates the government's

willingness to defend the currency, thereby enhancing agents' confidence.

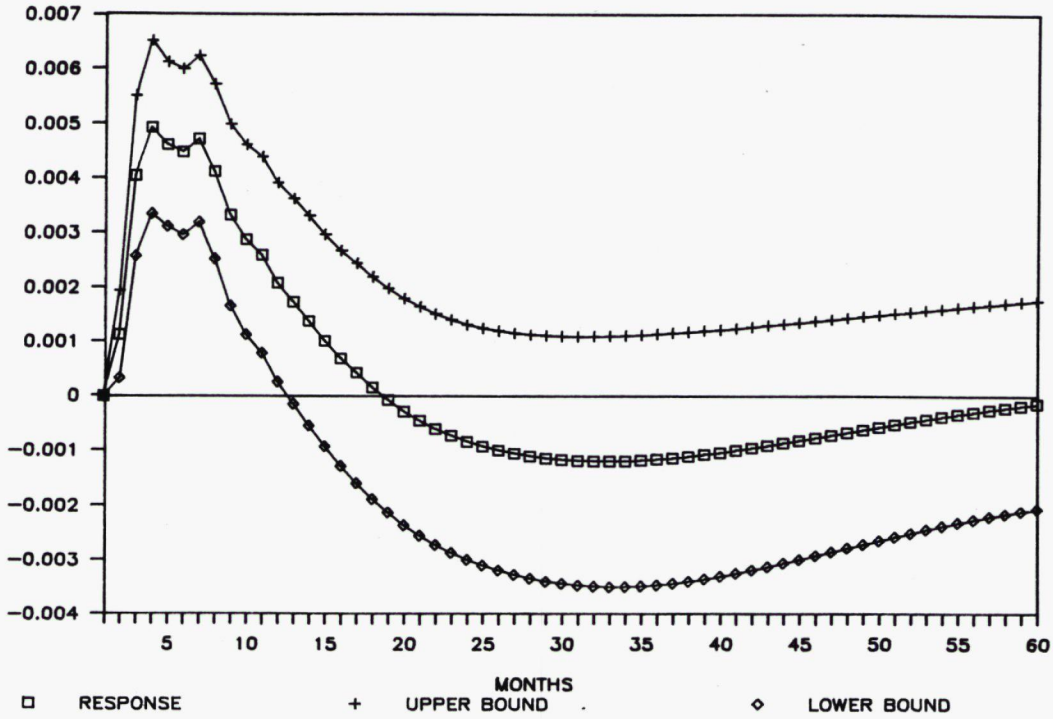
e) Shock to the Nominal Interest Rate.

The increase in the nominal rate is followed by an appreciation of the dollar which peaks in the sixth period. The exchange rate then tends back toward its initial value, the response ceasing to be statistically significant by month 20. This result is entirely in accord with the standard expectation of a higher interest rate attracting capital flows and placing appreciation pressure on the dollar.

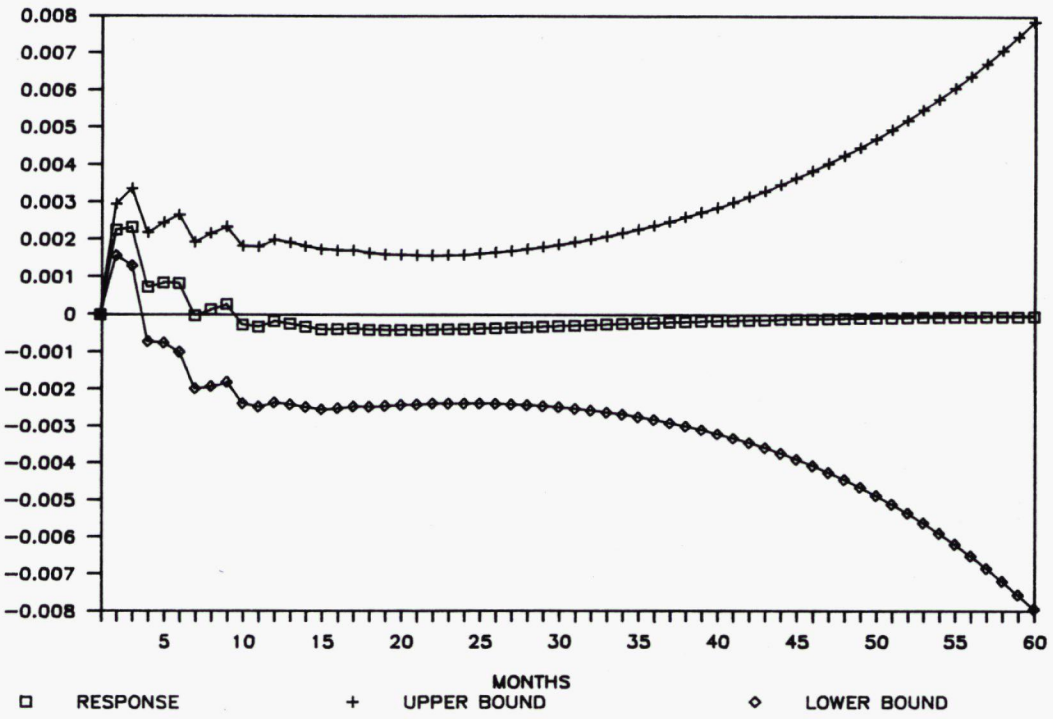
f) Shock to the Real Interest Rate.

No statistically significant impact is indicated.

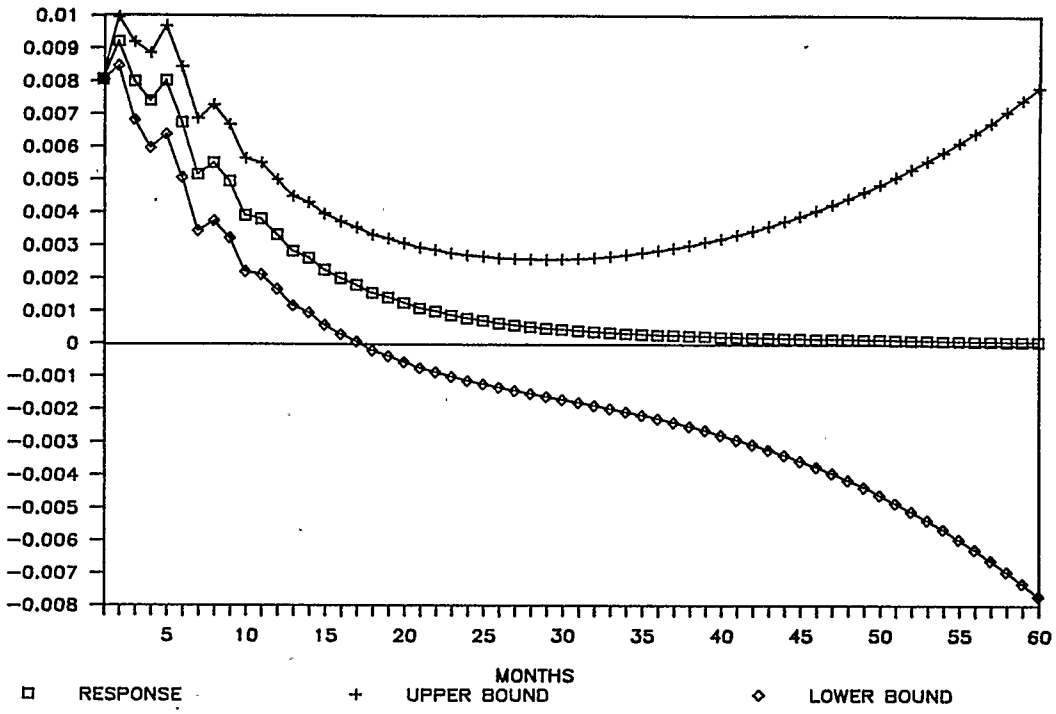
SHOCK TO I* – RESPONSE OF E



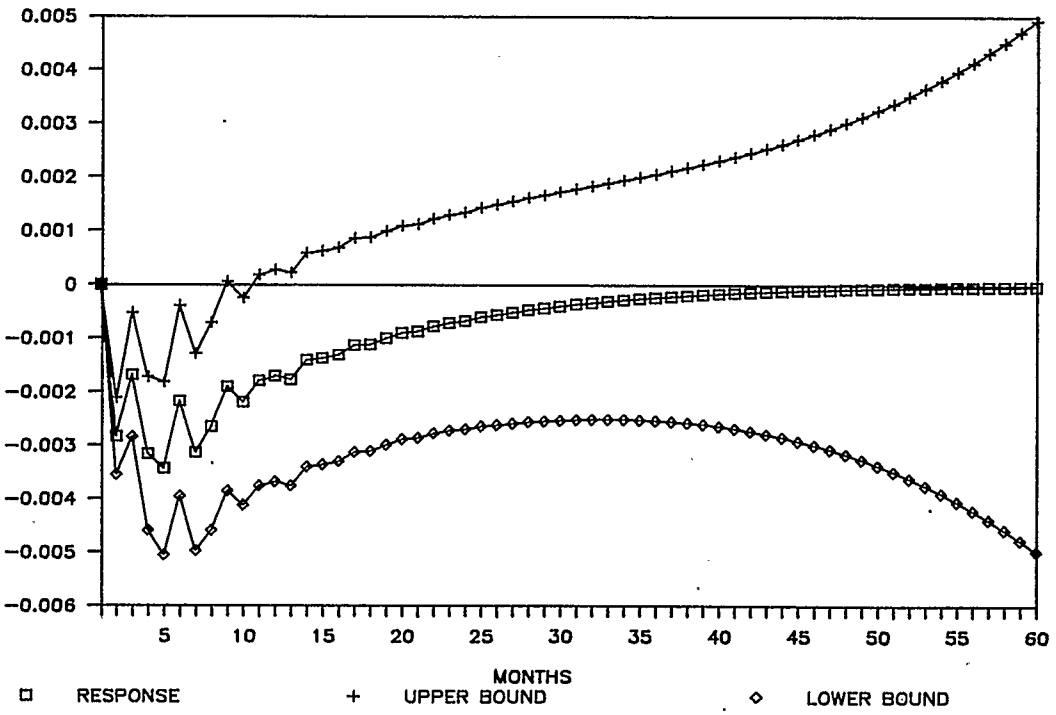
SHOCK TO R* – RESPONSE OF E



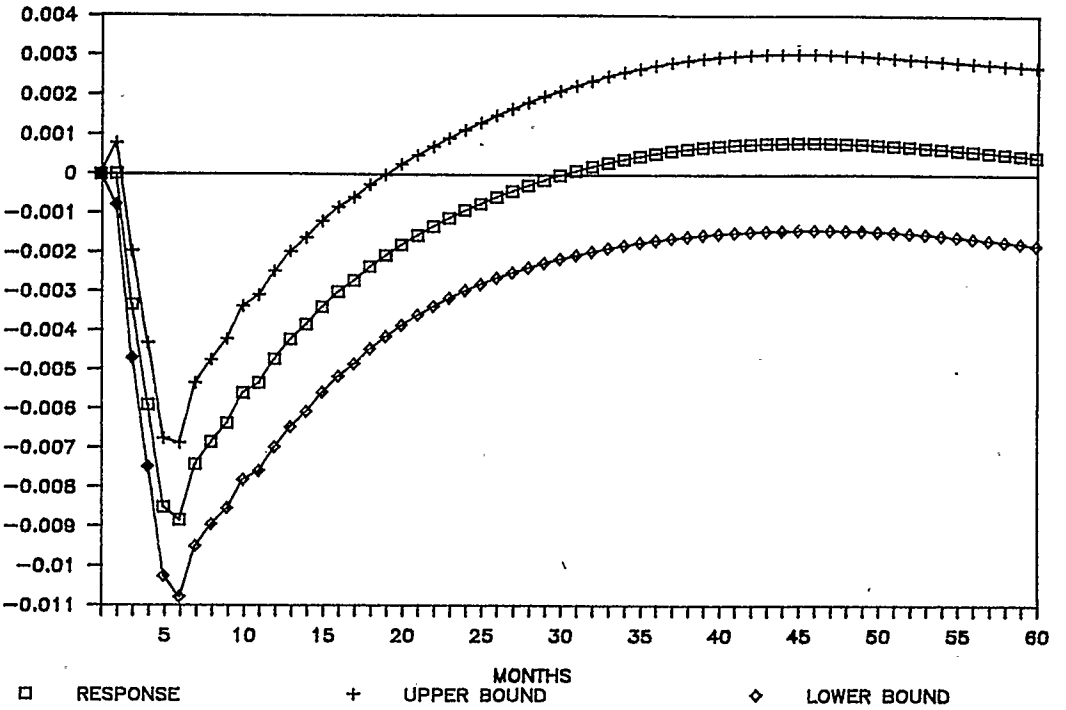
SHOCK TO E — OWN RESPONSE



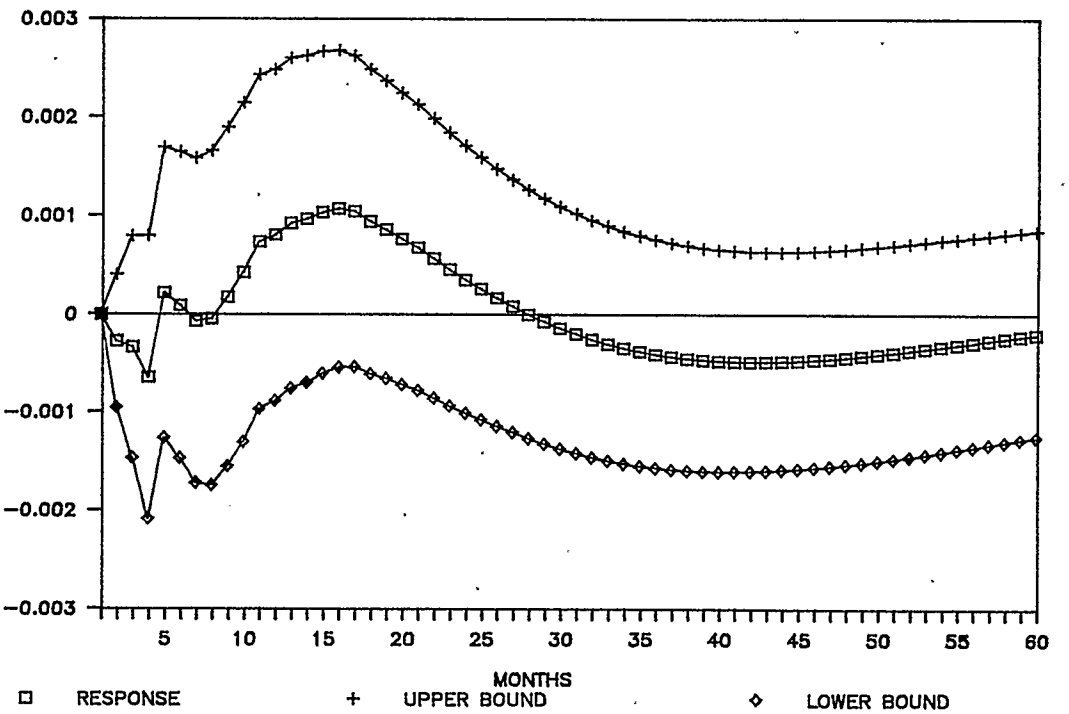
SHOCK TO RESERVES — RESPONSE OF E



SHOCK TO I — RESPONSE OF E



SHOCK TO R — RESPONSE OF E



iv) Response of Canadian Reserves of U.S. Dollars to Shocks

Reserves can be considered an endogenous variable only in the case of a fixed policy rule or reaction function. The results below are presented primarily for completeness. The question of a stable reaction function is beyond the scope of the present research; interpretation is therefore to some extent a question of the reader's experience and/or priors. In the comments which follow, the implicit assumption is one of a consistent use of reserves by policy makers to mitigate exchange rate movements.

a) Shock to the U.S. Nominal Interest Rate.

A higher foreign nominal rate is associated with a negative displacement in reserves. The greatest impact is seen in the fourth period, with the response continuing to be significantly negative until month 35. This result is clearly compatible with intervention to mitigate exchange rate depreciation.

b) Shock to the U.S. Real Interest Rate.

Reserves are initially depressed, but are then displaced upward in subsequent periods. The shock is significant until month 39.

c) Shock to the Exchange Rate.

A depreciation shock leads to a decrease in reserves in the first month, and upward displacement thereafter. While the lower bound takes two years to return to the zero axis, it is reasonably close for most of the period, implying that the upward displacement is not particularly strong.

d) Own Response.

The reserves shock is relatively long-lasting, taking three years to die out.

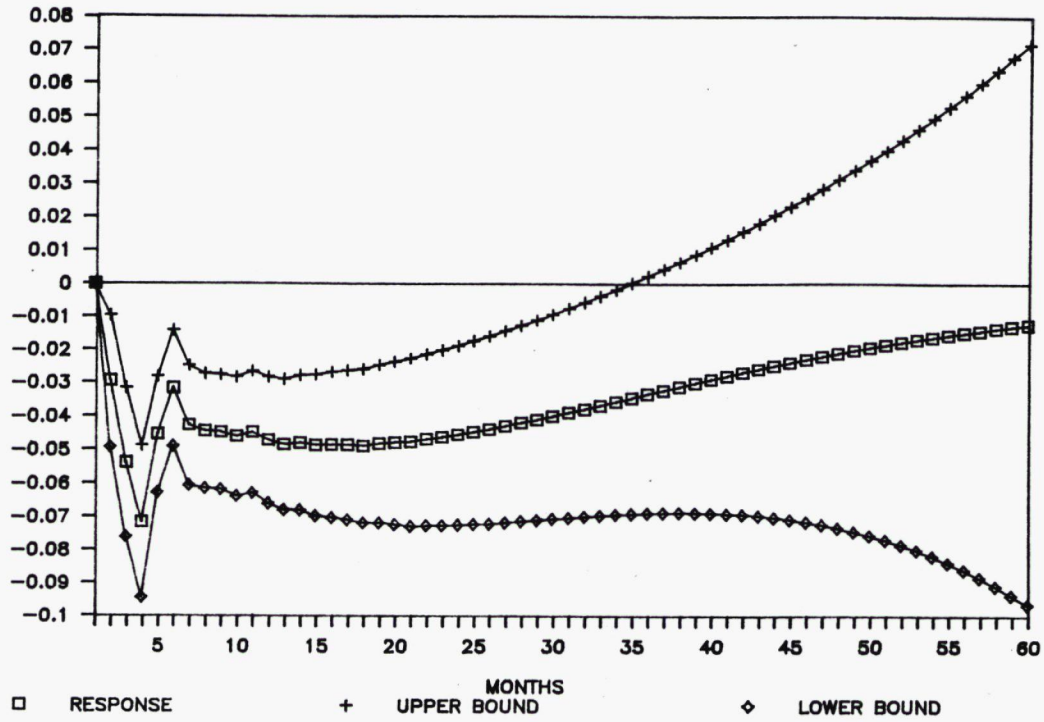
e) Shock to Nominal Interest Rate.

The graph indicates essentially no significant response. This may imply that the authorities are less strongly inclined to resist appreciation than depreciation. In other words, exchange rate policy might follow what has been termed a "convenient float".

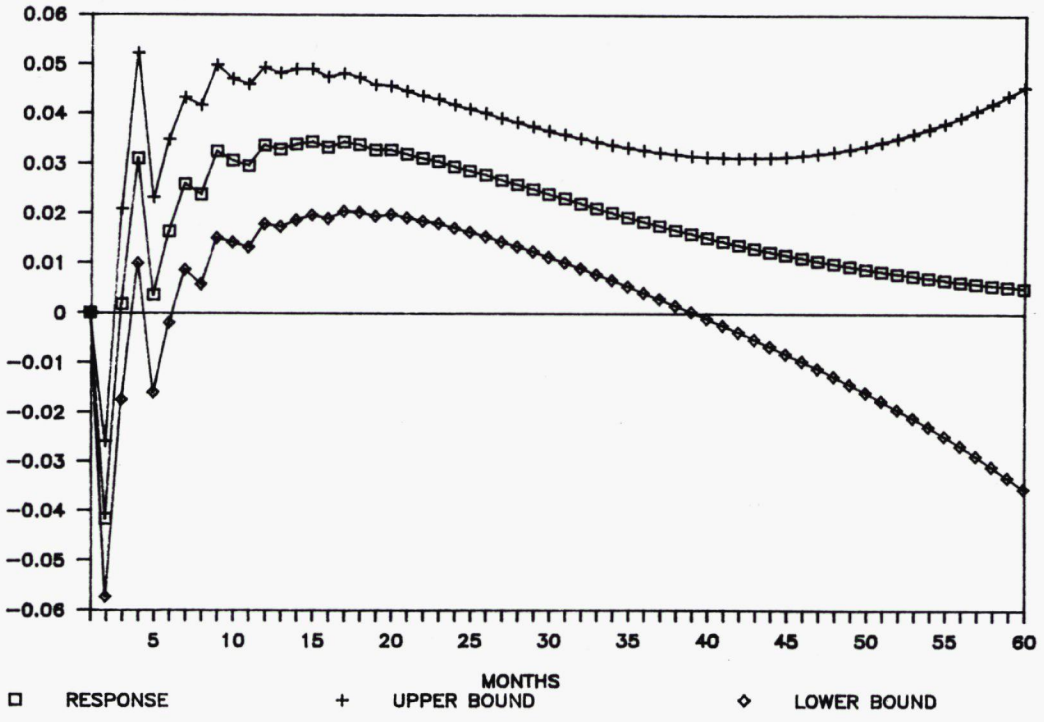
f) Shock to the Real Interest Rate.

No statistically significant response is indicated.

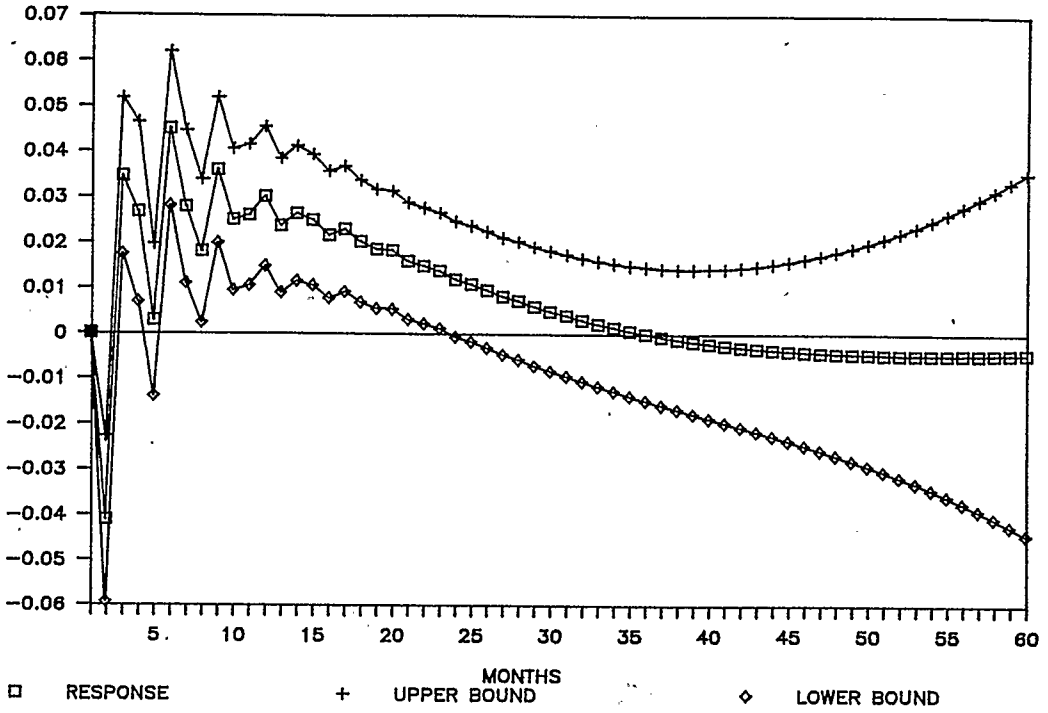
SHOCK TO I* — RESPONSE OF RESERVES



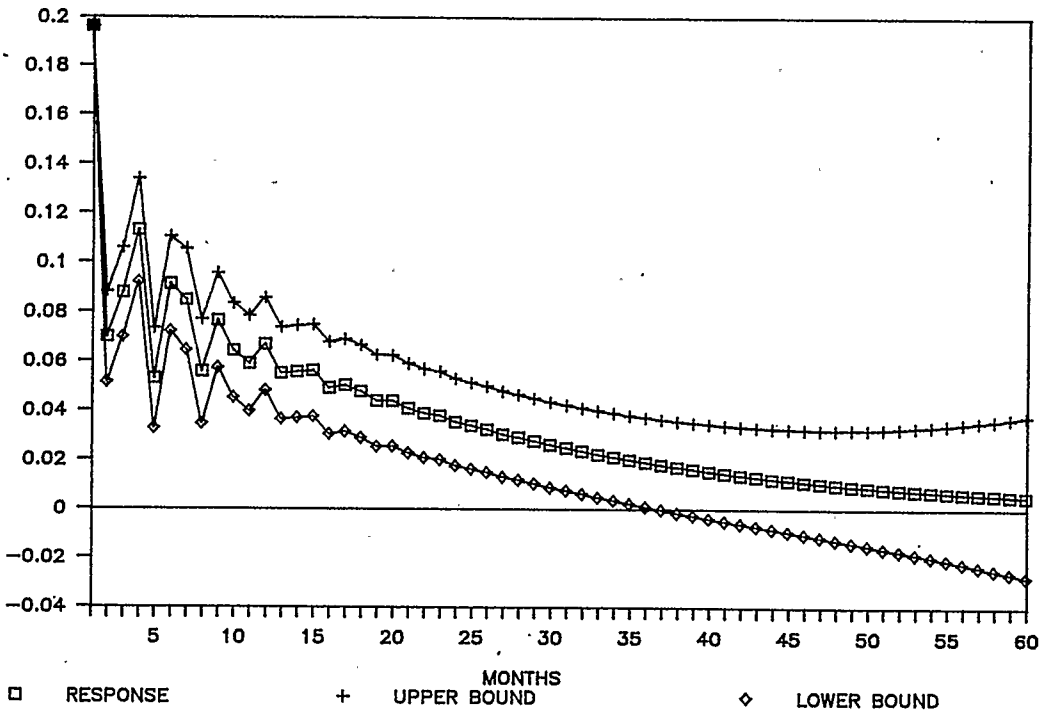
SHOCK TO R* — RESPONSE OF RESERVES



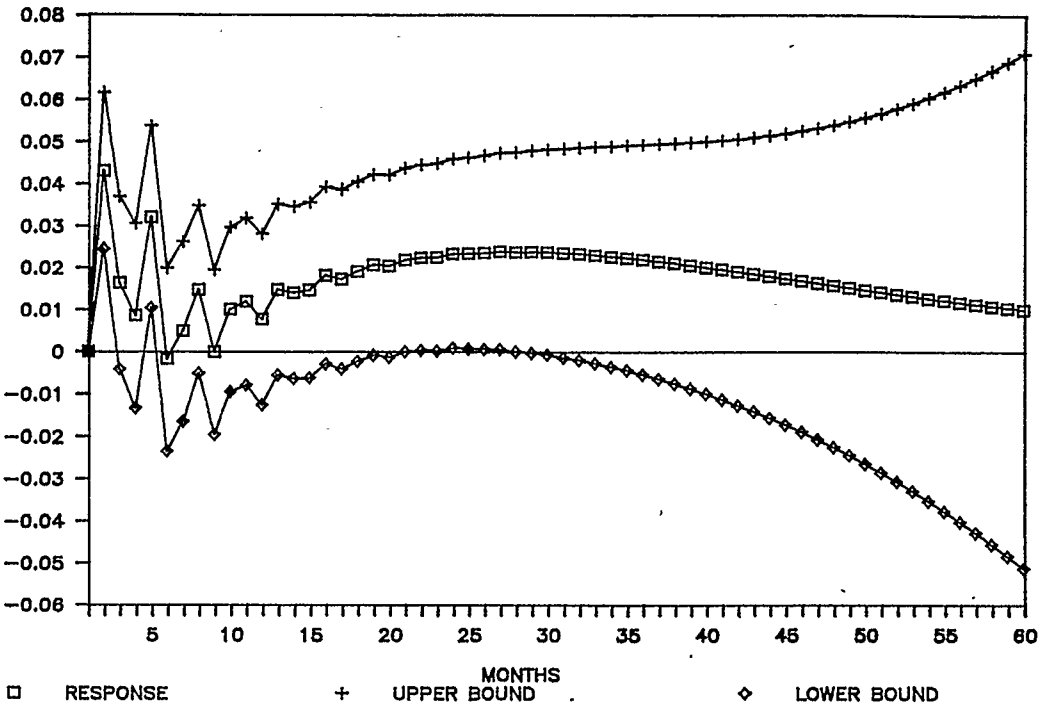
SHOCK TO E – RESPONSE OF RESERVES



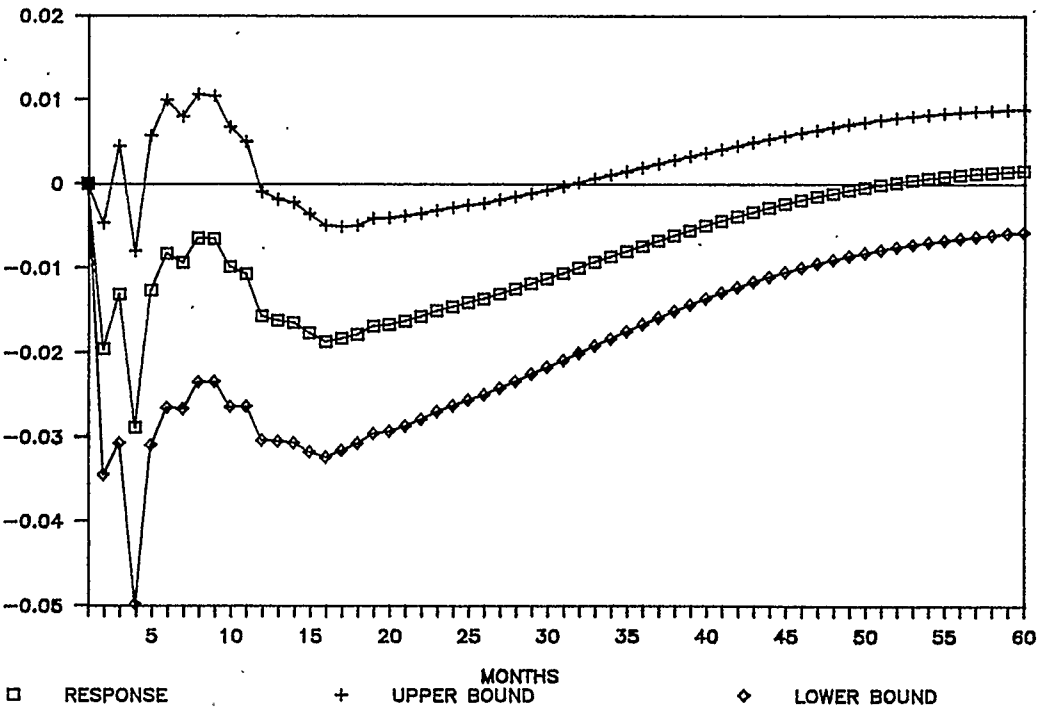
SHOCK TO RESERVES – OWN RESPONSE



SHOCK TO I — RESPONSE OF RESERVES



SHOCK TO R — RESPONSE OF RESERVES



v) Response of the U.S. Nominal Interest Rate to Shocks

a) Own Response.

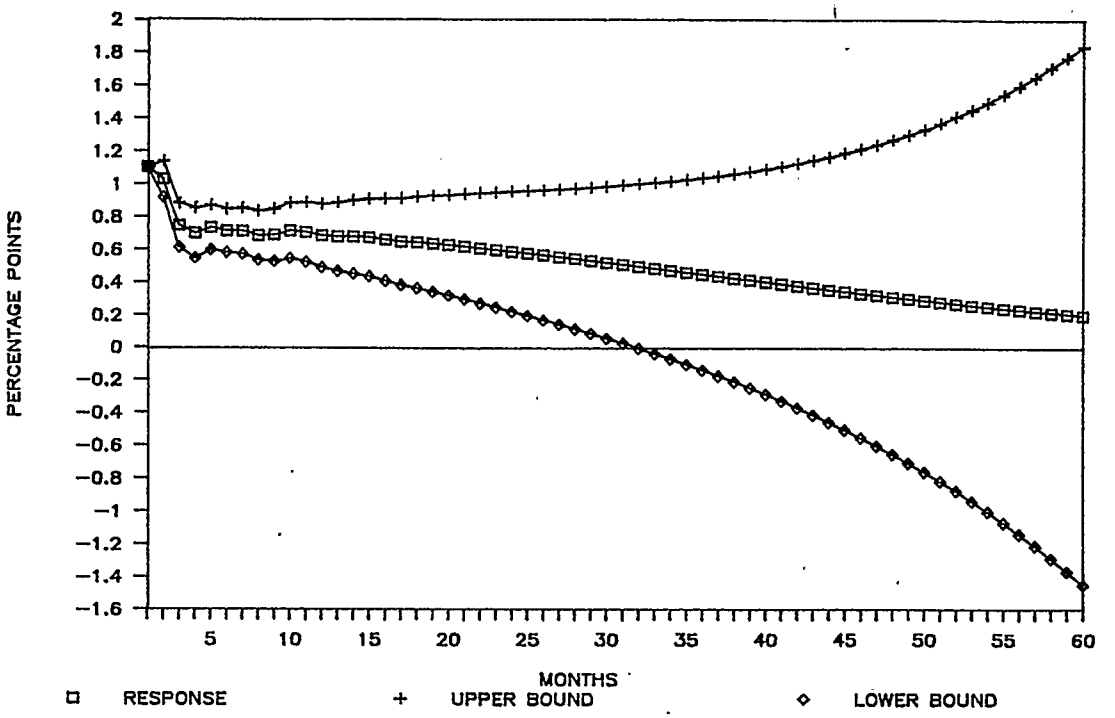
A shock to the foreign nominal rate implies an upward displacement on the order of 110 basis points. The shock is relatively long lasting, taking almost three years to subside.

b) Shock to the U.S. Real Interest Rate.

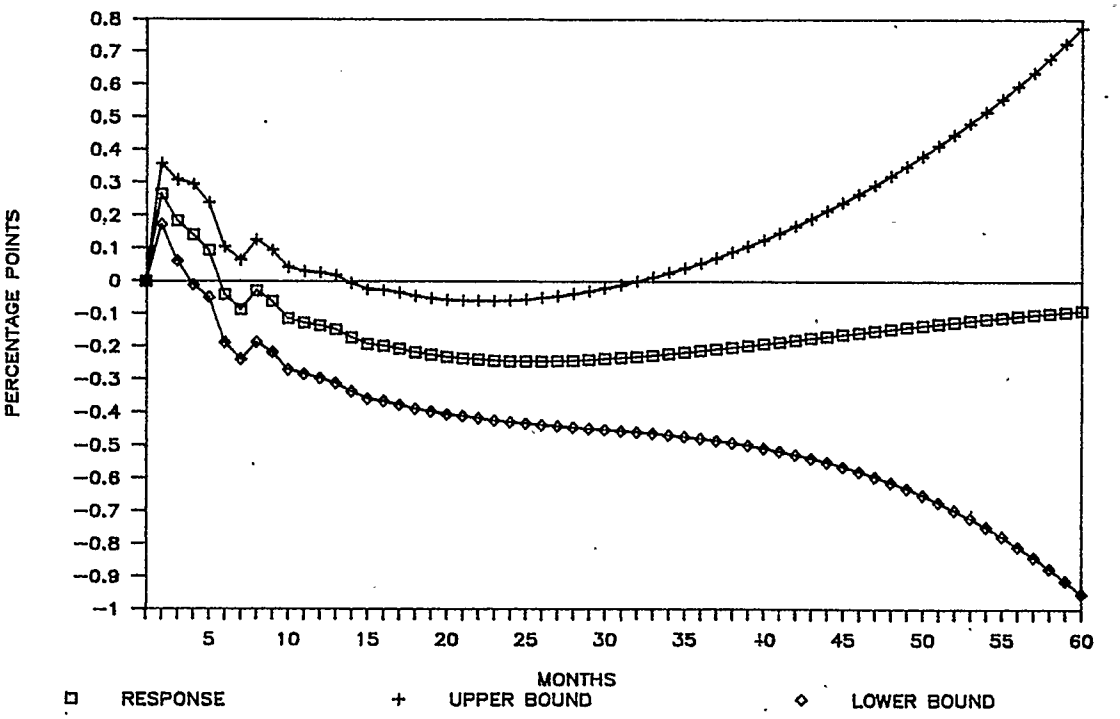
A shock to the foreign real rate yields a small upward displacement in the foreign nominal rate lasting four periods. The highest displacement of just under 30 basis points occurs in the second period. This result is consistent with that indicated in table 6.

No statistically significant response to a shock to any other variable in the model is indicated.

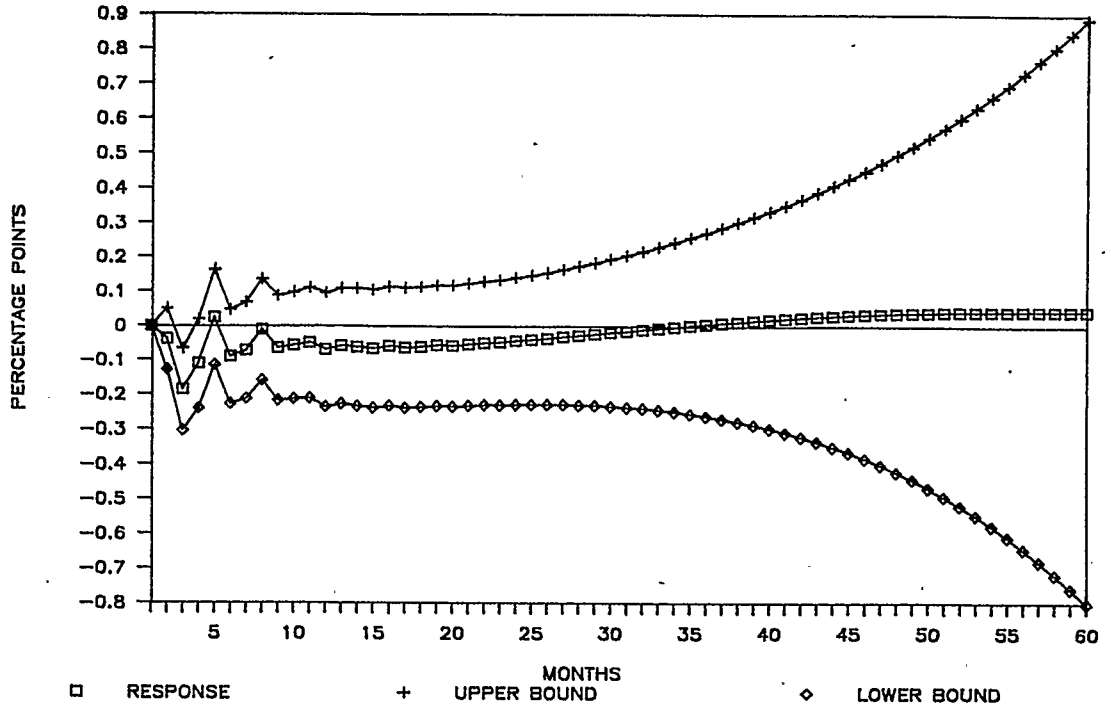
SHOCK TO I* — OWN RESPONSE



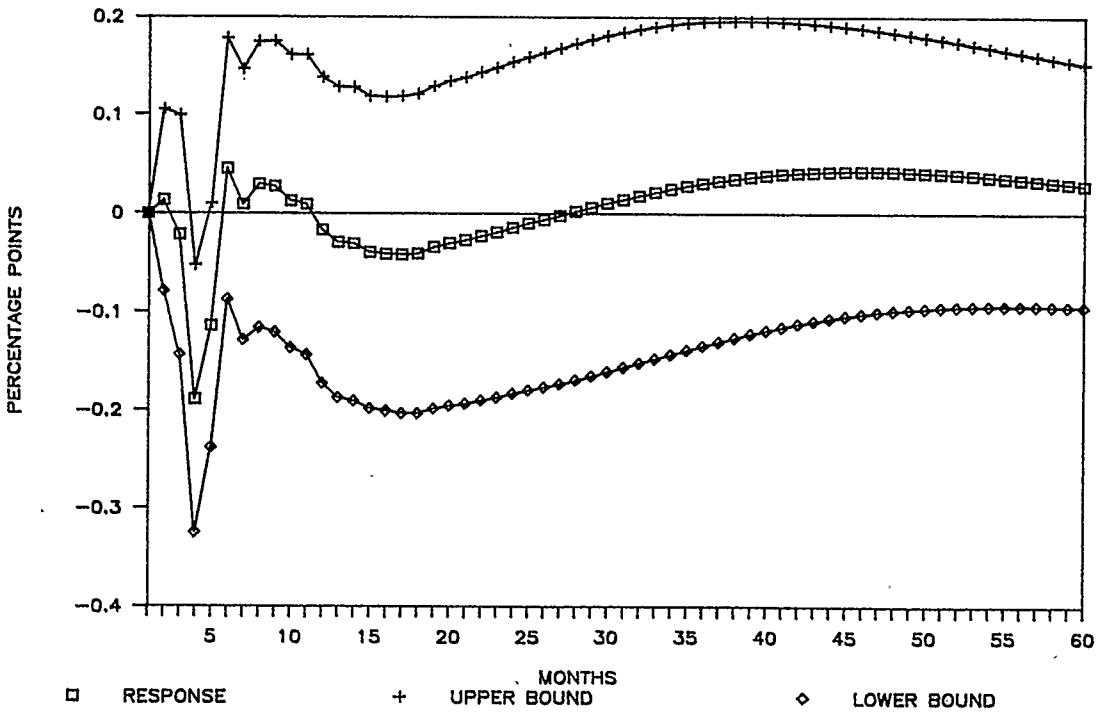
SHOCK TO R* — RESPONSE OF I*



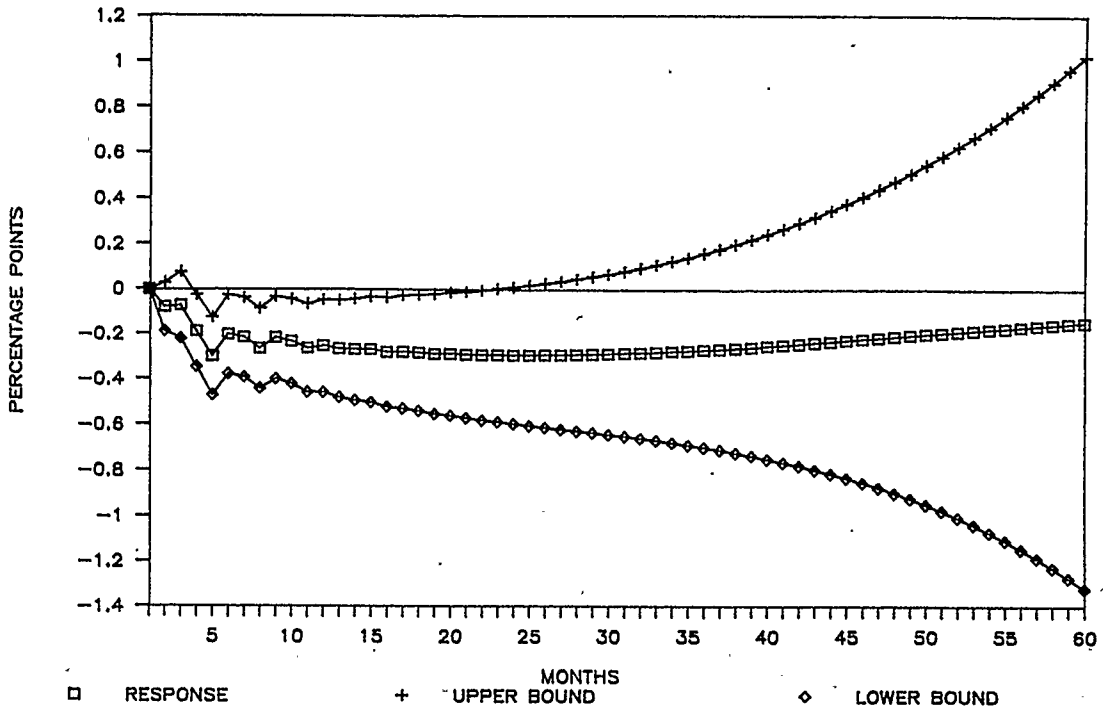
SHOCK TO E — RESPONSE OF I*



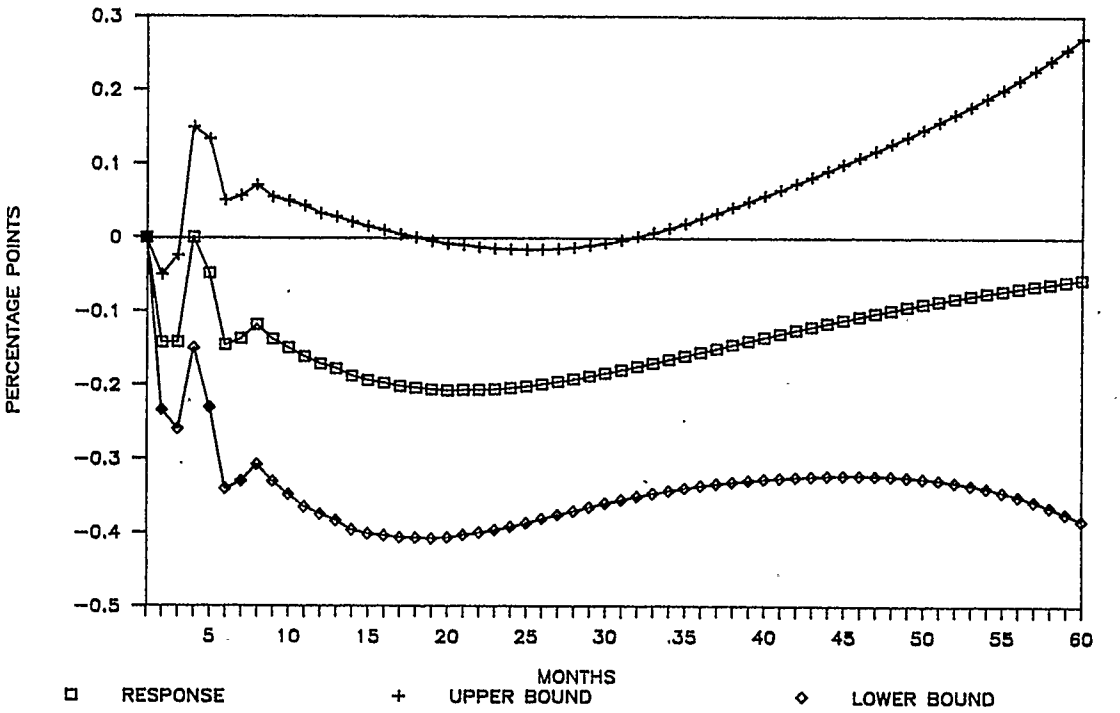
SHOCK TO RESERVES — RESPONSE OF I*



SHOCK TO I — RESPONSE OF I*



SHOCK TO R — RESPONSE OF I*



vi) Response of the U.S. Real Interest Rate to Shocks

a) Shock to the U.S. Nominal Rate.

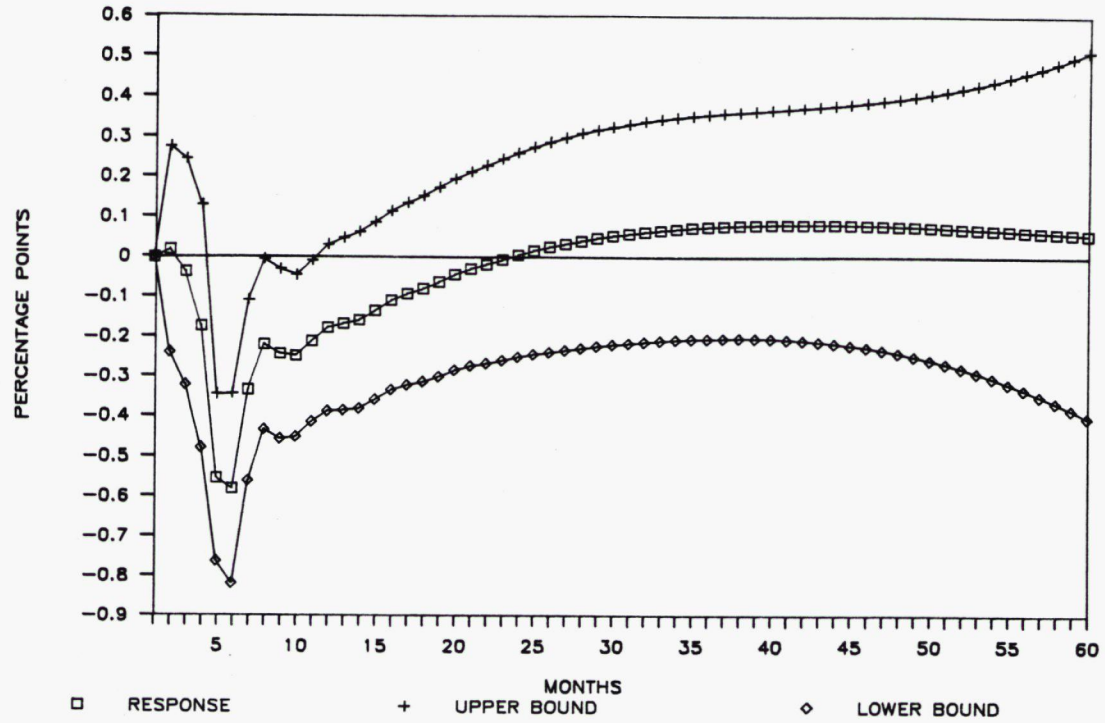
An increase in the foreign nominal rate is associated with a negative displacement in the foreign real rate for the first year. The maximum response in this interval is 50 basis points. Thereafter, the response is not significant.

b) Own Response.

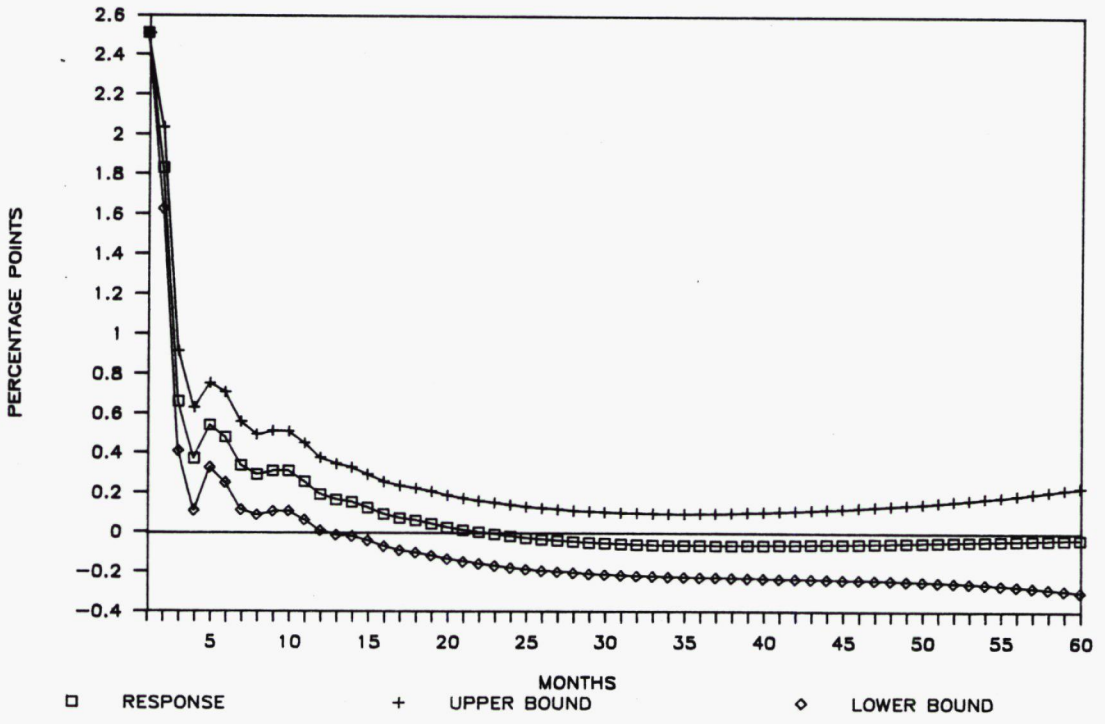
The response is similar to the domestic case. The shock in magnitude is relatively large, at 250 basis points. It returns to zero quite quickly, within twelve periods.

No statistically significant response to any other variable is indicated.

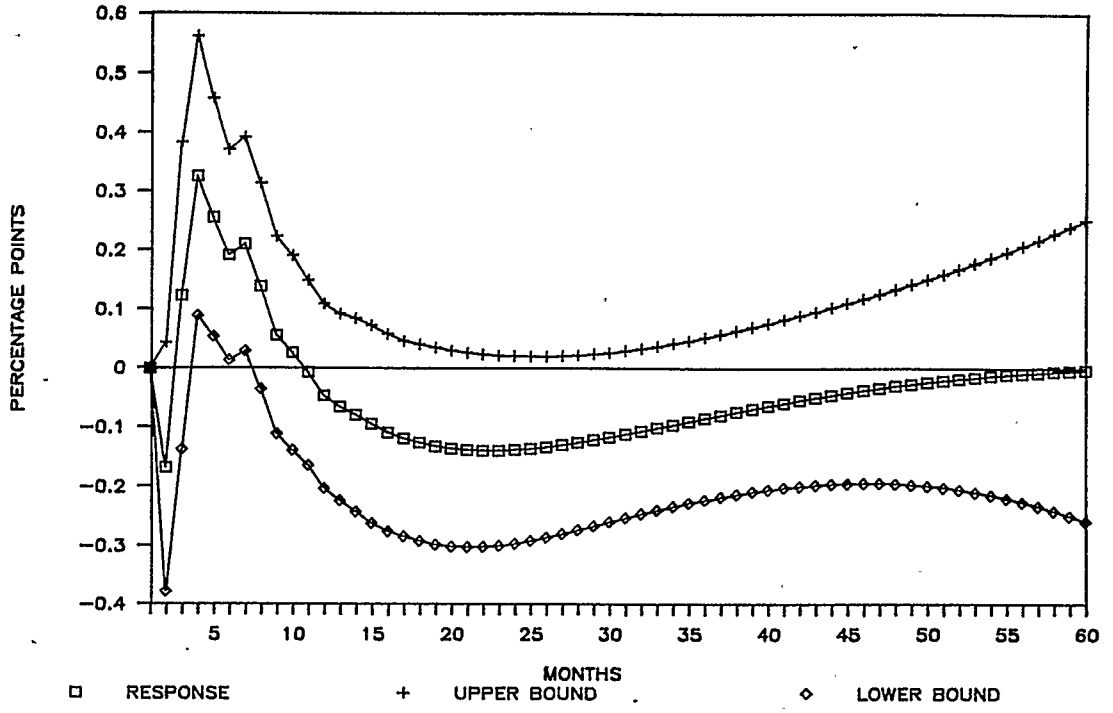
SHOCK TO I* — RESPONSE OF R*



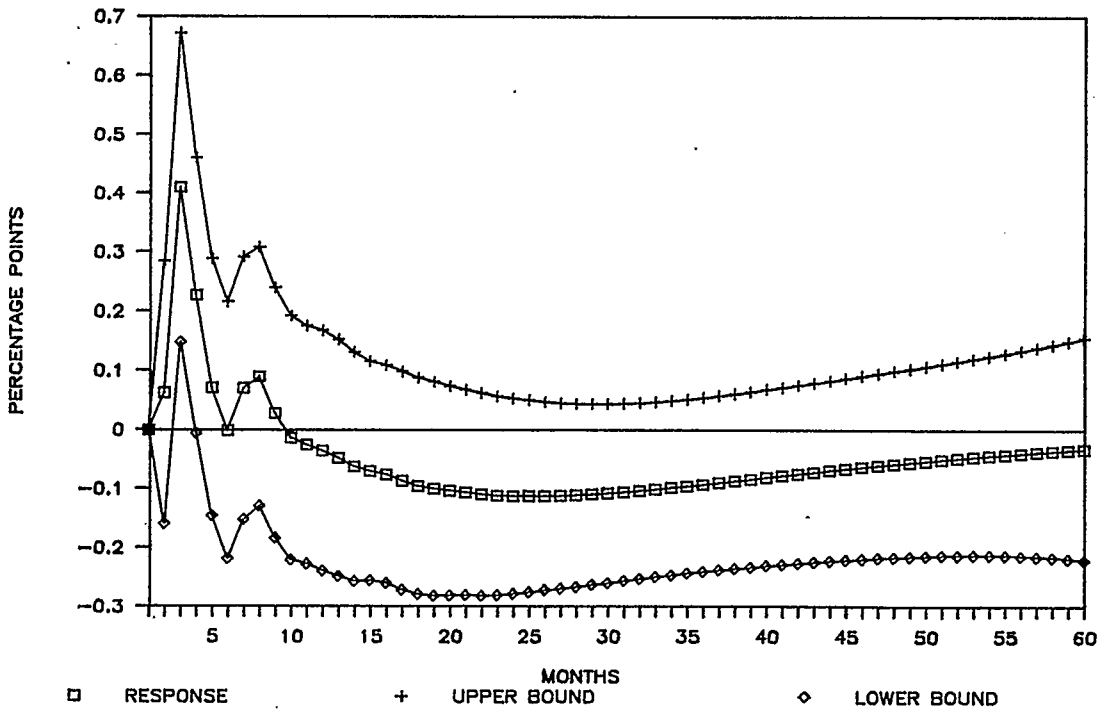
SHOCK TO R* — OWN RESPONSE



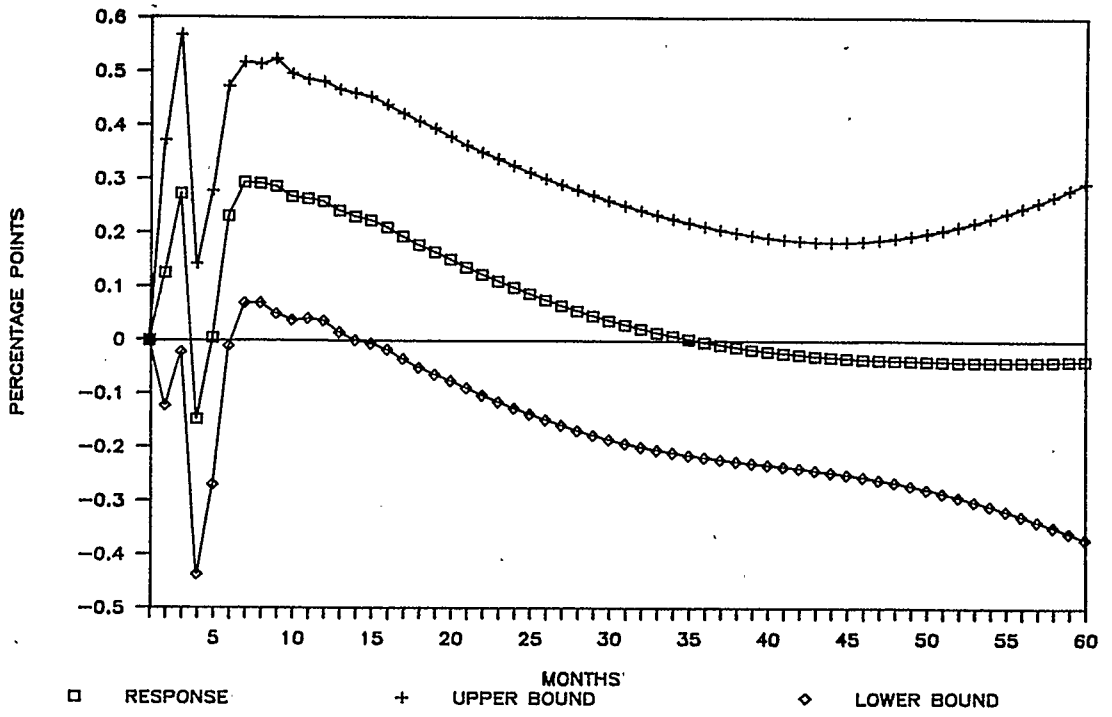
SHOCK TO E – RESPONSE OF R*



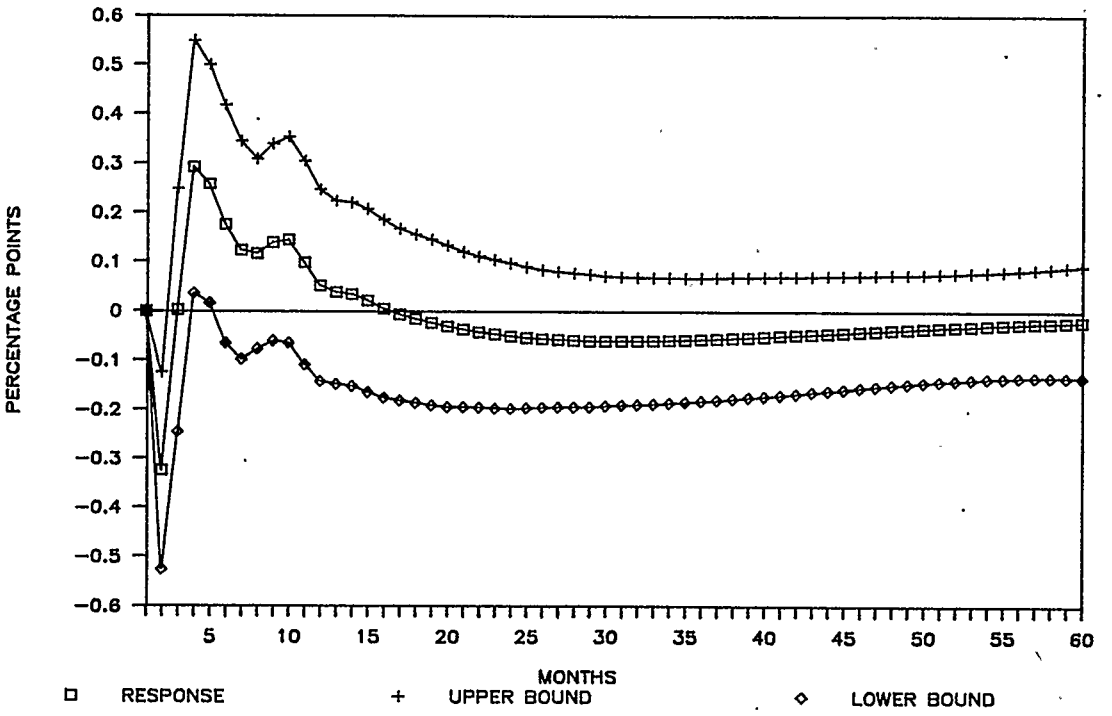
SHOCK TO RESERVES – RESPONSE OF R*



SHOCK TO I — RESPONSE OF R*



SHOCK TO R — RESPONSE OF R*



IV) Comments on the Empirical Results

The results presented above indicate that the data are consistent with the hypothesis that foreign exchange market intervention can impact upon the ex ante real interest rate. First, it has been shown that the initial impact of a depreciation is to increase the real rate. Second, we have shown that the initial consequence of a depreciation is a significant decrease in official holdings of U.S. dollar reserves. Third, evidence has been presented which indicates that an increase in reserves depresses the real interest rate. Under the assumption that reserves are manipulated symmetrically with respect to appreciation and depreciation, the logical inference is that a decrease in reserves in response to depreciation will result in an increase in the real interest rate. To the extent that the zero axis in the Canadian real interest rate graphs can be interpreted as the real interest rate parity line, the results shown here indicate that intervention can indeed "distort" the real interest rate.

Two relationships emerge as being particularly strong. The first is that between the nominal interest rates in both countries, with causality (in a statistical sense) running from the foreign to the domestic rate. The other is the intimate link between the domestic nominal interest rate and the exchange rate. Note that the observations are monthly, so that in terms of "model time", much of the adjustment is likely contemporaneous. That the results are nonetheless striking emphasizes the strength of the underlying relationship.

Other results presented are consistent, in broad terms, with the small country hypothesis. While the F-statistics presented in section III imply feedback from reserves to the U.S. nominal interest rate, this result is not confirmed by the impulse response data. In general, Canadian variables do not impact upon U.S. variables, while U.S. variables are significant in explaining the movements of the Canadian data. These are important results - any model which is not consistent with the small country hypothesis when dealing with such variables as nominal interest and exchange rates should be greeted with skepticism. The model presented here passes that test.

Several other results reflect favourably upon the model. Consider, for example, the response of the exchange rate to shocks. Standard priors would have us expect an appreciation following a domestic nominal interest rate increase, and a depreciation following a U.S. nominal rate increase. These are unambiguously the results shown above.

Nevertheless, it is important to bear in mind that the dynamics associated with vector autoregressive systems of the kind discussed here are tremendously complicated. In fact, some econometricians have referred to the dynamic properties of V.A.R.s as "black boxes", in which the process between input and output is not intuitively clear. This is a caveat to be borne in mind when interpreting results such as feedback from the foreign real interest rate to reserves.

Chapter Four

I) Summary and Conclusions

The question of influences on the ex ante real rate of interest follows naturally from examination of the recent Canadian economic and policy environment. Since the mid 1970s, the reduction of inflation has been perhaps the pre-eminent public policy objective. The Bank of Canada's initial response to high and rising inflation was to institute the programme of Monetary Gradualism, in an attempt to eliminate, or at least reduce, domestic price inflation and simultaneously mitigate adverse output effects. As the Canadian dollar began to depreciate in 1978 in response to relatively more restrictive U.S. Federal Reserve monetary policy, Gradualism was abandoned in order to try to defend the value of the Canadian dollar. As a result, Canadian interest rates reached unprecedented heights. While inflation fell as a consequence, so did output; the Canadian economy still bears the legacy in the form of high unemployment.

The goal of reducing inflation continues to guide the policies of the Bank of Canada. In recent years, careful attention has been paid to exchange rate movements. The stated objective has been to intervene to "smooth" exchange rate movements in either direction, although some observers have suggested that depreciation has been more strongly resisted than appreciation.

Concern over depreciation stems from the conviction that a fall in the external value of the currency leads to inflation. More succinctly, it is thought that higher prices for imported goods, reflected as

increases in the C.P.I., will be perceived by wage earners as inflation. Workers will resist erosion in their purchasing power - the ultimate consequence being a renewed wage-price spiral.

The central bank has therefore actively resisted currency depreciation. For the most part, the resistance is realized through the maintenance of higher short-term nominal interest rates in Canada than in the United States. Another tool is the use of foreign exchange holdings to purchase Canadian dollars, which ultimately has interest rate consequences. An interesting question, and one which has received little attention in the literature, is whether a policy of targeting the nominal interest rate differential vis-a-vis the United States, with an eye toward mitigating exchange rate movements, impacts upon the ex ante real rate of interest.

Economic theory tells us the circumstances under which there will be an impact. According to the Fisher identity, the real interest rate is determined by:

$$r_t = i_t - E_{t-1}(\pi_t).$$

The link between the real interest rate and the nominal exchange rate is expected inflation. If depreciation causes inflation, then the offering of a higher nominal interest rate in response to an incipient depreciation should not, in and of itself, influence the real interest rate. On the other hand, if the incipient depreciation was itself caused by higher inflation in Canada than elsewhere, and does not cause a one-for-one increase in expected inflation, then the higher nominal interest rate yields a higher real interest rate.

The question then arises: change the real interest rate relative to what? What determines the real rate? In a classical, or equilibrium, macroeconomic framework, the answer is that the equilibrium level of the Canadian ex ante real interest rate is that rate consistent with real interest parity between Canada and the United States. In chapter two, articles were discussed which indicate that real interest parity is the logical outcome of an equilibrium model. The major requisite assumptions are that both uncovered interest and ex ante purchasing power parity hold. Under these conditions, policy-induced changes in the Canadian real interest rate represent distortions from the real interest parity line. The objective of the empirical work described in chapter three was to determine whether the data indicated that such distortions had in fact occurred.

The empirical testing for impact was two-part. First, because the ex ante real interest rate is inherently unobservable, it was necessary to determine an appropriate proxy. The method used was to estimate a series of inflation forecasts, which were then subtracted from the nominal interest rate to derive estimates of the real rate.

The second step was to construct a vector autoregressive system. Included in the system were the U.S. and Canadian nominal and real interest rates, as well as the Canada-U.S. exchange rate and Canadian reserves of U.S. dollars. This latter variable was introduced to capture intervention information not clearly reflected in other variables.

The results of the system were presented in an "innovation accounting" framework. Each variable was shocked in period 0 - the responses of the other variables over the next 60 months were then

shown. The response of the domestic real rate to shocks is consistent with the existence of the hypothesized distortions. An increase in the domestic nominal rate is associated with an increase in the domestic real rate. The initial response of the real rate to a depreciation shock is positive. An increase in the foreign nominal interest rate is also associated with upward pressure on the domestic real rate. The only result which seems, at first glance, to be at odds with the hypothesis is the response to an increase in reserves. The model indicates that an increase in reserves is associated with a depressed real interest rate. Consider, however, the circumstances under which reserves are likely to be increased. The authorities are unlikely to replenish their stocks of U.S. dollars in any environment other than that of a strong Canadian dollar. Alternatively, they might borrow funds denominated in U.S. dollars, an event likely to have an announcement effect. In fact, the same shock to reserves is associated with appreciation pressure on the exchange rate. Thus, the reserves shock too is consistent with the hypothesis of a policy impact on the real interest rate.

The model passes a number of "reasonableness" tests. For example, a higher U.S. nominal interest rate is associated with a higher Canadian nominal rate, and a depreciated exchange rate. These results are consistent with findings by other researchers which indicate that the authorities allow the burden of adjustment to be shared by the interest and exchange rates. Furthermore, a higher Canadian nominal rate "causes" an appreciation of the exchange rate. That such standard priors are supported lends credibility to the model as a whole.

Based upon the results presented, it can be concluded that the real interest rate has been influenced by each of the variables in the model over the period of estimation. To the extent that any of these variables were subject to use as macroeconomic policy instruments, it can be further concluded that policy could have impacted upon the real rate. Note, however, that there is *no* implication that the real interest rate *per se* can be targeted. The Lucas critique reminds us of the dangers of inferring any type of "fundamental" economic relationship merely on the basis of observed historical patterns.

The implications of these results are clear. Assume that the response of the real rate to an increase in reserves is symmetric - that is, R increases as reserves are depleted. It follows that a policy of "leaning against the wind", in the case of depreciation pressure on the dollar, increases the ex ante real interest rate. The implication is that the cost of defending the dollar is higher than that implied only by the cost of buying Canadian currency in the market. Investment expenditure, and thereby the rate of capital accumulation, may also be depressed. Thus, in all likelihood, economic growth is slowed. In the cost-benefit calculus of the "dirty float", this is a cost which ought not be ignored.

II) Directions for Further Research

Regarding the inflation forecasting algorithm, recent events in the equity markets pose some interesting questions. In the weeks prior to October 19, 1987, it appears to have been widely accepted

that a resurgence of inflation was probable. The stock market crash eliminated perhaps as much as one trillion dollars, and apparently assuaged fears of higher inflation. Interestingly, deficit spending by the government of the United States since 1981 amounts to approximately one trillion dollars as well. American fiscal policy was almost certainly a significant factor in the high pre-crash inflation expectations. It is not clear that the short-run forecasting model presented in chapter three would capture such attitudes. While theory indicates that such information will be reflected in economic variables, it might nevertheless be desirable to incorporate data which are likely to be more closely correlated with broad longer-term fiscal impacts.

With respect to the model itself, a number of specific issues ought to be addressed. First, the sensitivity of the results to the particular inflation forecasting algorithm used should be examined. A useful comparison would be performance with ex post real rates. Given the small size of the average inflation forecast error, the results probably would not differ significantly. Nevertheless, the exercise would be useful in that it would clearly establish the correspondence with the work of Mark, Mishkin and others.

Second, a number of potential proxies for intervention activity are available. Among Bank of Canada economists, the sentiment is often expressed that the Bank's most important short-run policy instrument is the daily cash setting. As such, it might prove worthwhile to test the responses to the special call loan rate.

More generally, a number of variables were possible candidates for inclusion in the model. The tremendous data requirements of V.A.R.s give the researcher an a priori bias toward smaller rather than larger systems. Nevertheless, it would be desirable to explicitly include information on, for example, money and inflation. Data constraints could be loosened by using weekly or daily data.

The latter point leads in turn to a quite general question of timing. The pace of events in the foreign exchange markets can be quite fast - at times, one month could effectively represent an eternity. In that sense, the use of monthly data may be inappropriate. On the other hand, the significance of the ex ante real interest rate is probably greatest in relatively longer-term decisions. In the evaluation of a 20 year project, a one-month-ahead forecast of the real rate is not particularly useful. Thus while the results presented in chapter three indicate that the impact of some shocks can take 40 months to die out, it is not clear a priori what the impact would be on investment. Empirical research on the link between investment and real interest rates in this context would be most enlightening.

One important question which has received remarkably little coverage in the literature is the question of causality between inflation and depreciation. Given the policy emphasis on the exchange rate as a tool in the fight against inflation, it would be of great interest to hear the data speak on this question.

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III) Data

All data series were taken from the Cansim University Base. "Cansim" is an official mark of Statistics Canada.

Consumer Price Index (Canada): D 484000.

Consumer Price Index (United States): D 134010.

Three Month Treasury Bill Rate (Canada): B 14007.

Three Month Treasury Bill Rate (United States): B 54409.

Spot Exchange Rate, Canadian cents per U.S. dollar: B 40001.

Official Reserves of United States Dollars: B 3801.

M2 Aggregate (Canada): B 1630.

M2 Aggregate (United States): B 54357.

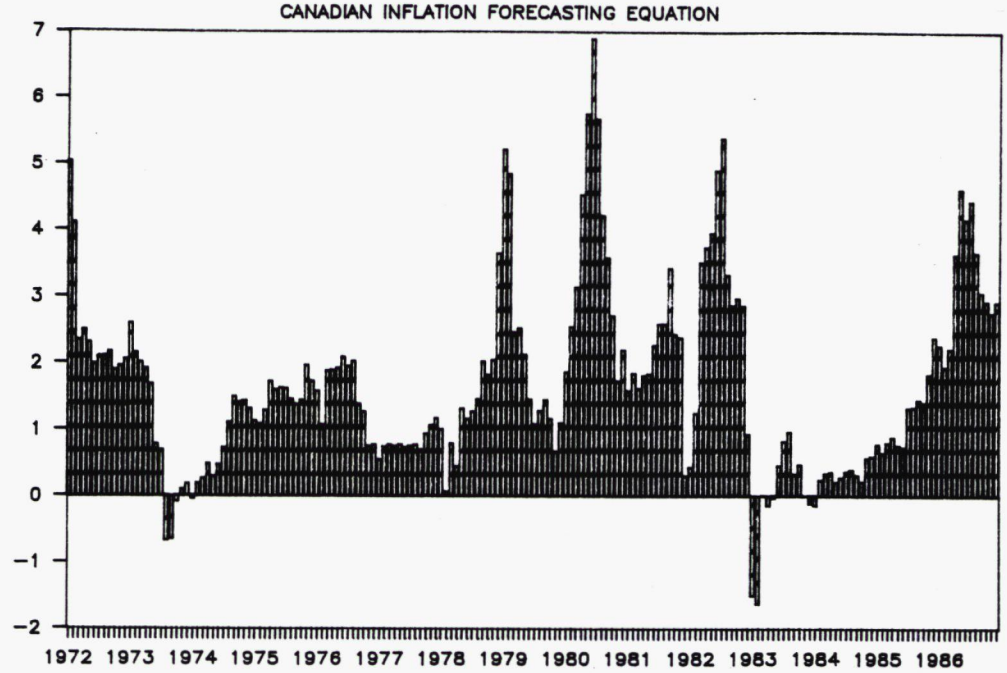
Unemployment Rate (United States): D 53106.

Appendix A

The following four pages show movements of the coefficients on the variables in the Canadian inflation forecasting equation over time. The remaining eight pages in this appendix show the coefficients in the U.S. inflation forecasting equation.

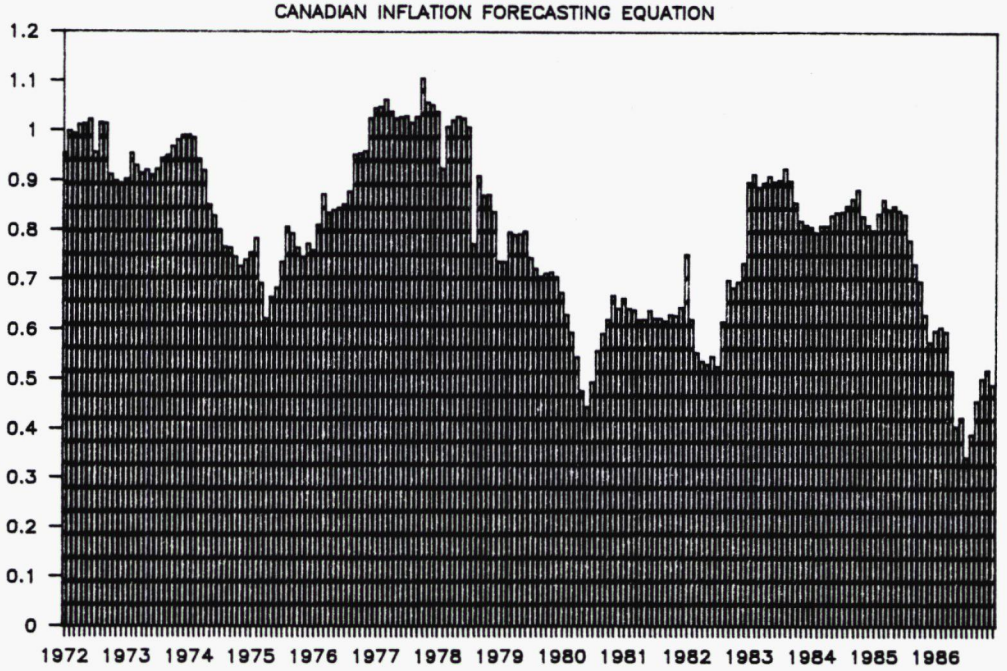
COEFFICIENT ON CONSTANT TERM

CANADIAN INFLATION FORECASTING EQUATION



COEFFICIENT ON FIRST INFLATION LAG

CANADIAN INFLATION FORECASTING EQUATION



COEFFICIENT ON SECOND INFLATION LAG

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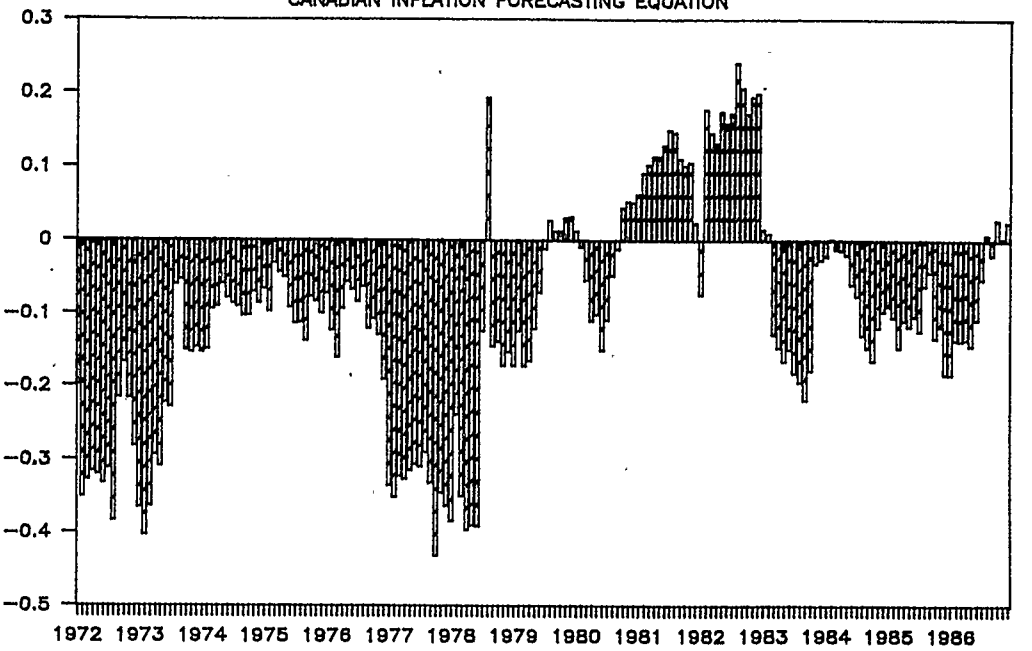

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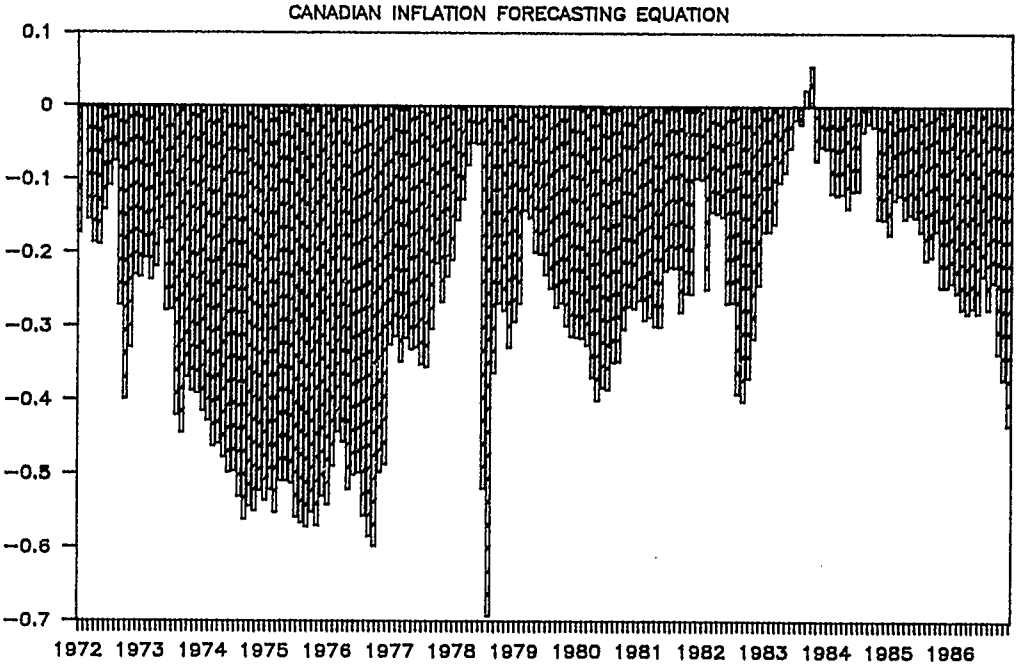

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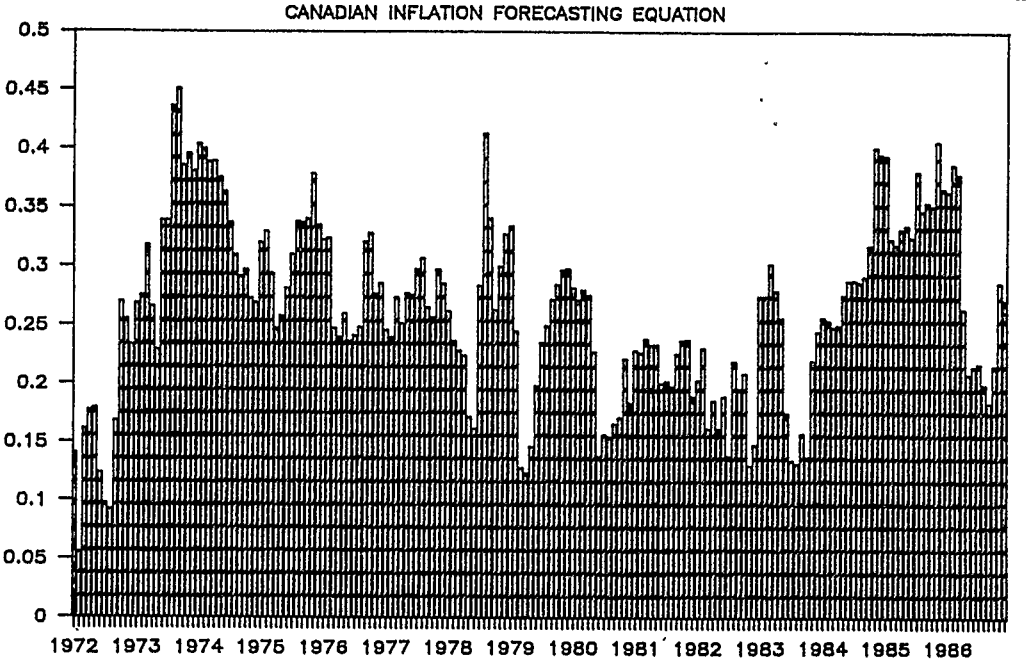

COEFFICIENT ON THIRD U.S. INFLATION LAG

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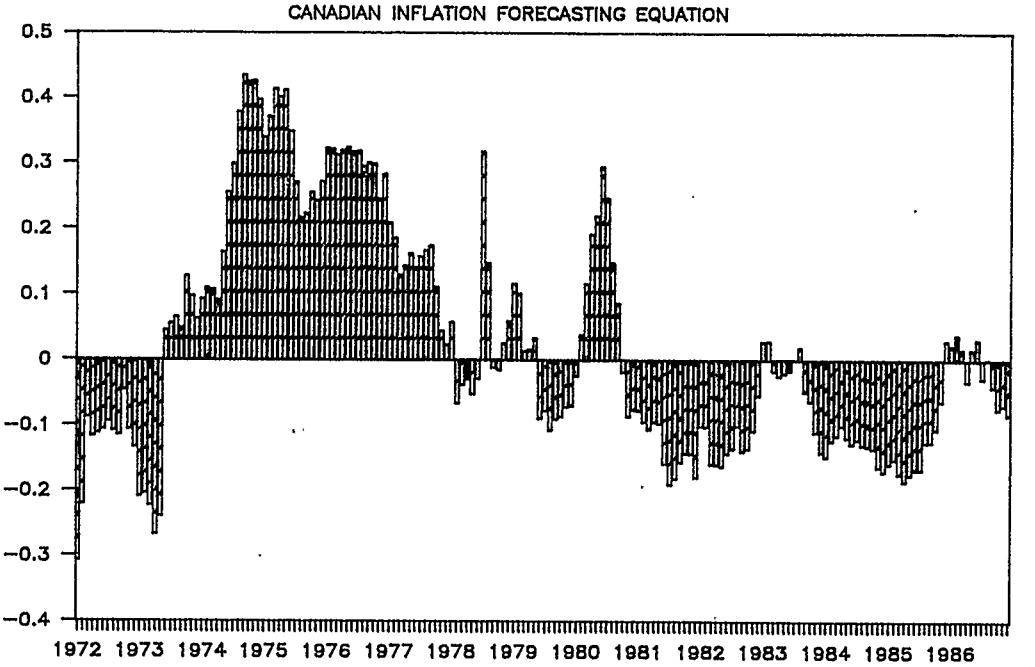
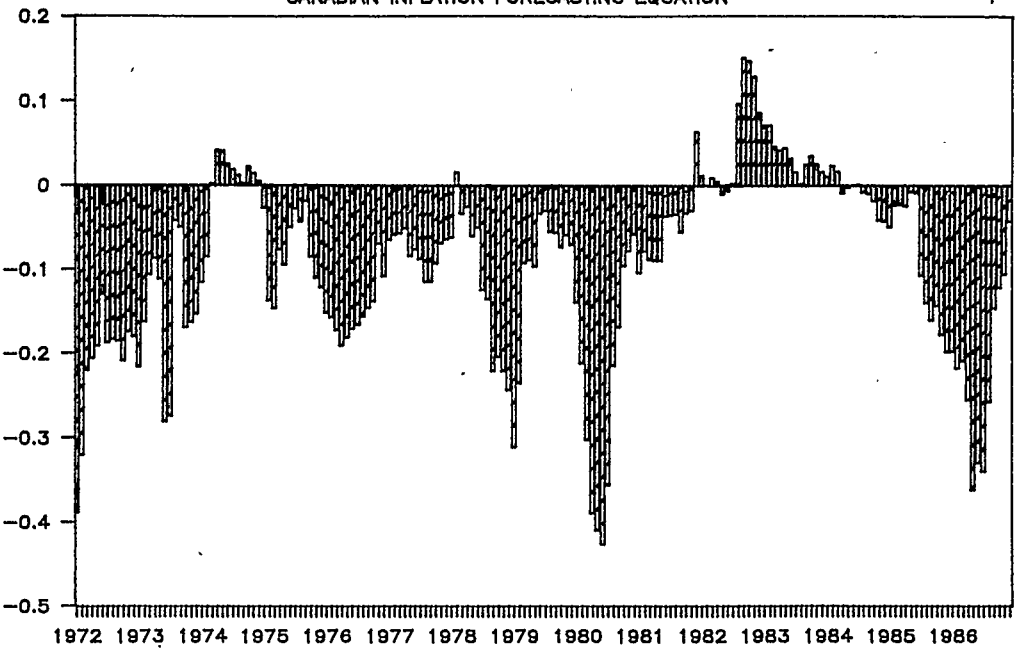


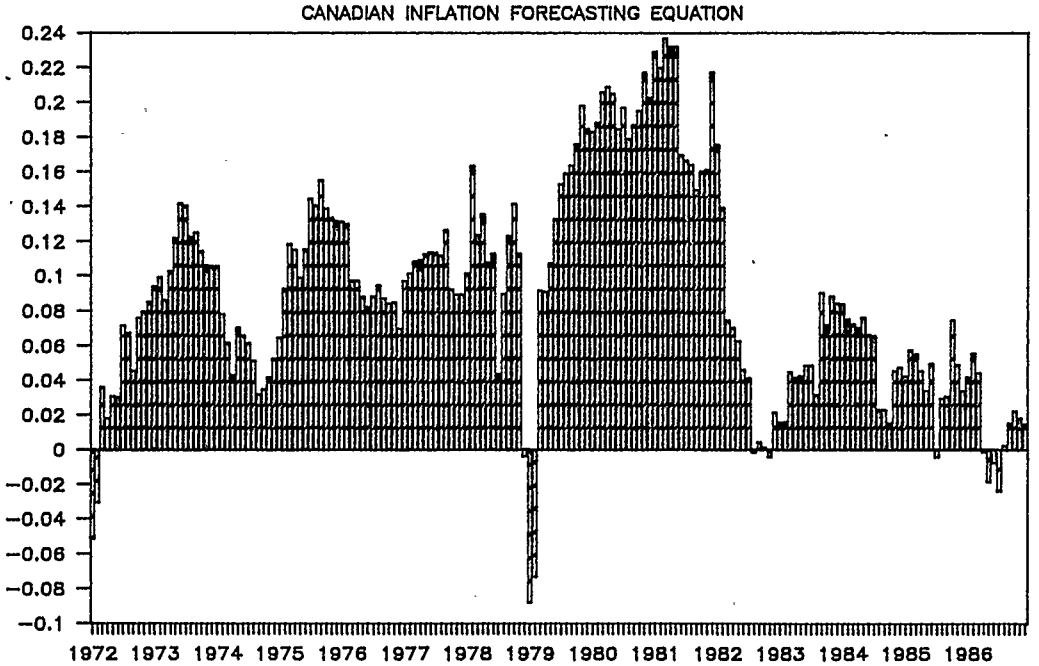
COEFFICIENT ON FIFTH U.S. INFLATION LAG

CANADIAN INFLATION FORECASTING EQUATION



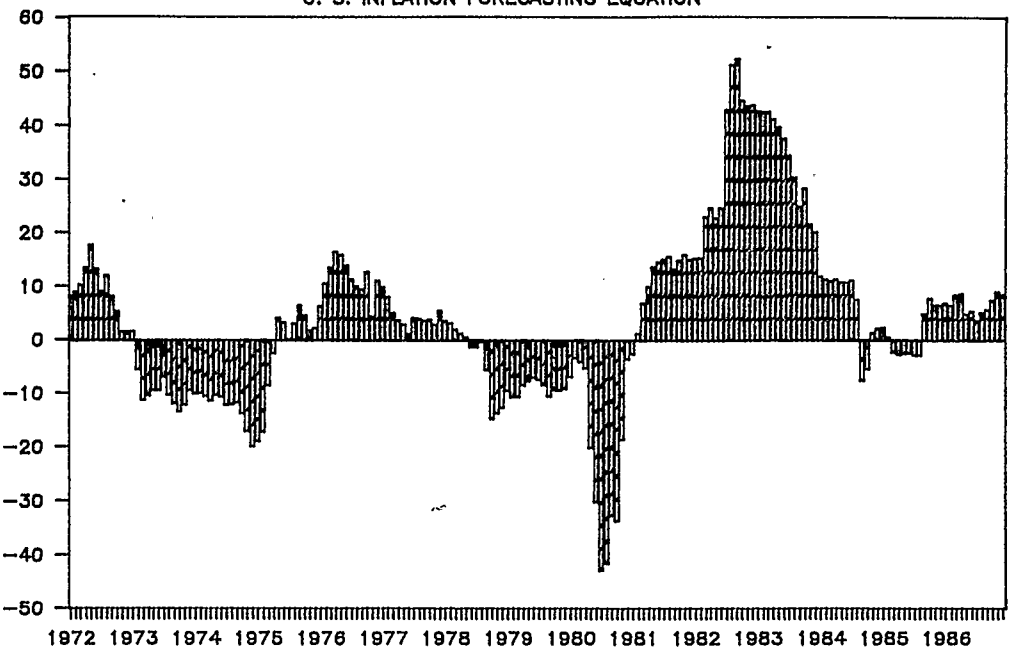
COEFFICIENT ON FOURTH LAG MONEY GROWTH

CANADIAN INFLATION FORECASTING EQUATION



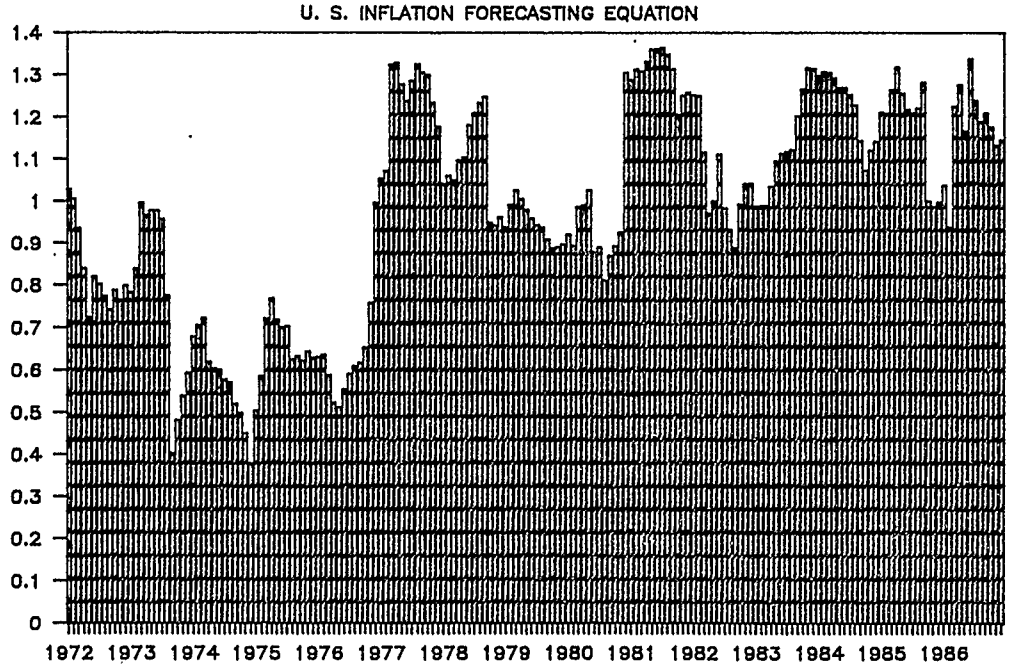
COEFFICIENT ON CONSTANT TERM

U. S. INFLATION FORECASTING EQUATION



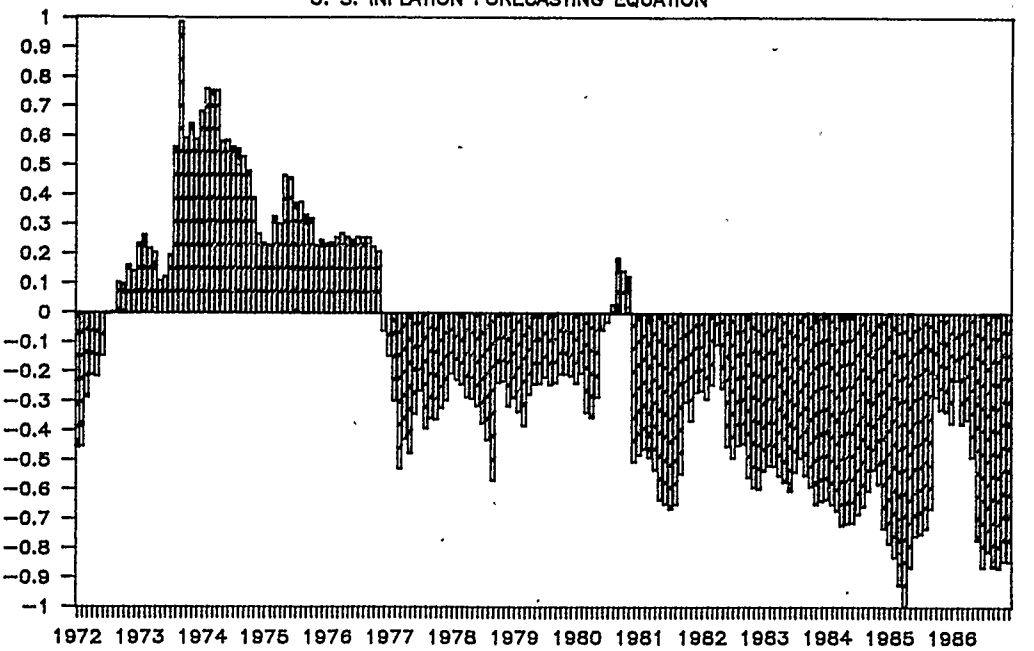
COEFFICIENT ON FIRST INFLATION LAG

U. S. INFLATION FORECASTING EQUATION



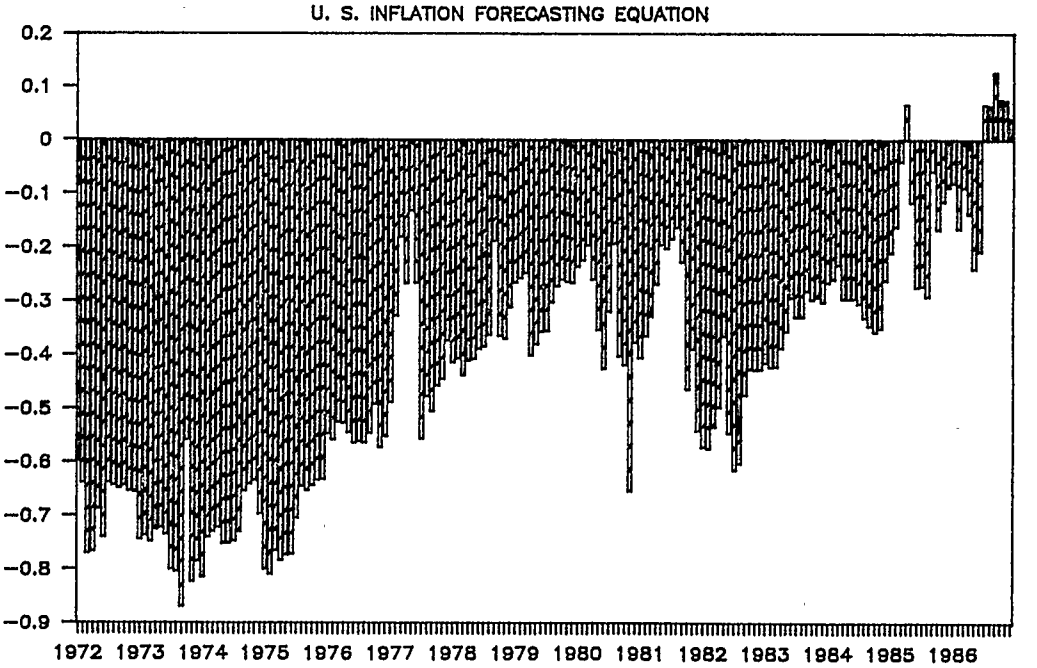
COEFFICIENT ON SECOND INFLATION LAG

U. S. INFLATION FORECASTING EQUATION



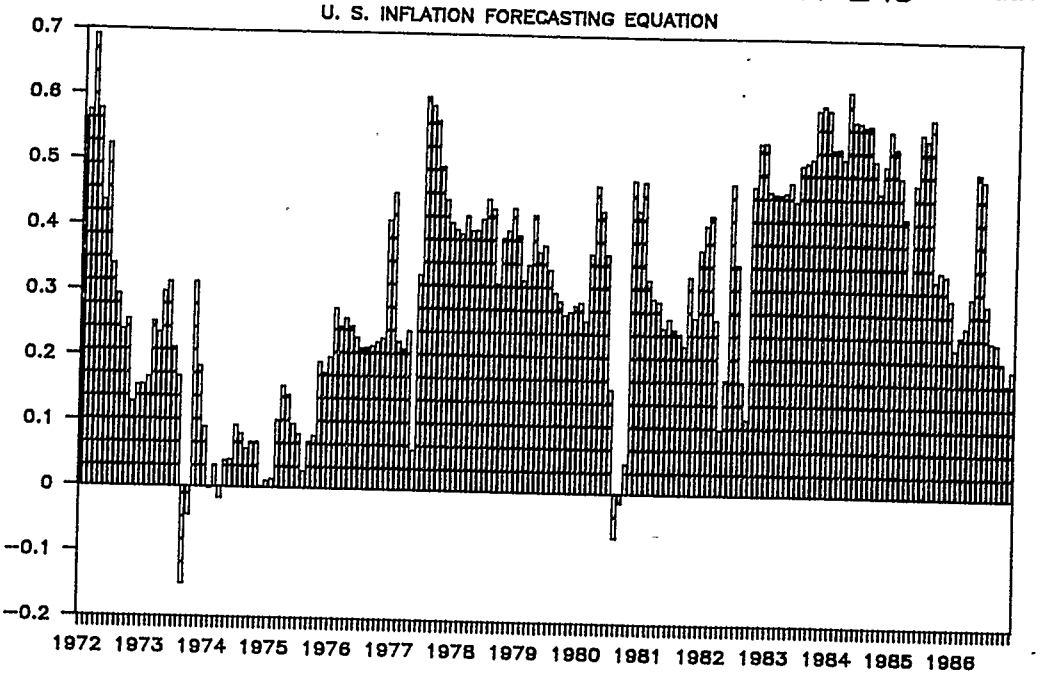
COEFFICIENT ON THIRD INFLATION LAG

U. S. INFLATION FORECASTING EQUATION



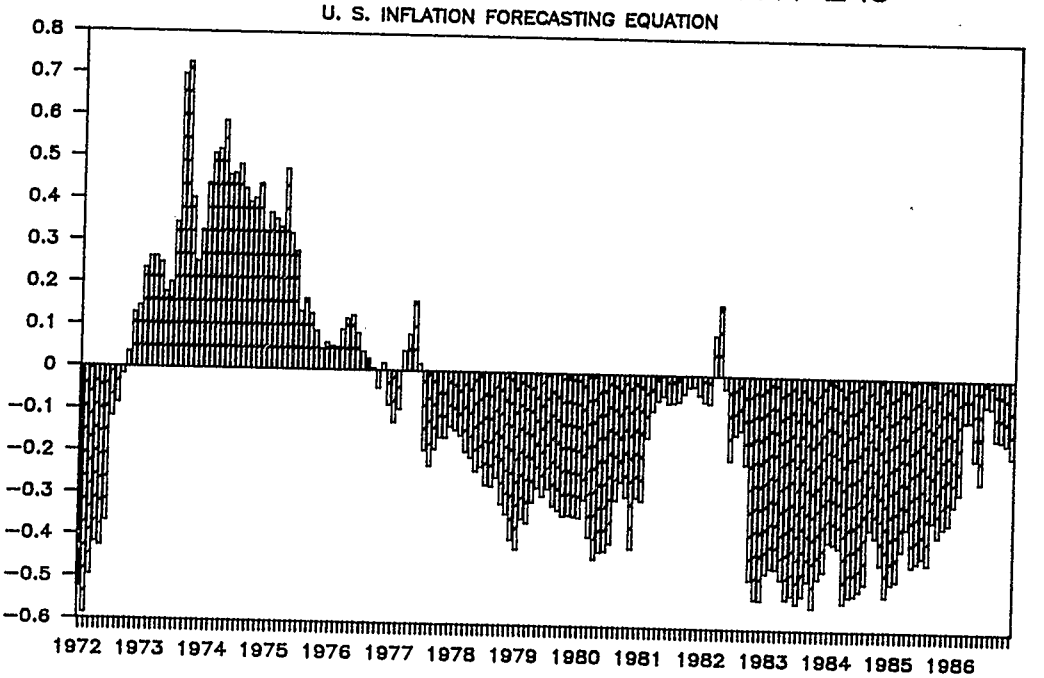
COEFFICIENT ON FOURTH INFLATION LAG

U. S. INFLATION FORECASTING EQUATION



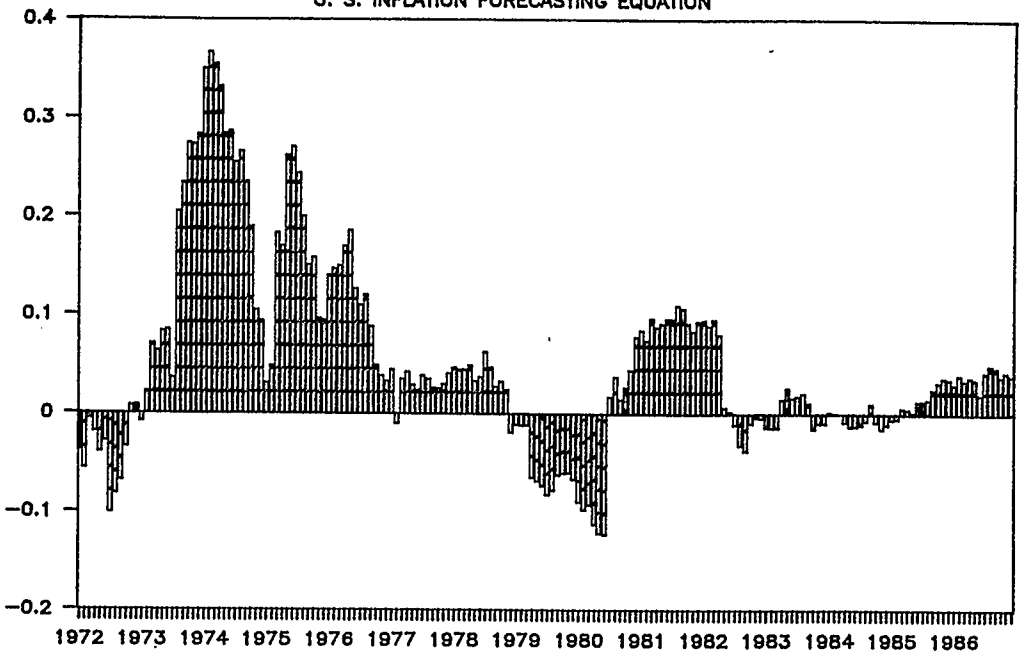
COEFFICIENT ON FIFTH INFLATION LAG

U. S. INFLATION FORECASTING EQUATION



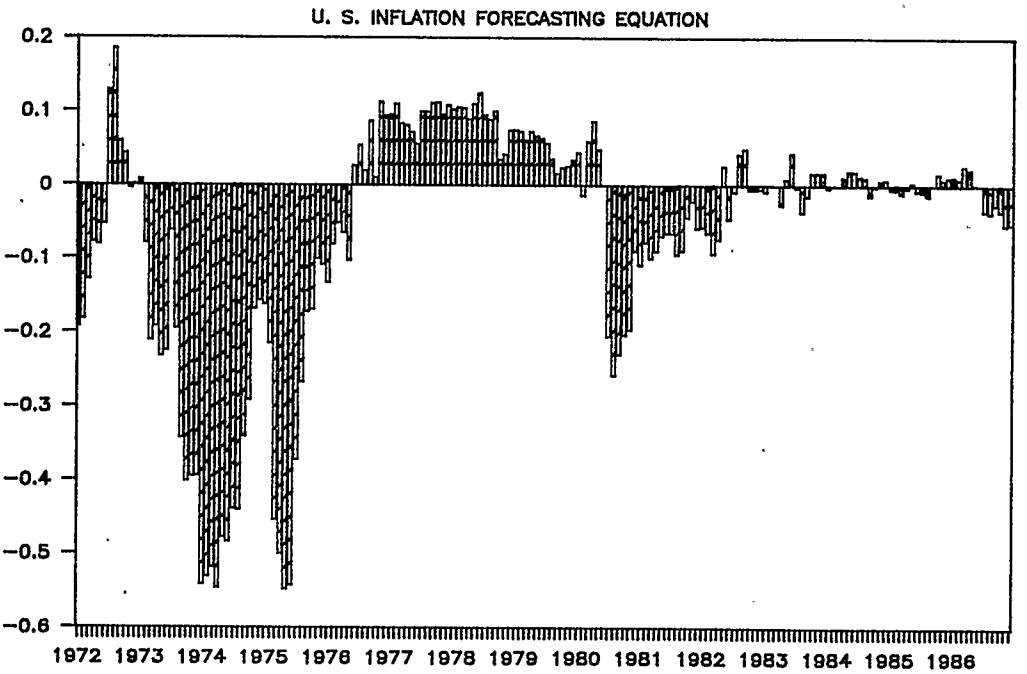
COEFFICIENT ON THIRD LAG MONEY STOCK

U. S. INFLATION FORECASTING EQUATION



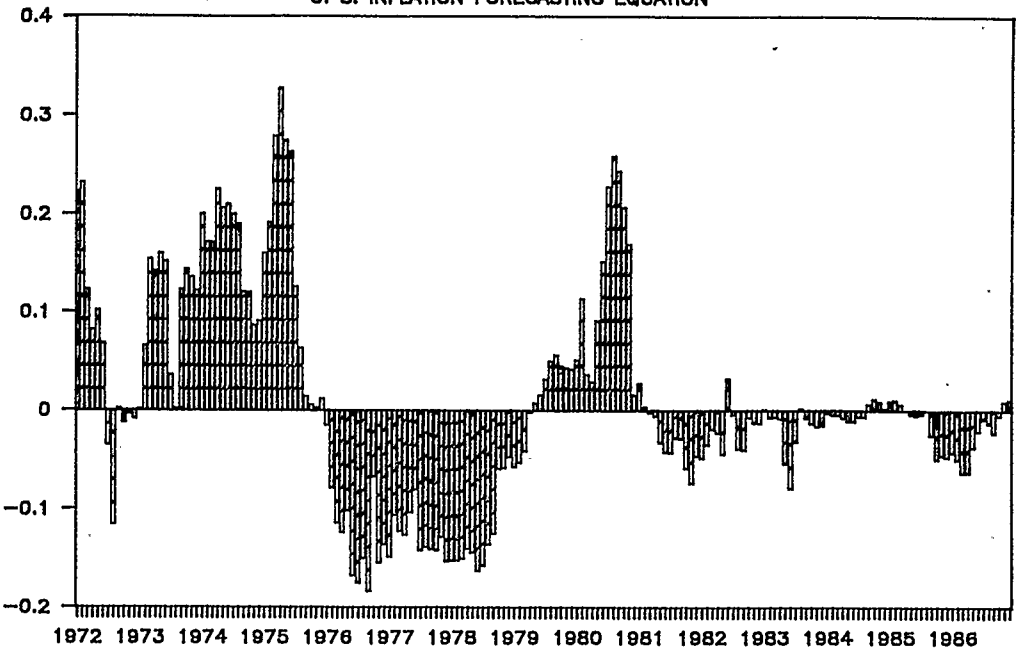
COEFFICIENT ON FOURTH LAG MONEY STOCK

U. S. INFLATION FORECASTING EQUATION



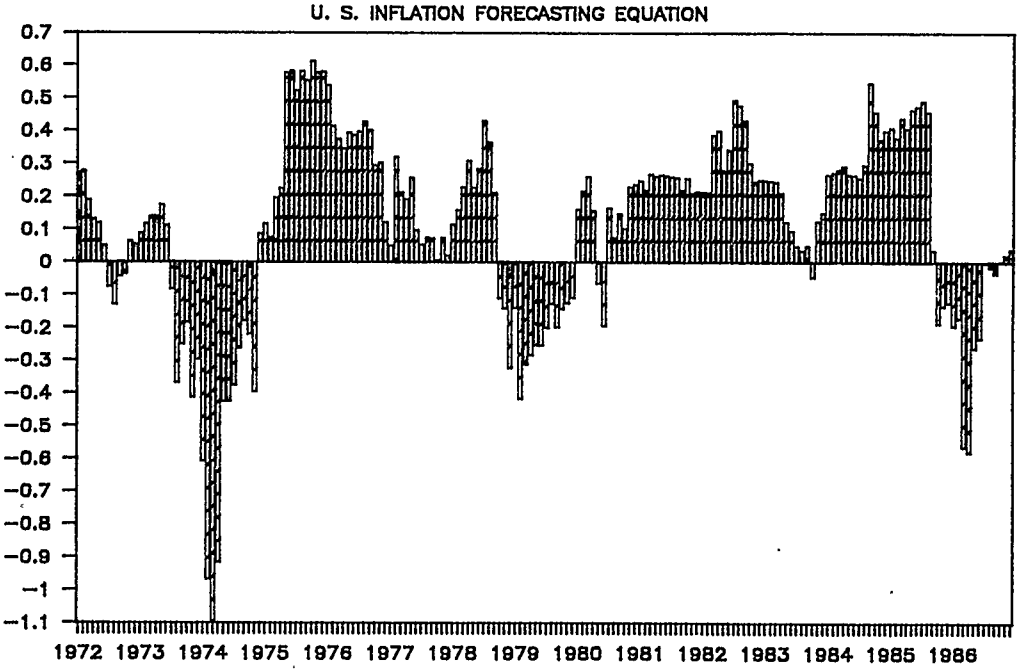
COEFFICIENT ON SIXTH LAG MONEY STOCK

U. S. INFLATION FORECASTING EQUATION



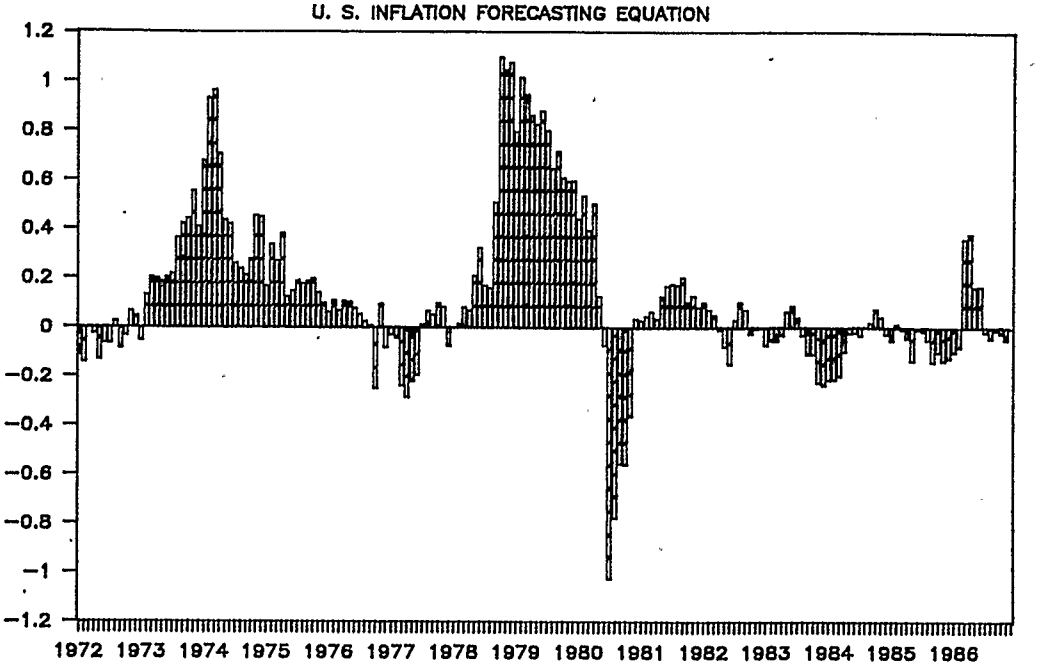
COEFFICIENT ON THIRD LAG INTEREST RATE

U. S. INFLATION FORECASTING EQUATION



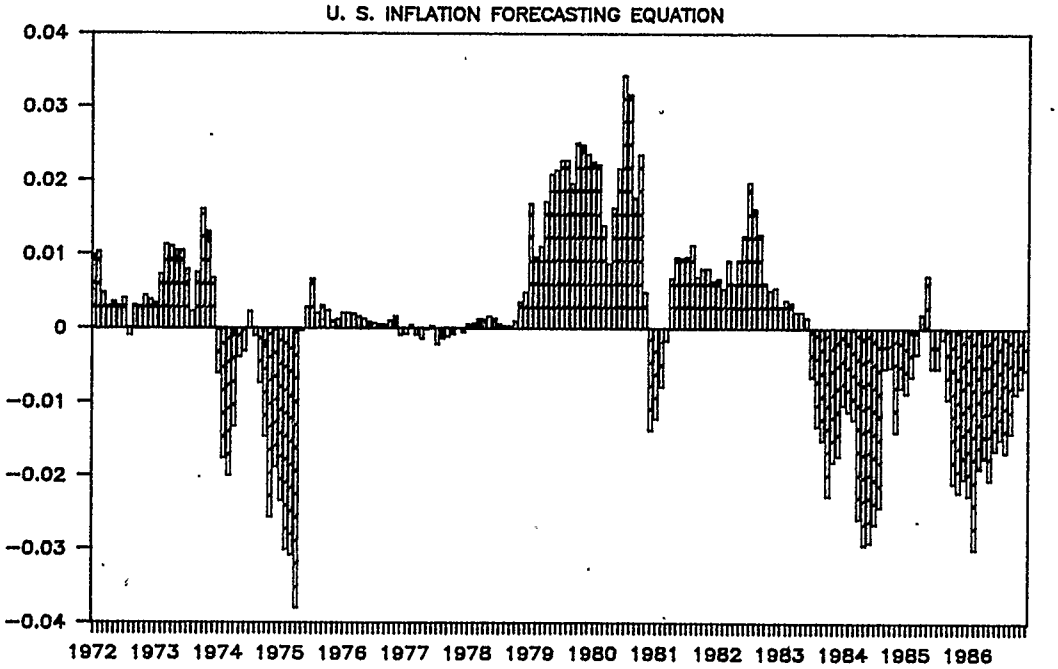
COEFFICIENT ON FIFTH LAG INTEREST RATE

U. S. INFLATION FORECASTING EQUATION

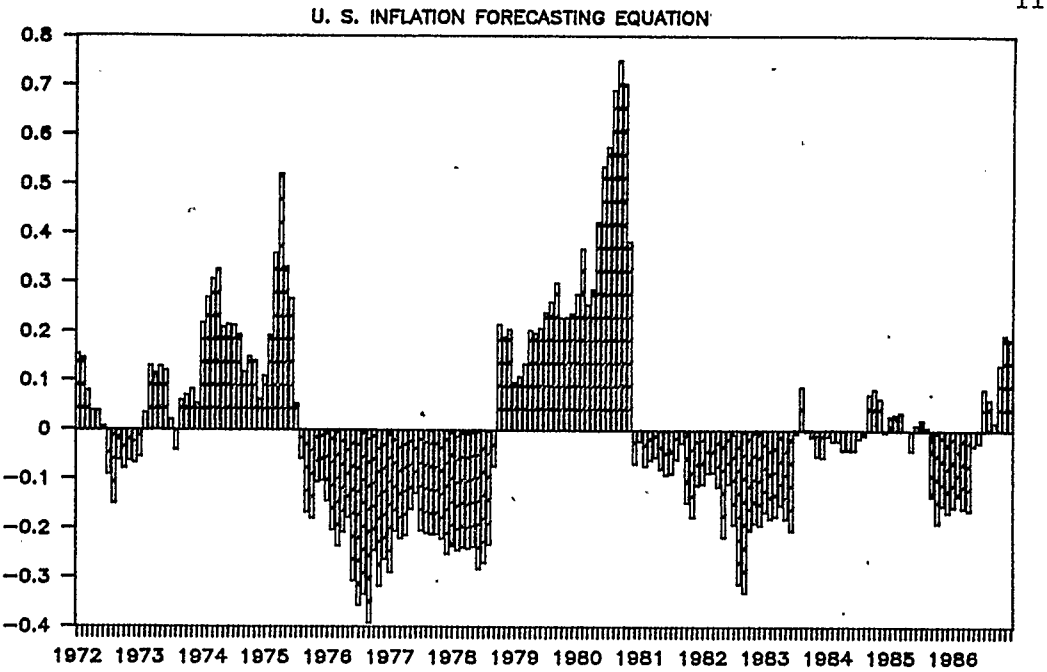


COEFFICIENT ON SEVENTH LAG UNEMPLOYMENT

U. S. INFLATION FORECASTING EQUATION



COEFFICIENT ON FOURTH LAG MONEY GROWTH



Appendix B

On the following six pages, the regression output for the V.A.R. discussed in chapter three is presented. Such output is notoriously difficult to interpret, and as such is inappropriate for inclusion in the text. Nevertheless, it is desirable to include such information in the thesis, due to the central role played by the V.A.R. in the presentation.

EQUATION 1
DEPENDENT VARIABLE 1 USTBILL
FROM 1973- 2 UNTIL 1987- 1
OBSERVATIONS 168 DEGREES OF FREEDOM 131
R**2 .89369691 RBAR**2 .86448385
SSR 161.06675 SEE 1.1088359
DURBIN-WATSON 2.04178857

NO.	LABEL	VAR	LAG	COEFFICIENT	STAND. ERROR	T-STATISTIC
***	*******	***	***	**********	**********	**********
1	USTBILL	1	1	.7858252	.1161952	6.762974
2	USTBILL	1	2	.2625782E-01	.1344880	.1952428
3	USTBILL	1	3	.2464462	.1385042	1.779341
4	USTBILL	1	4	-.5401740E-02	.1168644	-.4622228E-01
5	USRINT	2	1	.7386918E-01	.4206817E-01	1.755940
6	USRINT	2	2	-.4634400E-01	.5078987E-01	-.9124654
7	USRINT	2	3	.3740610E-01	.5226053E-01	.7157620
8	USRINT	2	4	-.9995580E-01	.4236947E-01	-2.359147
9	LSPOT	3	1	-4.719098	12.92251	-.3651842
10	LSPOT	3	2	-10.13465	19.04297	-.5321990
11	LSPOT	3	3	10.62538	17.75696	.5983785
12	LSPOT	3	4	1.983136	11.04552	.1795420
13	LRES	4	1	.4661932	.5530197	.8429958
14	LRES	4	2	-.3527217	.5927052	-.5951048
15	LRES	4	3	-1.668760	.6321421	-2.639849
16	LRES	4	4	.9663623	.6284430	1.537709
17	TBILL	5	1	.2222408	.2062746	1.077403
18	TBILL	5	2	-.4146009	.2862024	-1.448629
19	TBILL	5	3	-.1336371	.2902230	-.4604635
20	TBILL	5	4	.1808280	.1707843	1.058809
21	RINT	6	1	.1466499E-01	.5973466E-01	.2455022
22	RINT	6	2	-.8855693E-02	.7106203E-01	-.1246192
23	RINT	6	3	.5639952E-01	.6930600E-01	.8137754
24	RINT	6	4	-.2191448E-01	.5564762E-01	-.3938079
25	CONSTANT	0	0	15.85430	25.23207	.6283393
26	TREND	80	0	.3512911E-02	.1096969E-01	.3202380
27	SEAS	79	-11	-.1070827	.4708739	-.2274128
28	SEAS	79	-10	-.4943139E-01	.4758590	-.1038782
29	SEAS	79	-9	.4286388	.4677926	.9163010
30	SEAS	79	-8	-.3568872	.4435747	-.8045706
31	SEAS	79	-7	-.9261810E-02	.4472618	-.2070780E-01
32	SEAS	79	-6	-.5288282E-01	.4771957	-.1108200
33	SEAS	79	-5	.1398980	.4513162	.3099779
34	SEAS	79	-4	.3203066	.4507537	.7106023
35	SEAS	79	-3	-.5224807	.4629257	-1.128649
36	SEAS	79	-2	.4814454	.4714038	1.021301
37	SEAS	79	-1	-.3397577	.4786486	-.7098270

EQUATION 2
DEPENDENT VARIABLE 2 USRINT
FROM 1973- 2 UNTIL 1987- 1
OBSERVATIONS 168 DEGREES OF FREEDOM 131
R**2 .76904505 RBAR**2 .70557651
SSR 827.68545 SEE 2.5136049
DURBIN-WATSON 1.98811401

NO.	LABEL	VAR	LAG	COEFFICIENT	STAND. ERROR	T-STATISTIC
1	USTBILL	1	1	-.2174321	.2634013	-.8254783
2	USTBILL	1	2	-.1775387E-01	.3048690	-.5823442E-01
3	USTBILL	1	3	.4144902E-02	.3139732	.1320146E-01
4	USTBILL	1	4	.2223771E-01	.2649184	.8394176E-01
5	USRINT	2	1	.6911181	.9536374E-01	7.247179
6	USRINT	2	2	-.1258761	.1151348	-1.093293
7	USRINT	2	3	.3409754E-01	.1184687	.2878190
8	USRINT	2	4	.1284999	.9604677E-01	1.337889
9	LSPOT	3	1	-25.08022	29.29387	-.8561595
10	LSPOT	3	2	25.20460	43.16825	.5838690
11	LSPOT	3	3	3.741086	40.25300	.9293930E-01
12	LSPOT	3	4	-1.637339	25.03895	-.6539170E-01
13	LRES	4	1	.3345207	1.253633	.2668411
14	LRES	4	2	-.1545205E-01	1.343595	-.1150053E-01
15	LRES	4	3	.5425863	1.432994	.3786382
16	LRES	4	4	.9547858	1.424609	.6702092
17	TBILL	5	1	.2639720	.4676009	.5645241
18	TBILL	5	2	.1390285	.6487882	.2142895
19	TBILL	5	3	-.7921886	.6579024	-1.204113
20	TBILL	5	4	.7587698	.3871485	1.959894
21	RINT	6	1	-.3365638E-01	.1354117	-.2485486
22	RINT	6	2	.1468088	.1610895	.9113488
23	RINT	6	3	-.6916847E-01	.1571088	-.4402584
24	RINT	6	4	-.1220562	.1261468	-.9675729
25	CONSTANT	0	0	-28.41074	57.19822	-.4967067
26	TREND	80	0	.1950206E-01	.2486704E-01	.7842536
27	SEAS	79	-11	1.838805	1.067417	1.722667
28	SEAS	79	-10	.1768294E-02	1.078718	.1639254E-02
29	SEAS	79	-9	.2597384	1.060432	.2449363
30	SEAS	79	-8	.2430670	1.005533	.2417295
31	SEAS	79	-7	-.5024960	1.013892	-.4956112
32	SEAS	79	-6	.5579722	1.081748	.5158059
33	SEAS	79	-5	-.7808375	1.023082	-.7632206
34	SEAS	79	-4	1.055533	1.021807	1.033006
35	SEAS	79	-3	.1730113	1.049400	.1648669
36	SEAS	79	-2	.7871626	1.068619	.7366168
37	SEAS	79	-1	.5485735	1.085042	.5055782

EQUATION 3
DEPENDENT VARIABLE 3 LSPOT
FROM 1973- 2 UNTIL 1987- 1
OBSERVATIONS 168 DEGREES OF FREEDOM 131
R**2 .99615938 RBAR**2 .99510394
SSR .85535343E-02 SEE .80804799E-02
DURBIN-WATSON 1.98315244

NO.	LABEL	VAR	LAG	COEFFICIENT	STAND. ERROR	T-STATISTIC
***	*******	***	***	**********	**********	**********
1	USTBILL	1	1	.5800391E-03	.8467557E-03	.6850135
2	USTBILL	1	2	.9291029E-03	.9800617E-03	.9480046
3	USTBILL	1	3	.5481512E-03	.1009329E-02	.5430849
4	USTBILL	1	4	-.6979769E-03	.8516325E-03	-.8195753
5	USRINT	2	1	.8244567E-03	.3065656E-03	2.689332
6	USRINT	2	2	-.6282637E-03	.3701237E-03	-1.697442
7	USRINT	2	3	.5094521E-04	.3808409E-03	.1337703
8	USRINT	2	4	-.1751683E-03	.3087613E-03	-.5673258
9	LSPOT	3	1	1.026889	.9417094E-01	10.90453
10	LSPOT	3	2	-.1075748	.1387729	-.7751863
11	LSPOT	3	3	.7734120E-01	.1294012	.5976852
12	LSPOT	3	4	-.1238736	.8049265E-01	-1.538943
13	LRES	4	1	-.1738651E-01	.4030050E-02	-4.314218
14	LRES	4	2	.1616058E-01	.4319252E-02	3.741522
15	LRES	4	3	-.1154137E-01	.4606643E-02	-2.505376
16	LRES	4	4	.3071669E-03	.4579686E-02	.6707161E-01
17	TBILL	5	1	.1470012E-02	.1503196E-02	.9779248
18	TBILL	5	2	-.4898496E-02	.2085658E-02	-2.348657
19	TBILL	5	3	-.6706273E-03	.2114957E-02	-.3170879
20	TBILL	5	4	.2408441E-02	.1244565E-02	1.935166
21	RINT	6	1	-.4101378E-03	.4353076E-03	-.9421792
22	RINT	6	2	-.1393612E-03	.5178542E-03	-.2691128
23	RINT	6	3	.6676404E-03	.5050573E-03	1.321910
24	RINT	6	4	-.2666495E-03	.4055239E-03	-.6575433
25	CONSTANT	0	0	.6823316	.1838750	3.710845
26	TREND	80	0	.2553839E-03	.7994001E-04	3.194695
27	SEAS	79	-11	-.7793574E-02	.3431425E-02	-2.271236
28	SEAS	79	-10	-.3612496E-02	.3467753E-02	-1.041740
29	SEAS	79	-9	.2115485E-03	.3408970E-02	.6205642E-01
30	SEAS	79	-8	-.3968518E-02	.3232486E-02	-1.227699
31	SEAS	79	-7	-.3600616E-02	.3259355E-02	-1.104702
32	SEAS	79	-6	-.6257759E-03	.3477494E-02	-.1799503
33	SEAS	79	-5	-.3328237E-02	.3288901E-02	-1.011960
34	SEAS	79	-4	.3647446E-03	.3284802E-02	.1110401
35	SEAS	79	-3	-.5750905E-02	.3373503E-02	-1.704728
36	SEAS	79	-2	-.1921066E-02	.3435286E-02	-.5592156
37	SEAS	79	-1	-.2292855E-02	.3488082E-02	-.6573400

EQUATION 4
DEPENDENT VARIABLE 4 LRES
FROM 1973- 2 UNTIL 1987- 1
OBSERVATIONS 168 DEGREES OF FREEDOM 131
R**2 .78344989 RBAR**2 .72393994
SSR 5.0338439 SEE .19602625
DURBIN-WATSON 1.86097694

NO.	LABEL	VAR	LAG	COEFFICIENT	STAND. ERROR	T-STATISTIC
1	USTBILL	1	1	-.1600626E-01	.2054164E-01	-.7792102
2	USTBILL	1	2	-.4780668E-01	.2377554E-01	-2.010750
3	USTBILL	1	3	.2213226E-01	.2448554E-01	.9038911
4	USTBILL	1	4	.2343884E-01	.2065995E-01	1.134506
5	USRINT	2	1	-.1091862E-01	.7437047E-02	-1.468140
6	USRINT	2	2	.1519100E-01	.8978918E-02	1.691852
7	USRINT	2	3	-.7662669E-02	.9238909E-02	-.8293911
8	USRINT	2	4	.1229863E-01	.7490313E-02	1.641939
9	LSPOT	3	1	-1.800951	2.284515	-.7883297
10	LSPOT	3	2	6.165563	3.366523	1.831433
11	LSPOT	3	3	-4.842224	3.139174	-1.542515
12	LSPOT	3	4	1.237342	1.952690	.6336605
13	LRES	4	1	.3976848	.9776592E-01	4.067724
14	LRES	4	2	.1631019	.1047818	1.556587
15	LRES	4	3	.4208587	.1117536	3.765951
16	LRES	4	4	-.1701105	.1110997	-1.531152
17	TBILL	5	1	.3015832E-01	.3646637E-01	.8270174
18	TBILL	5	2	-.1415997E-01	.5059646E-01	-.2798608
19	TBILL	5	3	-.7882694E-03	.5130724E-01	-.1536371E-01
20	TBILL	5	4	-.3559511E-02	.3019220E-01	-.1178950
21	RINT	6	1	.5196464E-02	.1056023E-01	.4920788
22	RINT	6	2	-.5490056E-02	.1256275E-01	-.4370108
23	RINT	6	3	.7765995E-04	.1225230E-01	.6338396E-02
24	RINT	6	4	-.2920433E-02	.9837699E-02	-.2968614
25	CONSTANT	0	0	-1.702474	4.460666	-.3816636
26	TREND	80	0	-.2971697E-02	.1939283E-02	-1.532368
27	SEAS	79	-11	-.3716576E-01	.8324373E-01	-.4464692
28	SEAS	79	-10	-.9892701E-01	.8412504E-01	-1.175952
29	SEAS	79	-9	-.1115088	.8269900E-01	-1.348370
30	SEAS	79	-8	-.5086522E-01	.7841762E-01	-.6486453
31	SEAS	79	-7	-.1150078	.7906946E-01	-1.454516
32	SEAS	79	-6	-.1490869	.8436133E-01	-1.767243
33	SEAS	79	-5	-.9339545E-01	.7978621E-01	-1.170571
34	SEAS	79	-4	-.8152426E-01	.7968678E-01	-1.023059
35	SEAS	79	-3	-.6575658E-01	.8183860E-01	-.8034910
36	SEAS	79	-2	-.1044816	.8333741E-01	-1.253718
37	SEAS	79	-1	-.6898492E-01	.8461819E-01	-.8152493

EQUATION 5
DEPENDENT VARIABLE 5 TBILL
FROM 1973- 2 UNTIL 1987- 1
OBSERVATIONS 168 DEGREES OF FREEDOM 131
R**2 .97151173 RBAR**2 .96368289
SSR 50.000905 SEE .61780765
DURBIN-WATSON 1.95836219

NO.	LABEL	VAR	LAG	COEFFICIENT	STAND. ERROR	T-STATISTIC
1	USTBILL	1	1	.2611272	.6474023E-01	4.033462
2	USTBILL	1	2	-.1121145	.7493238E-01	-1.496209
3	USTBILL	1	3	.4742397E-01	.7717005E-01	.6145386
4	USTBILL	1	4	-.5889485E-01	.6511310E-01	-.9045008
5	USRINT	2	1	-.2757138E-03	.2343903E-01	-.1176302E-01
6	USRINT	2	2	.2086314E-01	.2829848E-01	.7372531
7	USRINT	2	3	-.6106459E-02	.2911788E-01	-.2097151
8	USRINT	2	4	-.1576659E-01	.2360690E-01	-.6678806
9	LSPOT	3	1	-9.306134	7.200009	-1.292517
10	LSPOT	3	2	-6.241013	10.61013	-.5882127
11	LSPOT	3	3	6.740429	9.893603	.6812916
12	LSPOT	3	4	3.376836	6.154210	.5487033
13	LRES	4	1	-.5914641	.3081247	-1.919561
14	LRES	4	2	-.3995830	.3302362	-1.209991
15	LRES	4	3	-.8876073	.3522092	-2.520114
16	LRES	4	4	.8807235	.3501482	2.515288
17	TBILL	5	1	1.041666	.1149295	9.063522
18	TBILL	5	2	-.2596538	.1594627	-1.628304
19	TBILL	5	3	.3127304E-01	.1617029	.1933982
20	TBILL	5	4	.4723879E-02	.9515549E-01	.4964379E-01
21	RINT	6	1	.1481538E-01	.3328223E-01	.4451438
22	RINT	6	2	-.3500508E-01	.3959347E-01	-.8841123
23	RINT	6	3	.1899300E-01	.3861507E-01	.4918545
24	RINT	6	4	-.2189771E-01	.3100506E-01	-.7062624
25	CONSTANT	0	0	33.23298	14.05849	2.363908
26	TREND	80	0	.1038865E-01	.6111958E-02	1.699726
27	SEAS	79	-11	-.2058598	.2623557	-.7846589
28	SEAS	79	-10	.7630909E-01	.2651333	.2878140
29	SEAS	79	-9	-.2954497E-01	.2606389	-.1133559
30	SEAS	79	-8	-.1318245	.2471455	-.5333882
31	SEAS	79	-7	-.9031502E-01	.2491999	-.3624200
32	SEAS	79	-6	.5004431E-01	.2658780	.1882228
33	SEAS	79	-5	.1025092	.2514588	.4076580
34	SEAS	79	-4	-.1269591	.2511455	-.5055202
35	SEAS	79	-3	-.2208947	.2579273	-.8564224
36	SEAS	79	-2	-.7558672E-01	.2626510	-.2877838
37	SEAS	79	-1	-.3858137	.2666876	-1.446688

EQUATION 6
DEPENDENT VARIABLE 6 RINT
FROM 1973- 2 UNTIL 1987- 1
OBSERVATIONS 168 DEGREES OF FREEDOM 131
R**2 .85158664 RBAR**2 .81080129
SSR 352.07638 SEE 1.6393919
DURBIN-WATSON 1.99755749

NO.	LABEL	VAR	LAG	COEFFICIENT	STAND. ERROR	T-STATISTIC
1	USTBILL	1	1	.1876905	.1717923	1.092543
2	USTBILL	1	2	-.1674874	.1988378	-.8423314
3	USTBILL	1	3	-.2689163	.2047756	-1.313224
4	USTBILL	1	4	.1848981	.1727817	1.070125
5	USRINT	2	1	.4146396E-01	.6219695E-01	.6666559
6	USRINT	2	2	-.7750084E-01	.7509181E-01	-1.032081
7	USRINT	2	3	.1197299	.7726615E-01	1.549578
8	USRINT	2	4	-.2986343E-01	.6264242E-01	-.4767285
9	LSPOT	3	1	25.12684	19.10568	1.315150
10	LSPOT	3	2	-74.33556	28.15465	-2.640259
11	LSPOT	3	3	56.15487	26.25331	2.138964
12	LSPOT	3	4	-5.963271	16.33059	-.3651596
13	LRES	4	1	-1.098734	.8176286	-1.343806
14	LRES	4	2	-.3565771E-02	.8763029	-.4069108E-02
15	LRES	4	3	-1.700698	.9346096	-1.819688
16	LRES	4	4	2.673955	.9291405	2.877881
17	TBILL	5	1	.1097197	.3049728	.3597689
18	TBILL	5	2	.2853738	.4231445	.6744122
19	TBILL	5	3	-.5449123E-01	.4290889	-.1269929
20	TBILL	5	4	-.1634180	.2525011	-.6471970
21	RINT	6	1	.7070865	.8831651E-01	8.006278
22	RINT	6	2	-.1770588	.1050638	-1.685251
23	RINT	6	3	-.1098778	.1024675	-1.072318
24	RINT	6	4	.2301704	.8227390E-01	2.797612
25	CONSTANT	0	0	-5.536887	37.30511	-.1484217
26	TREND	80	0	.1016680E-01	.1621847E-01	.6268657
27	SEAS	79	-11	1.135270	.6961777	1.630719
28	SEAS	79	-10	1.086719	.7035482	1.544626
29	SEAS	79	-9	.2829748	.6916220	.4091467
30	SEAS	79	-8	-.6714428	.6558163	-1.023828
31	SEAS	79	-7	.9048956	.6612677	1.368425
32	SEAS	79	-6	.3222562	.7055243	.4567613
33	SEAS	79	-5	-.9061433	.6672620	-1.358002
34	SEAS	79	-4	-.3231386	.6664304	-.4848798
35	SEAS	79	-3	.2491122	.6844264	.3639723
36	SEAS	79	-2	2.246993	.6969612	3.223986
37	SEAS	79	-1	-.4980232	.7076724	-.7037482