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MACROECONOMIC IMPLICATIONS OF ALTERNATIVE EXCHANGE RATE MODELS

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Macroeconomic Implications of Alternative Exchange Rate Models

ABSTRACT

In this paper we estimate and compare several alternative exchange rate models that have received wide attention, but little comparison, during the 1970s. In order to compare purchasing power parity (PPP), nominal interest rate parity, real interest rate parity, and portfolio balance models, we first strip each down to its essential core and undertake comparable single-equation tests of both 'hard' and 'easy' (more and less constrained) versions of each model. We then embed each of the 'hard' versions in a new macroeconomic model of Canada, and assess their implications for the impacts of monetary and fiscal shocks.

Using annual Canadian data from the 1950s and 1970s, all of the models have single-equation errors of about 3%, except for the 'hard' versions of PPP and real interest parity, which are heavily rejected by the data. In a macroeconomic context, the models have modestly different implications for the effects of fiscal shocks, and diverge more widely under monetary shocks.

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1. INTRODUCTION

For all economies open to substantial trade and capital flows, exchange rates are central macroeconomic variables. As such, they influence, and are influenced by, all of the important forces of the economy. The general 1970s move to more flexible exchange rates has given rise to a variety of apparently competing theories of exchange rate determination. Some of these theories have been subjected to single-equation tests of quasi-reduced-form equations explaining the exchange rate. The partial nature of many of those competing models poses problems of interpretation. On the purely theoretical level,[1] the apparently conflicting implications of the various theories are often the consequence of alternative assumptions about what is held constant elsewhere in the economy, and vanish when the theories are embedded in a broader macroeconomic framework. Similarly, the empirical tests depend on different sets of macroeconomic variables that cannot generally be assumed to be independent of each other. In addition, estimation procedures and data samples are seldom used comparably for alternative theories. This poses problems of two types. First, it is not easy to tell to what extent the various models are competitors, rather than alternative renormalizations of the same broad system; and, to the extent that there is competition it is difficult to find comparable tests. This often makes it difficult for macro-economic model builders, as well as for policy-makers, to know which framework they should be using for

[1]. These issues are spelled out in some detail in Gylfason and Helliwell (1981).

exchange-rate analysis. Second, since the alternative theories are usually not compared within a quantitative macroeconomic framework, it is not possible to assess their implications for the national and international transmission of economic disturbances and policies.

In this paper, we will make a two-pronged attack on these problems. We shall start by comparably estimating four different models of exchange rate determination, based respectively on purchasing power parity, nominal interest parity, real interest parity, and portfolio balance. We shall apply and test each of these models on a structural basis, that is, as a renormalization of a single equation within a structural model. The equations will be estimated using annual data from the Canadian flexible exchange rate experience of the 1950s and 1970s.

We shall then put each of these models in a full macroeconomic model of the Canadian economy, and assess their implications for the domestic and international transmission of real and monetary shocks. For our example shocks, we shall use a sustained increase in real government spending, and a once-and-for-all increase in the stock of base money.

How does our paper fit in with some other recent empirical work on the role of exchange rates in empirical macroeconomics? It differs from the earlier Helliwell-Maxwell (1974) study of flexible exchange rates in three important respects. That paper compared the macroeconomic consequences of alternative exchange rate systems (e.g. rigidly fixed, Bretton Woods, crawling peg, and flexible) while in the current paper we compare alternative models of the determination of flexible exchange rates. The earlier paper emphasized bilateral linkage, through joint simulations with the RDX2 and MPS quarterly models of Canada and the United States, while in this paper we use a new, and much more compact, annual model of Canada with all world variables treated as exogenous. Finally, the earlier paper used flexible exchange rate data drawn mainly from Canadian experience of the 1950s, while the current data and estimates are based on almost equal amounts of data from the 1950s and 1970s.

Most recent studies of exchange rates in multilateral models involve a particular model of exchange rate determination.[2] To the extent that alternative exchange rate mechanisms are examined, it is usually fixed vs. flexible exchange rates, or alternative intervention strategies.

Recent studies of exchange rates in national models also have tended to focus on the comparison between fixed exchange rates and a particular model of the determination of flexible exchange rates (e.g. Amano, 1979; Carr et al., 1976), or on the implications of alternative expectations processes and intervention strategies (Jonson et al., 1981). Our paper can be seen as a modest extension of research towards a comparable macroeconomic evaluation of alternative models of the determination of flexible exchange rates. The structure of the paper is as follows: Section 2 contains the specification and

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[2]. Examples include the Japanese EPA World Economic Model (e.g. Amano, 1981), the U.S. Federal Reserve MCM Model (e.g. Hooper, Haas, and Symansky, 1981), the Mark III International Transmission Model (Darby, 1980), the Project LINK model (Hickman, 1981), the IMF's MERM model (Artus and McGuirk, 1981), and the WEXRAM model (Armington, 1980; Richard, 1980).

single-equation results for the alternative models of the exchange rate; section 3 describes the basic structure of the macro model, section 4 presents the results of the macroeconomic evaluations, and section 5 concludes the paper.

2. ALTERNATIVE MODELS OF THE EXCHANGE RATE

We have chosen four alternative theories for comparable specification and testing. We refer to them as purchasing power parity, interest parity, real interest parity and portfolio models. All of these theories have been called 'asset market' theories of exchange rate determination because the three former theories have often been estimated in conjunction with money demand equations and the latter involves asset stocks and portfolio balance directly. However, some of them can equally well be referred to as 'structural' or 'balance-of-payments components' models, because they have been used as elements of complete models in which the levels of current and capital accounts interact in the determination of the exchange rate. This is particularly true of the portfolio model, in which the accumulated stock of foreign assets or liabilities is an important determinant of the exchange rate.

In developing comparable forms of these theories, for testing and inclusion in a macroeconomic model, we have had to purge them of any elements that were already estimated elsewhere in the model. Since the MACE model already contains a demand for money equation, we have removed the money demand equations from the specification of the purchasing power parity and interest parity models and have directly estimated the remaining parts of the hypotheses.

In the case of the money plus purchasing power parity model, we have therefore estimated an exchange rate equation based on the the ratio of Canadian to US aggregate price levels. Table 1 shows two versions, a 'hard' version assuming full and immediate PPP, and an 'easy' version in which the current exchange rate depends on the lagged exchange rate and the current ratio of relative prices, with weights constrained to sum to 1.0. Although the 'easy' version is much preferred by the data, we use the 'hard' version in our macroeconomic analysis in order to show more clearly the implications of the PPP hypothesis.

The nominal interest parity model is initially a statement about the linkage between interest rate differentials and the forward exchange differential. It only becomes a theory of the level of the spot exchange rate if one assumes that the forward exchange rate is an accurate and unbiased estimator of the future spot rate and invokes another theory to tie down the expected future spot rate. The mechanism we have chosen, and applied to the interest parity model, is to assume that forecasts of the future spot rate are made optimally based on an information set including the current ratio of relative prices, the lagged exchange rate, and the current rates of inflation at home and abroad. In all cases, our estimates of the parameters of the optimal forecasting equation rejected the inclusion of current rates of inflation. Thus the equation used to generate the expected future spot rate is that shown in the notes to Table 1.

We developed and tested both 'hard' and 'easy' versions of the interest parity model, and once again used the 'hard' version for our macroeconomic assessments. The hard version forces the coefficients on the interest differential and the expected future spot rate to have the theoretically expected coefficient sizes, while the easy version allows the coefficients on the interest differential and on the expected future exchange rate to both be freely estimated. Unlike the PPP model, the constrained form of the IP model is not rejected in favour of the less constrained form.

Real and nominal interest parity are equivalent if purchasing power parity is continuously maintained. Thus our 'hard' version of real interest parity (RIP) combines hard interest parity with hard PPP, as shown by the equation for PFXHAT2 in the notes to Table 1, and is empirically the least successful of all of the models. It does not contribute anything to explaining the variance of the exchange rate (the adjusted coefficient of determination is negative), and its theoretical

Table 1

Alternative Model Estimates

Easy PPP Model

Dependent Variable:log(PFX) Procedure:restricted OLS

variable	coefficient	absolute t-ratio
constant	-0.0136	1.18
log(PQ/PA2)	0.3410	2.29
log(PFX(-1))	0.6589	4.44

Period:1953-61,71-78 RB2=.5235 SEE=.0294 DW=2.00

F-test on restriction: F(1,14)=0.01

Hard PPP Model

Dependent Variable:log(PFX) Procedure:restricted OLS

constant	-0.0549	5.50
log(PQ/PA2)	1.0	--

Period:1952-61,71-78 RB2=-.032 SEE=.0423 DW=0.91

F-test on restriction: F(1,14)=10.52

Easy IP Model

Dependent Variable:log(PFX) Procedure:OLS

constant	-0.0054	0.71
log(PFXE)	0.8693	4.57
log((1+RM2)/(1+RS))	3.1934	2.04

Period:1953-61,71-78 RB2=.5466 SEE=.0287 DW=1.23

Hard IP Model

Dependent Variable:log(PFX) Procedure:restricted OLS

constant	-0.0115	1.58
log(PFXHAT1)	1.0	--

Period:1953-61,71-78 RB2=.5026 SEE=.0300 DW=1.40

F-test on restriction: F(1,15)=0.96

Table 1 con't

Easy RIP Model

variable	coefficient	absolute t-ratio
Dependent Variable:log(PFX)		Procedure:restricted OLS
constant	-0.0170	0.99
log(PFXHAT2)	0.2466	1.58
log(PFX(-1))	0.7753	4.84

Period:1953-61,71-78 RB2=.4480 SEE=.0317 DW=1.92

F-test on restriction: F(1,14)=.008

Hard RIP Model

Dependent Variable:log(PFX)		Procedure:restricted OLS
constant	-0.0912	7.64
log(PFXHAT2)	1.0	--

Period:1953-61,71-78 RB2=-.329 SEE=.0492 DW=1.00

F-test on restriction: F(1,15)=11.7

Portfolio Model

Dependent Variable:PFX		Procedure:OLS
constant	-0.2005	0.56
LF1	0.6129	1.47
LF1(-1)	-0.3259	0.92
RS-RM2	-3.9956	2.17
PFXE	1.095	3.83

Period:1954-61,71-78 RB2=.5107 SEE=.0304 DW=1.25

Notes:
1. The variable PFXE represents the expected future value of the spot exchange rate, and was constructed by using the predicted values of the following equation:

log(PFX(+1)=-0.018+0.6460*log(PA2/PQ)+0.3539*log(PFX(-1)
(1.15) (3.10) (1.70)

Period:1953-61,71-78 RB2=.5107 SEE=.0413 DW=1.05
F-test on restriction: F(1,14)=0.25
the coefficients of the two explanatory variables were constrained to sum to 1.0.

2. The variable log(PFXHAT1)=log((1+RM2)/(1+RS))+log(PFXE).
3. The variable log(PFXHAT2)=
log(PQ(1+PQDOT)/PA2(1+PA2PA2DOT))+log((1+RM2)/(1+RS)).
4. LF1 is defined as follows: LF1=LF/(VKB+LB+HPM).

restrictions are rejected (F=11.7). The 'easy' version of real interest parity has both PFXHAT2 and the lagged exchange rate as explanatory variables, with the sum of the coefficients constrained (with no loss of goodness of fit) to sum to 1.0. The easy version of real interest parity fits much better than the hard version, but less well than any of the other models except hard PPP.

The portfolio model estimated here for comparison with the other models is an approximate[3] renormalization of the structural portfolio demand equation estimated as part of the MACE model. In its structure and properties it is rather similar to the 'easy' version of the interest parity model, as the terms representing the size and the change in the size of the value of net liabilities to foreigners do not add materially to the goodness of fit of the equation or alter the coefficients on the expected future exchange rate and the interest differential.

Purchasing power parity is imposed as part of the 'hard' versions of the PPP and real interest parity models, and plays a lesser, but still substantial, explanatory role in all the other versions of the directly estimated exchange-rate equations. PPP plays no direct role in the structural portfolio demand

[3] The two equations differ in their variables as well as their parameters. We have found, as have Hooper et al (1981) and others, that renormalizing the portfolio demand equation as an exchange-rate equation causes some variables to drop out, and others to be preferred. For example, some of the portfolio composition variables thus do not appear in the portfolio exchange rate equation. More importantly, the PPP-based PFXE has no impact if it is used in the portfolio structural equation, and we use instead the change in the exchange rate. By contrast, the portfolio exchange rate equation much prefers PFXE to the lagged exchange rate as a measure of expectations.

equation, where the lagged exchange rate replaces the ratio of national price levels as the proxy for the expected future exchange rate.

The unconstrained versions of all four models have standard errors of about 3%, and thus do not provide strong grounds in themselves for choosing among the alternative specifications. In earlier work, Boothe (1981) has constructed monthly and quarterly versions of these same models, and used rolling estimation periods and pure forecasts of exogenous variables to construct ex ante out-of-sample forecasting tests of the models against each other, against the forward rate, and against autoregressive forecasts of the exchange rate. He found that all of the models forecasted materially better than the forward rate or the pure time-series models. He also found that the information in the models could be combined with the information in the forward rate to produce better forecasts than provided from either alone. However, and this is the point that is most relevant to our current paper, he also found that the forecasting tests did not provide any strong ranking among the competing models.

3. THE MACROECONOMIC FRAMEWORK

As our test bench for the alternative foreign exchange models, we employ the MACE model of the Canadian economy, based on annual data from 1952 through 1978. The equation structure and parameter estimates of the version used for this paper are included in the Appendix.

In its broad structure, the model provides a two-sector description of the Canadian economy. The energy sector has been singled out for special treatment for several reasons: the price of energy rose so rapidly during the 1970s as to destroy any Hicksian grounds for treating energy and non-energy output as a single aggregate; the economic rents generated have been so large as to require separate accounting for factor returns and taxation in that sector; the value of energy trade in both directions has become very large and variable during the 1970s; and energy is an important input into non-energy production. Energy exploration, production and taxation are the subject of several hundred equations in the MACE model. For the purposes of this paper, the energy production sector can be regarded as a 'black box' that determines energy investment demand, certain revenue items, energy prices, and the quantities and prices of aggregate imports and exports of energy, given the simultaneously determined aggregate price indices and energy demands from the macro block.

The production structure of the non-energy sector can be best envisaged as a hierarchy. At the top level, there is an implicit CES function for the utility of final sales, with domestic gross output q and non-energy imports as the inputs. The elasticity of substitution is estimated to be about .4 in the current year and 1.25 in the long term. In the short term, the proportion of final sales met by imports is also determined by domestic capacity utilization. Gross production of the non-energy sector is based on a two-level function, with capital and energy bundled together in a vintage CES function and then combined with labour in a higher level Cobb-Douglas function.

The actual level of output is modelled as an estimated supply decision (equation 1.11) in which the chosen rate of factor utilization depends upon the ratio of current operating costs to the output price, current final sales relative to capacity output, and the gap between actual and desired inventories.[4]

Factor demands are based on partial adjustment towards the cost-minimizing input levels required to produce (at normal utilization rates) the forward looking estimates of profitable future output (equations 1.16 and 1.19), involving adjustment for unintended inventory changes and for lags in the adjustments of trade flows to relative prices. The pace of investment spending, but not the equilibrium capital stock, is also determined by Tobin's q, the ratio of the stock-market value to the replacement value of the business capital stock.

In addition to investment in the energy and non-energy sectors, the main components of final demand are consumption, exports, and government spending. The latter is taken to be exogenous, in real terms. Consumption spending is based on a life-cycle model, in which the proportion of disposable income that is spent depends on the real after-tax interest rate and the ratio of the market value of wealth to income. Energy

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[4] There is an increasing number of other macroeconomic models with supply-determined levels of output (e.g., the METRIC model of France, de Menil et al., 1977; the Australian RBA76 model, Jonson et al, 1977 and 1982; the Reserve Bank of New Zealand core model, G.H. Spencer, ed., 1980; and the Bank of Canada's SAM model, Masson et al., 1980), although they differ in the extent to which the actual level of output is determined by an explicit function of measured factor inputs. Since all these models determine inventory changes as the difference between production and sales, they usually employ the inventory stock discrepancy as an important determinant of prices, imports, production and factor demands.

exports are determined in the energy sector, while the quantity and price of non-energy exports are determined by two quasi-reduced-form equations that display the usual Canadian feature of relatively small responses of exports to relative prices.

The proportionate change in annual wages (equation 3.1) depends on the rate of increase in the absorption price, changes in the terms of trade, changes in the rate of overall factor utilization, the ratio of the 'natural' to the actual unemployment rate, and dummy variables reflecting the operation of Canada's system of wage controls in 1976-1978. Homogeneity is imposed (and easily accepted) by constraining the sum of the coefficients on the absorption price increase and the lagged wage change to equal 1.0. The terms-of-trade effect is large, being about equal to the share of exports in GNP. This has important implications for the efficacy of exchange rate changes in restoring the balance of trade in response to a shock. If a devaluation worsens the terms of trade, as is normally the case, the terms-of-trade effect in the wage equation slows down the response of the wage rate to the rise in the absorption price.

The proportionate increase in the price of the output of the non-energy sector depends on proportionate changes in the price of competing world output, domestic wages, and the costs of capital and energy, with coefficients constrained (easily) to sum to 1.0. There is a strong additional effect from the ratio of actual to desired inventories. The absorption price is a quasi-identity based on the prices of output of the non-energy sector, and the price of non-energy imports. It should be remembered that energy is an input to the non-energy sector, and the prices and quantities of the output of that sector include value-added by labour, capital, and energy.

In the balance of payments sector, a final category of trade has been singled out for special treatment - interest and dividend payments on net liabilities to foreigners. Throughout the 1970s, the market value of these liabilities has been about one-third of total government debt plus the market value of all business assets. Interest and dividend payments (not including retained earnings and capital gains, which are much larger on average) have risen to over 2% of GNP. This means that in the Canadian case, as for any open economy with easy access to foreign capital, it is important to introduce debt service payments as a wedge between GNP and GDP, with expected GDP driving factor demands and expected GNP driving consumption and accumulation decisions.

The version we use here is only slightly altered from that used in Helliwell, Boothe and McRae (1982). The main additions have been in the financial sectors, since the earlier paper was based on the small open economy assumption that capital was perfectly mobile between Canada and other countries, and hence that only tiny interest rate changes in Canada were required to finance any current account deficits or surpluses at unchanged exchange rates. The demand for high-powered money depends on nominal GNP (with an elasticity close to 1.0) and on the short-term interest rate. In the current version of the model, we exogenized the supply of high-powered money, and inverted the demand-for-money equation to determine the short-term interest rate. We considered alternative formulations in which real balances were deflated by the absorption price instead of the output price, and where money balances were given an explicit buffer role, but the simpler equation we use was empirically superior. We added a long-term interest-rate equation (5.7) based on current current and short-term interest rates, lagged long-term rates, and the medium-term U.S. bond rate. The market value of business assets is determined by a two-asset portfolio balance relationship similar to that used in RDX2, where the current earnings yield on equity is determined by the current yield on bonds, the expected rate of growth of profits, the relative supplies of government debt and business assets, and the gap between the U.S. yields on equity and debt. The market value of business assets, which influences investment spending through Tobin's q and consumption spending via wealth effects, is therefore an important channel for the operation of monetary policy.

The model is completed by equations for the market value of the foreign demand for Canadian assets, an equation explaining revaluation and retained earnings on the existing stock, and finally an identity determining the balance of payments measure of capital inflows as the change in the market value of foreign liabilities, minus the revaluation variable. These equations are used when the basic version of the model is run, with the balance of payments equilibrium condition used to solve for the exchange rate. When one of the estimated exchange rate equations of section 2 is used, it replaces the capital movements equation, as described in the next section.

4. EFFECTS OF FISCAL AND MONETARY POLICIES UNDER ALTERNATIVE EXCHANGE RATE MODELS

One of the difficulties in applying partial models of the exchange rate in a macroeconomic context (as emphasized by Amano, 1981) is that it is not always clear how they should be made consistent with an overall model. Mindful of this problem at the outset, we trimmed down each partial model until its estimated form could reasonably be regarded as a re-normalization of a particular equation in a structural model. Thus, to take the example of the money-plus-PPP model of exchange rate determination estimated by Bilson (1978) and by most of the authors in Frenkel and Johnson, eds. (1979), we split the PPP part of the hypothesis from the money demand equation (since our model, like most others, already had a money demand equation) and fitted the PPP relationship directly for the exchange rate. Since the PPP hypothesis relates to the close linkage of national output markets, it is natural to treat the PPP relation as saying that any amount of a country's output could be sold abroad at a given foreign price. To implement this assumption in the hard PPP simulations, we suppress the model's equation for non-energy exports of goods, and thus use the balance-of-payments identity to determine non-energy exports, with the exchange rate set at the value determined by the PPP definition.

The money-plus-interest-parity and the money-plus-real-interest-parity theories were also separated into their two component parts, with money demand being determined by the MACE equation, and the exchange rate equations estimated in section 2 being used to replace the capital flow equations. Since both these theories rest on the perfect mobility of capital, they can be treated as alternative versions of the small open economy assumption used in Helliwell, Boothe, and McRae (1982). The inflow of capital is therefore simply equal to the negative of the current account balance, after allowing for any official foreign exchange intervention.

We have simulated two versions of the portfolio model. One is the directly estimated structural equation (4.4) reported in the appendix, and the other is the re-normalized version estimated as an exchange rate equation and reported in section 2. We have used both versions in simulation because we found, as have Hooper et al. (1981), that directly estimated portfolio equations usually have a smaller estimated role for exchange-rate-stabilizing capital flows than is implied by the same equation when it is estimated as an exchange rate equation. In the latter case, any shock to the trade account simply adds to or subtracts from net foreign liabilities, and only influences the exchange rate through the feedback from the accumulating asset or liability. By contrast, with the explicit model the exchange rate has to move to keep payments in balance, and a trade account shock will only be buffered by accommodating capital movements to the extent that the trade account or the exchange rate enters explicitly in the determination of the desired portfolio liability.

To demonstrate the properties of the alternative exchange rate models, we first prepared a 1974-1980 control solution for the each version of the macro model, and then subjected the models to monetary and fiscal shocks. The fiscal shock is a sustained bond-financed increase in government spending. The size of the increase is one billion 1971 Canadian dollars, so that the real GNP responses of Figures 1, 3, and 5, which are also reported in billion 1971 dollars, can be read as expenditure multipliers. The monetary shock is a once-and-for-all 5% increase in the stock of high-powered money. The size of the increase, which takes place in 1974, is $465 million.

To provide a summary comparison of the properties of the alternative exchange rate models, we have prepared six figures, each of which shows the responses of several alternative systems. Figures 1, 3, and 5 show responses to the government expenditure shock and Figures 2, 4, and 6 show the responses to the increase in high- powered money. Figures 1 and 2 show the exchange rate responses, Figures 3 and 4 the real GNP responses, and Figures 5 and 6 the responses of the rate of increase in the absorption price. In all cases, the results are shown in shock minus control format. To ensure comparability of the shock minus control results, we have used separate control solutions for each of the exchange rate models. However, we report in the tables only the control solution for one version of model, since single-equation errors are added back in all cases to make the control solutions almost identical.

Figure 1 shows that the price of foreign exchange increases under the fiscal shock in the PPP and real interest parity cases, while being reduced in the portfolio and nominal interest parity cases. In the exchange rate systems with capital mobile in response to nominal interest differentials, the capital inflow effects of the higher interest rates more than offset the effects of the current account deficit, while in the two systems that are most responsive to inflation rate and price level differentials, the domestic currency depreciates throughout the simulation period.

In response to the monetary expansion, the price of foreign currency increases in all cases, although now the increases are greatest and fastest for the models (portfolio and nominal interest parity) in which capital movements and exchange rates are most dependent on nominal interest rate differentials. The PPP rate moves only slowly in response to the monetary shock, a result that would be qualified if the PPP model were given a more forward-looking expectations structure. Note that the structural portfolio model, with its more explicit but more limited role for exchange-rate-stabilizing capital movements, has a more volatile response than the other systems to both fiscal and monetary shocks, especially the latter.

Figure 3 shows that the initial multiplier responses to an expansion of government spending are almost identical for all the exchange rate systems, but start to diverge rapidly after the second year, with the net GNP effects soon becoming negative for the more inflation-sensitive flexible exchange rate models (PPP and real interest parity) and for the fixed exchange system.

The GNP responses to monetary expansion are much more divergent right from the beginning, a result that is to be expected, since the exchange rate moves very differently under monetary expansion in the different models, and the exchange rate in turn has very important effects on spending and output. The response appears to be importantly cyclical for all of the models, and may be diverging from a stable path in the case of real interest parity.

Figure 5 shows clearly the strong links between the exchange rate and the domestic absorption price, as the systems with the least induced inflation from the fiscal expansion are those (portfolio and nominal interest parity) in which the higher interest rates accompanying the fiscal expansion lead to a revaluation of the domestic currency. The inflation responses to the monetary shock are as divergent as the exchange rate effects of the monetary expansion, and for essentially the same reasons.

5. SUMMARY AND EXTENSIONS

The results reported in the figures and tables are helpful in showing where the selection of one or another model of exchange rate determination has important effects on the dynamic responses of a macroeconomic model. It is clear that the results of the various models differ much more with respect to monetary than with respect to fiscal shocks. In general, the four exchange rate models seem to fall into two broad classes with respect to their macroeconomic implications, with the PPP and real interest parity models in one group and the nominal interest parity and portfolio models in the other group.

We must qualify our results by noting that they are probably sensitive to the country and the macro-model (and even the version of the macro model) used for the experiments. If such tests are to be useful, they should probably be replicated for a broader class of macro models covering countries with different structures than that of Canada.

The fact that single-equation tests of competing exchange market models do not provide strong grounds for selection and rejection, and the obvious importance that the choice of exchange rate model has for the properties of macroeconomic models, suggests to us that model builders and users would be well advised to regularly test the sensitivity of their results to the selection of a particular model for the determination of exchange rates.

We think that it will be useful to use alternative exchange rate models in macroeconomic analysis, and also to use macroeconomic tests to help evaluate exchange rate models. The estimation results reject fairly easily the strong versions of some of the models, but this does not help to establish clear rankings in the very large class of less constrained alternatives. Macroeconomic analysis should probably be an integral part of the selection process for exchange rate models to be used in national or multilateral modelling.

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FIG.1: EXCHANGE RATE RESPONSE TO FISCAL SHOCK

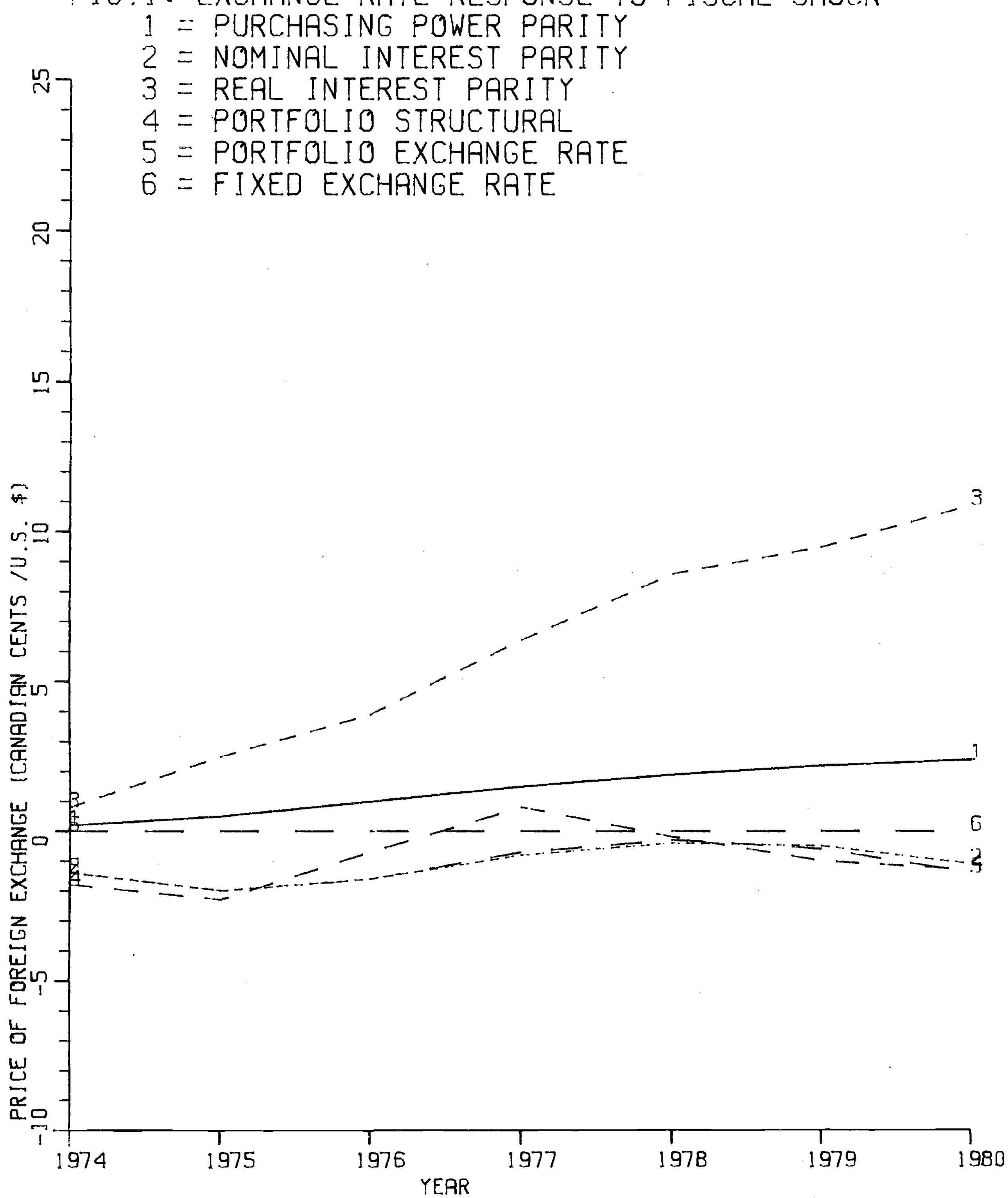


FIG.2: EXCHANGE RATE RESPONSE TO MONETARY SHOCK

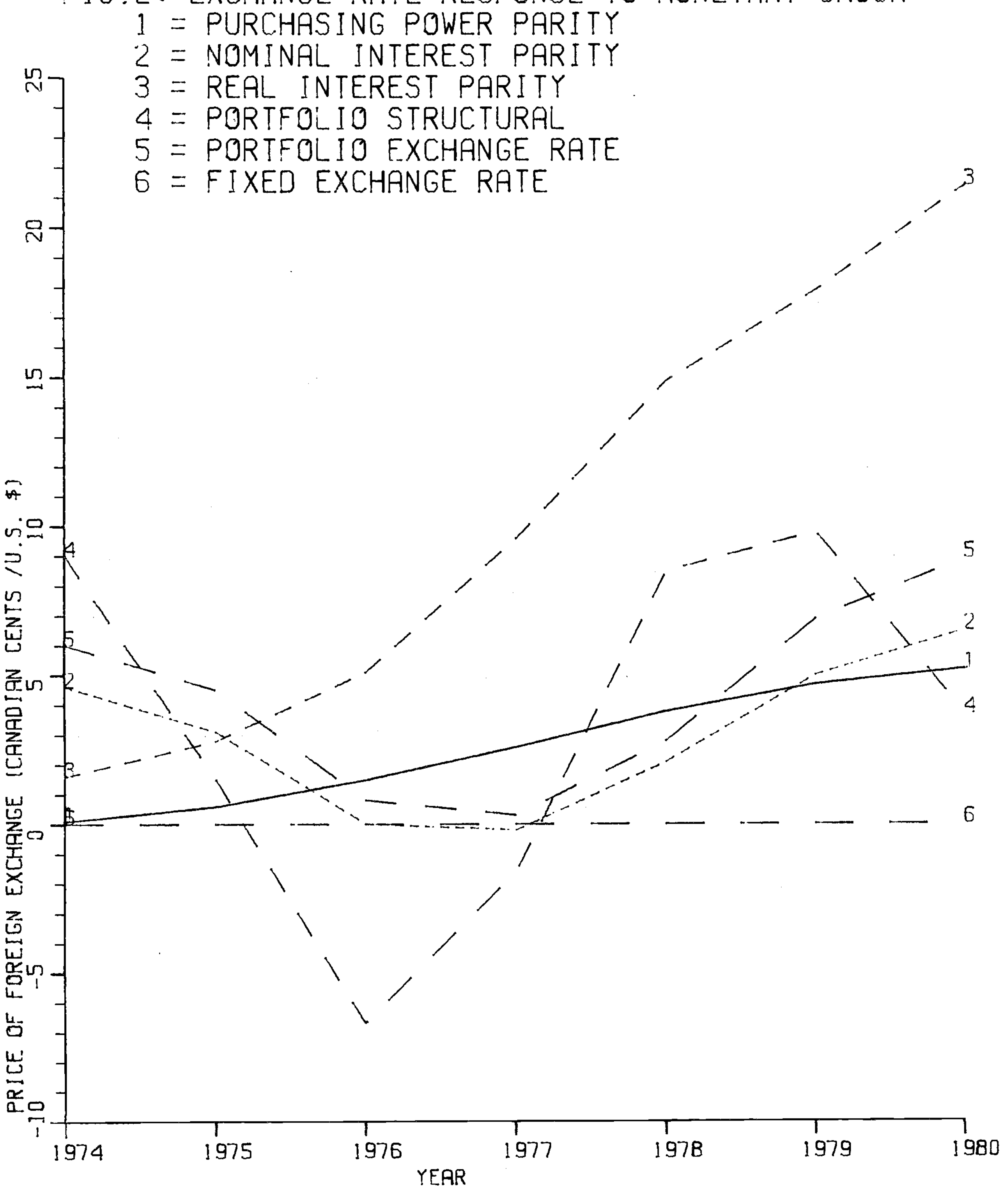
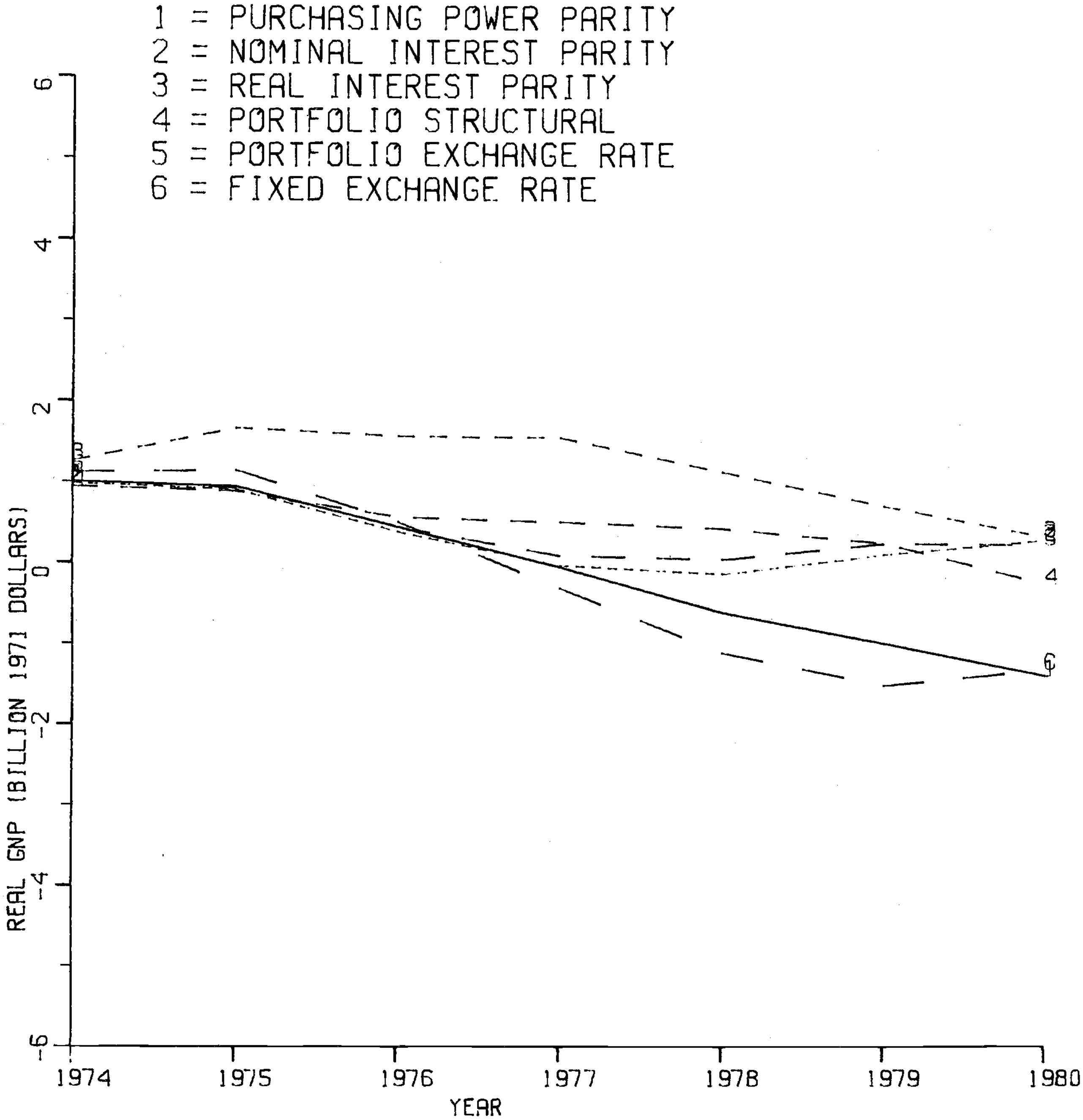


FIG.3: REAL GNP RESPONSE TO FISCAL SHOCK



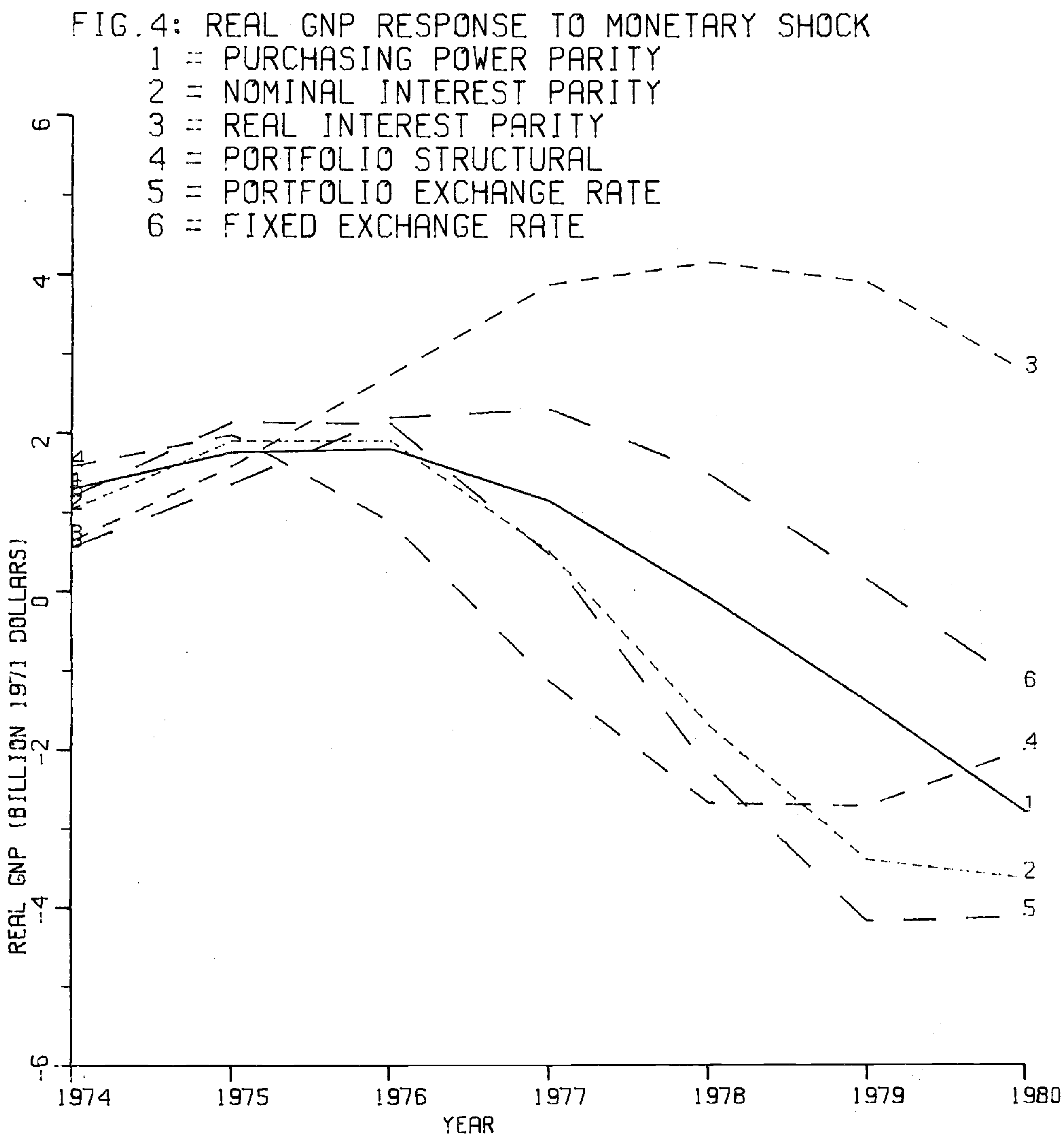


FIG.4: REAL GNP RESPONSE TO MONETARY SHOCK
1 = PURCHASING POWER PARITY
2 = NOMINAL INTEREST PARITY
3 = REAL INTEREST PARITY
4 = PORTFOLIO STRUCTURAL
5 = PORTFOLIO EXCHANGE RATE
6 = FIXED EXCHANGE RATE
REAL GNP (BILLION 1971 DOLLARS)
6
4
2
0
-2
-4
-6
1974
1975
1976
1977
1978
1979
1980
YEAR
3
6
4
1
2
5

FIG.5: INFLATION RATE RESPONSE TO FISCAL SHOCK

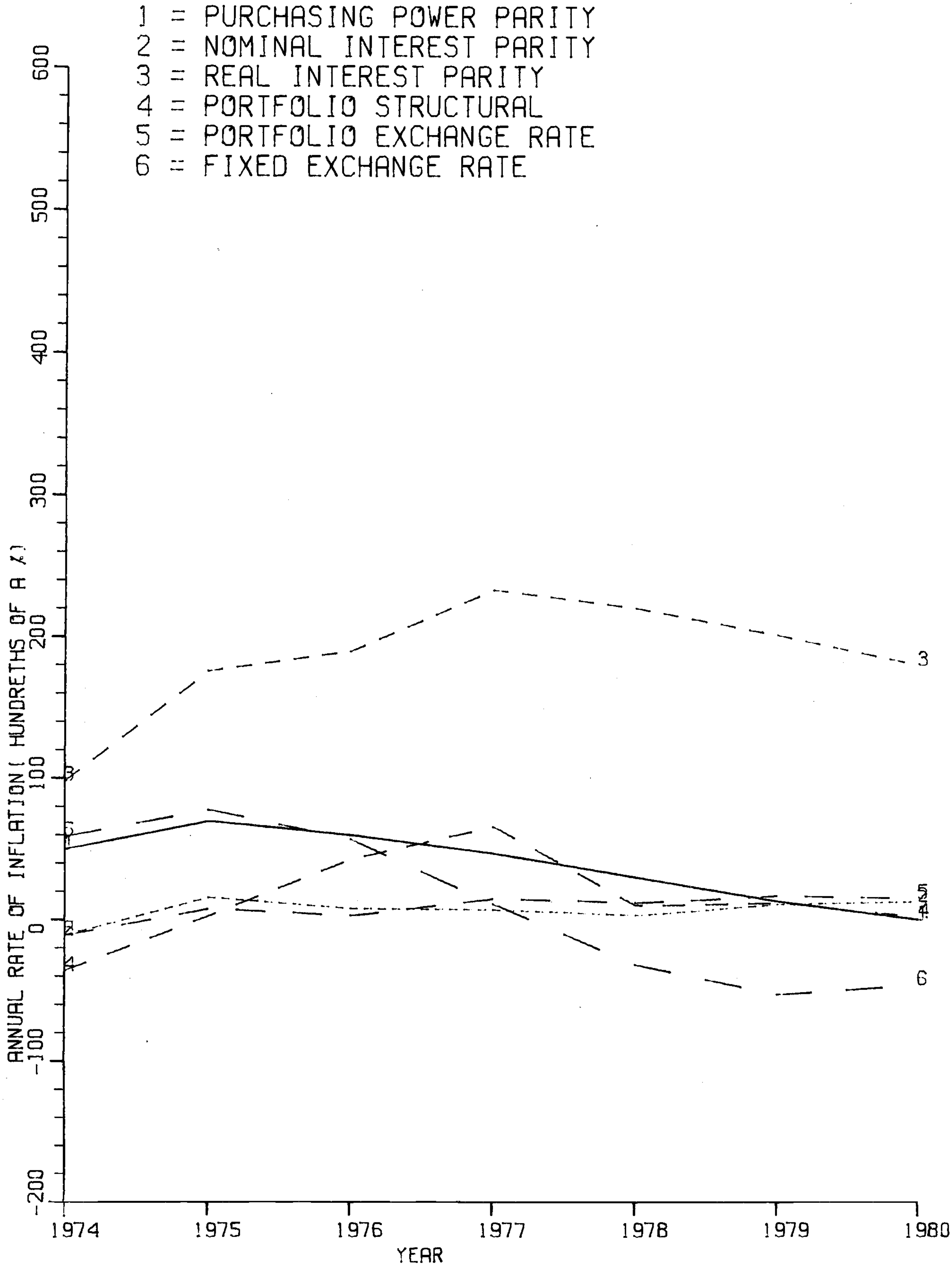
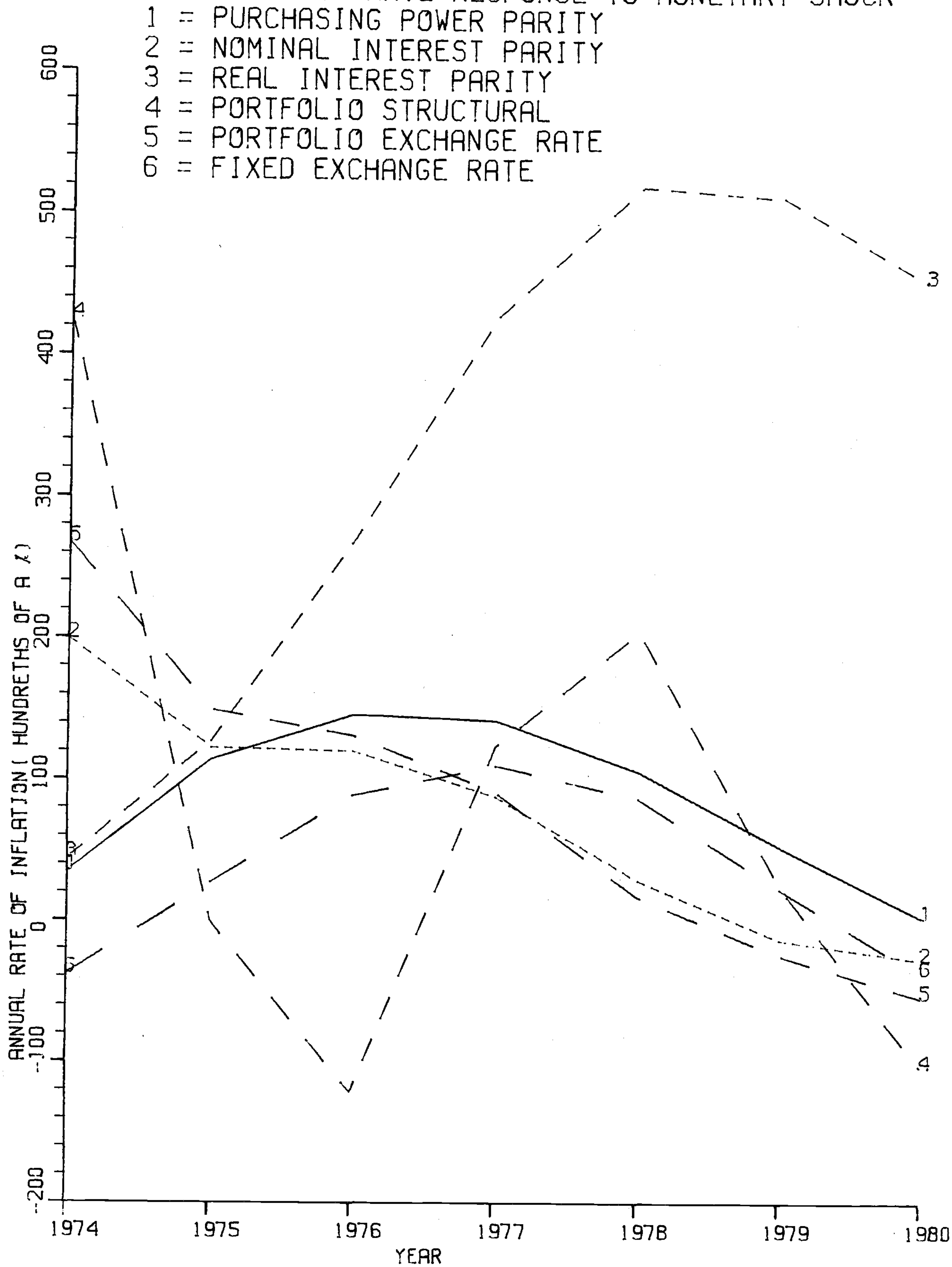


FIG.6: INFLATION RATE RESPONSE TO MONETARY SHOCK



THE LIST OF VARIABLES

Conventions

$*$ denotes desired value, e.g., k^*_{ib}

$\tilde{}$ denotes quantity given by a CES bundle, e.g., $\tilde{k}_e$

— denotes a two period average, e.g., $\bar{k}_{ne} = \frac{1}{2}(k_{ne} + k_{ne-1})$

-t denotes a lag of t years, e.g., q_{-1}

$\hat{}$ denotes equilibrium value at full capacity utilization after lags are worked out, e.g., $\hat{m}_{ne}$

• denotes one-period proportionate change, e.g.,
$\dot{p}_a = (p_a - p_{a-1})/p_{a-1}$

Variable	Equation No.	Description
a	2.3	Real absorption, billion 1971 $
B	4.6	Current account of the balance of payments, billion $
B_e	4.9	The balance of trade in energy, billion $
c	2.1	Personal consumption expenditures, billion 1971 $
C_{ca}	Exogenous	Capital consumption allowance, billion $
c_q	1.10	Production costs relative to output price for q
e	1.8	Energy expenditure, billion 1971 $
e_v	1.4	Vintage-based energy requirement, billion 1971 $

Variable	Equation No.	Description
F_i	4.1	Net capital inflows excluding official monetary movements, billion $
F_{ireva}	4.7	Retained earnings and revaluation on foreign-held domestic assets, billion $
F_{xo}	4.2	Official purchases of foreign exchange, billion US $
g	Exogenous	Real government current and capital expenditures on goods and services, billion 1971 $
G_{misc}	Exogenous	Balancing item to link government National Accounts Balances to changes in government money and debt outstanding, including government transfers, billion $
G_{fsubo}	Exogenous	Federal government subsidies to oil importers
H	5.4	High powered money, billion $
i_e	Link	Energy investment, billion 1971 $
i_{ib}	1.13	Value of physical change in non-farm inventories, billion 1971 $
i_{ne}	1.1	Business fixed investment (excluding energy investment), billion 1971 $
i_{new}	1.3	Re-investment with energy use malleable in the current year, billion 1971 $
$\tilde{k}_{ev}$	1.3	Vintage measure of capital and energy, billion 1971 $
k_{ib}	1.14	Stock of non-farm inventories, billion 1971 $
k_{ne}	1.2	Business fixed capital stock (excluding energy), billion 1971 $
L_b	5.3	Net stock of government non-monetary liabilities, billion $

Variable	Equation No.	Description
L_f	4.4	Net liabilities to non-residents (excluding official reserves), billion $
M_{car2}	Exogenous	Imports of cars from U.S., billion $
m_e	Link	Canadian imports of energy fuels, billion 1971 $
M_{id}	4.5	Interest and dividend payments to foreigners, billion $
m_{ne}	1.12	Imports of goods and services (excluding energy), billion 1971 $
N_e	1.6	Total employed (excluding armed forces), millions of persons
N_ℓ	Exogenous	Total civilian labour force, millions of persons
N_p	Exogenous	Average population in each period, millions of persons
p_a	3.4	Implicit price of absorption, 1971 = 1.0
P_e	Link	Price of primary energy, 1971 = 1.0
p_{fx}	4.3	Spot price of foreign exchange, \$CDN per \$US
p_{me}	Link	Price index for imported energy, 1971 =1.0
p_{mne}	3.5	Price of imports of goods and services (excluding energy), 1971 = 1.0
p_{mw}	Exogenous	Index of world price of Canadian imports (excluding energy), $p_{mw} = p_{mne}/p_{fx}$
p_q	3.2	Implicit price for gross domestic output, including imported energy, 1971 = 1.0
p_w	Exogenous	OECD real output deflator, 1971 = 1.0

Variable	Equation No.	Description
p_{wxg}	Exogenous	Price index of world exports of goods, 1971 = 1.0
p_{xe}	Link	Price of energy exports, 1971 = 1.0
p_{xne}	3.3	Price of exports of goods and services (excluding energy), 1971 = 1.0
q	1.11	Gross output (at factor cost) of the non-energy sector, billion 1971 $. (Equals real GDP plus net energy imports)
q_a	1.15	Aggregate demand (output less unintended inventory accumulation), billion 1971 $
q_s	1.9	Synthetic supply variable, billion 1971 $
q^*	1.16	Desired level of profitable future output for investment demand, billion 1971 $
q_ℓ^*	1.19	Desired level of profitable future output for labour demand, billion 1971 $
q_{sv}	1.17	Vintage-based synthetic supply, billion 1971 $
r_d	Exogenous	Ratio of Canadian bonds held by foreigners to total net liabilities to foreigners
r_{ep2}	Exogenous	Earnings/price ratio for U.S. equities, percent
$r_{\ell f}$	Exogenous	Fraction of population of labour force age
r_ℓ	5.7	Average yield on Government of Canada bonds, 10 years and over, percent
r_{m2}	Exogenous	Average yield on U.S. government equities, 3-5 years, percent
r_{nat}	Exogenous	Natural rate of unemployment, percent
r_{nu}	1.7	Unemployment rate, percent
r_{part}	Exogenous	Participation rate in labour force
r_s	5.5	Average yield on Government of Canada bonds, 1-3 years, percent

Variable	Equation No.	Description
r_{tb2}	Exogenous	Yield on 91-day U.S. Treasury bills converted to Canadian equivalence, percent
r_{tp}	Exogenous	Total personal income tax rate
r_{ti}	Exogenous	Indirect tax rate
r_{vb}	2.4	Proportion of business capital stock owned by foreigners
t		Time, 1900 = 0
T_{cne}	5.45	Total corporate taxes, billion $
T_d	5.2	Total direct taxes on corporations and persons, billion $
T_i	5.1	Indirect taxes less subsidies, billion $
V	5.10	Market value of private sector wealth, billion $
V_{kb}	5.6	Market value of year-end stock of business fixed capital and inventories in Canada, billion $
W	3.1	Wage rate, thousands of dollars per year per employed person
X_{car2}	Exogenous	Exports of cars to U.S., billion $
x_e	Link	Exports of primary energy, billion 1971 $
X_{id}	Exogenous	Interest and dividend receipts from non-residents, billion $
x_{ne}	2.2	Exports of goods and services (excluding energy), billion 1971 $
X_{tr}	Exogenous	Net Transfers plus misc. other items required to satisfy the Balance of Payments identify, billion $
y	3.6	Real gross national product, billion 1971 $
Y	3.7	Nominal gross national product, billion $

Variable	Equation No.	Description
y_w	Exogenous	Real output in major OECD economies, billion 1975 US $
δ_1	Exogenous	Annual rate at which energy/capital proportions become malleable in k_{ev}
δ_2	Exogenous	Depreciation rate. We set $\delta_2 = .05$
Π	Exogenous	Labour productivity index for Harrod-neutral technical progress in Cobb-Douglas function for Q
ρ_r	Exogenous	Real supply price of capital, percent. We take $\rho_r = 7.0$

MACE Model Structure

1. Supply and Factor Demands

Fixed business investment:

(1.1)
$$i_{ne}/\bar{k}_{ne} = \underset{(5.66)}{.4709}\ i_{ne-1}/\bar{k}_{ne-1} + \underset{(7.71)}{.087765}\ k^{*}-\bar{k}_{ne}/\bar{k}_{ne}$$

$$+ \underset{(2.20)}{.013624}\ \bar{V}_{kb}/p_a\bar{k}_{ne} - \underset{(6.64)}{.17607}\ c_q + \underset{(6.47)}{.20708}$$

OLS 1954 - 1978: s.e.e = .00251; $\bar{R}^2$ = .8986; Durbin-H = -.690

where

$$k^{*} = \frac{q^{*}}{4.5336}\left[\beta+\gamma^{\sigma}\left(\beta\frac{p_e}{p_k}\right)^{1-\sigma}\right]^{\frac{\sigma}{1-\sigma}}\left[\frac{\alpha W}{\Pi(1-\alpha)(\beta^{\sigma}p_k{}^{1-\sigma}+\gamma^{\sigma}p_e{}^{1-\sigma})}\right]^{1-\sigma}$$

is the desired long term level of capital and $p_k = (\delta_2 + .01\rho_r)p_a$ is the price of capital services

Business fixed capital stock:

(1.2) $$k_{ne} = (1-\delta_2)k_{ne-1} + i_{ne}$$

Vintage bundle of capital and energy ("energized capital"):

(1.3) $$\tilde{k}_{ev} = (1-\delta_1)\tilde{k}_{ev-1} + i_{new}\left[\beta + \gamma \left(\frac{\gamma p_k}{\beta p_e}\right)^{\sigma-1}\right]^{\frac{\sigma}{\sigma-1}}$$

where

$$i_{new} = i_{ne} + (\delta_1-\delta_2)k_{ne-1}$$

is re-investment with energy use malleable in the current year.

Vintage-based energy requirement:

(1.4) $$e_v = (1-\delta_1)e_{v-1} + \left(\frac{\gamma p_k}{\beta p_e}\right)^{\sigma} i_{new}$$

Labour force:

(1.5) $$N_\ell = r_{\ell f}\, r_{part}\, N_p \qquad \text{(currently exogenous)}$$

Employment:

(1.6) $$N_e = \underset{(84.76)}{.82100}\, N_{e-1} + \underset{(18.48)}{.17900}\, \frac{1}{\Pi}\left(\frac{q_\ell^{*}\, \tilde{k}_{ev}^{-\alpha}}{4.5336}\right)^{\frac{1}{1-\alpha}}$$

OLS = 1955 - 1978; s.e.e. = .0559; $\bar{R}^2$ = .9984

Unemployment rate:

$$r_{nu} = 100 \; \frac{N_\ell - N_e}{N_\ell} \tag{1.7}$$

Energy demand:

$$\ln e = \underset{(15.52)}{0.24484} + \underset{(68.09)}{1.1898} \ln \bar{k}_{ne} - \underset{(18.77)}{.67286} \frac{\sum_{i=0}^{3} (1-\delta_1)^{i+1} p_{e-i}/p_{k-i}}{\sum_{i=0}^{3} (1-\delta_1)^{i+1}} \tag{1.8}$$

OLS 1955 - 1978; s.e.e = .0158; $\bar{R}^2$ = .9989; D-W = 1.54

Synthetic supply variable:

$$q_s = 4.5336 \; \tilde{k}_e^{\alpha} \left(\Pi \; N_e\right)^{1-\alpha} \tag{1.9}$$

where

$$\tilde{k}_e = \left(\beta \, k_{ne}^{\frac{\sigma-1}{\sigma}} + \gamma \, e^{\frac{\sigma-1}{\sigma}}\right)^{\frac{\sigma}{\sigma-1}}$$

is the CES bundle of capital and energy

Vintage based synethetic supply:

(1.17) $$q_{sv} = 4.5336\ (\overline{\tilde{k}_{ev}})^{\alpha}(\Pi\ N_e)^{1-\alpha}$$

Average unit cost, relative to output price for producing gross output of the non-energy sector:

(1.10) $$c_q = \frac{ep_e + \overline{k}_{ne}p_k + N_eW}{qp_q}$$

Output equation:

(1.11) $$\ln q = \underset{(5.75)}{-.16676} + \underset{(146.47)}{.99326} \ln q_{sv} - \underset{(6.86)}{.44012} \ln c_q$$

$$+ \underset{(10.54)}{.48017} \ln \frac{a + x_{ne}}{q_{sv}} + \underset{(.618)}{.018998} \ln \frac{k^*_{ib}}{\overline{k}_{ib}}$$

OLS 1955 - 1978; s.e.e. = .00454; $\overline{R}^2$ = .9998; D-W = 1.59

where $k^*_{ib} = .13357\ \overline{k}_{ne}$

Non-energy imports:

(1.12) $$\ln\left(m_{ne} - M_{car2}/p_{mne}\right) = -\underset{(6.39)}{1.2010} + \underset{(21.90)}{.91363}\ln q$$

$$-\underset{(6.48)}{1.2535}\ln\left(\frac{1}{3}\sum_{i=1}^{3}\frac{p_{mne-i}}{p_{q=i}}\right) + \underset{(3.13)}{1.3898}\ln\left(\frac{\overline{q}}{q_{sv}}\right)$$

OLS 1955 - 1978: s.e.e = .0288; $\bar{R}^2$ = .9944; D-W = 2.16

Change in non-farm business inventories:

(1.13) $$i_{ib} = q + T_i/p_q - a - x_{ne} + m_{ne}$$

Stock of non-farm business inventories:

(1.14) $$k_{ib} = k_{ib-1} + i_{ib}$$

Aggregate demand:

(1.15) $$q_a = q - \left[i_{ib} - .08\left(k^*_{ib} - \overline{k}_{ib}\right)\right]$$

or, in cases where expected output is taken to be exogenous:

(1.15)' $$\ln q_a = 1.0277 + .047889t$$

Desired level of future output for investment demand:

(1.16) $$q^* = 1.07^{\frac{3}{4}}\ q_a\left(\frac{q}{q_{-2}}\right)^{\frac{1}{4}} \quad ,$$

Desired level of future output for labour demand:

(1.19) $$q_\ell^* = 1.07^{\frac{1}{4}} q_a \left[1 + .1(m_{ne} - \hat{m}_{ne})/q\right]\left(\frac{q}{q_{-2}}\right)^{\frac{3}{4}}$$

where $\hat{m}_{ne}$ is the equilibrium level of imports at full capacity with lags worked out

$$\ln(\hat{m}_{ne} - M_{car2}/p_{mne}) = -1.2010 + .91363 \ln q_{sv} - 1.2535 \ln \frac{p_{mne}}{p_q}$$

2. Personal and Foreign Expenditure on Goods and Services

Personal expenditure:

(2.1) $$c/y_d = \underset{(11.18)}{.75952}\, c_{-1}/y_d - \underset{(3.50)}{.33278}\left[r_s(1-r_{tp}) - \dot{p}_a'\right]/100 + \underset{(1.92)}{.023729}\, \overline{V}/(Y-T_d) + \underset{(3.35)}{.15916}$$

where y_d = real disposable income = $(Y-T_d)/p_a$ and

$\dot{p}_a' = 200(p_a - p_{a-1})/(p_a + p_{a-1})$

OLS 1954 - 1978; s.e.e. = .0092; $\overline{R}^2$ = .8764; D-W = 1.84

Non-energy exports:

(2.2)
$$\ln(x_{ne}-X_{car2}/p_{xne}-X_{id}/p_{xne}) = \underset{(17.48)}{-6.9978}$$

$$+ \underset{(24.87)}{1.2277} \ln y_w - \underset{(2.54)}{.4284} \left(\frac{1}{3} \sum_{i=0}^{2} \frac{p_{xne-1}}{p_{fx-i}p_{w-i}}\right)$$

OLS 1955 - 1978: s.e.e. = .0412; $\bar{R}^2$ = .9910; D-W = 1.33

Real absorption:

$$a = c + g + i_{ne} + i_e$$

Return to non-residents on Canadian business assets, as a fraction of the total return:

(2.4)
$$r_{vb} = \underset{(16.90)}{.2404} + \underset{(19.03)}{.6731} \left(1-r_d\right) \frac{L_f}{V_{kb}}$$

OLS 1954 - 1978: s.e.e. = .0115; $\bar{R}^2$ = .9377; D-W = .95

3. Prices, Wages and National Income

Proportionate annual wage change:

$$(3.1)\quad \dot{W} = \underset{(.25)}{.0014817} + \underset{(4.39)}{.36381}\ \dot{W}_{-1} + \underset{(7.67)}{.63619}\ \dot{p}_a + \underset{(2.98)}{.16984}\ \left(\frac{p_{xne}}{p_{mne}}\right)^{\bullet}$$

$$+ \underset{(2.14)}{.22425}\ \left(\frac{\dot{\bar{q}}}{q_{sv}}\right) + \underset{(3.24)}{.023240}\ r_{nat}/r_{nu}$$

$$- \underset{(.38)}{.00221}D_{76} - \underset{(4.69)}{.022570}\ D_{77} - \underset{(4.87)}{.025765}\ D_{78}$$

with coefficients on $\dot{W}_{-1}$ and $\dot{p}_a$ constrained to sum to unity.

3SLS 1955 - 1978: s.e.e. = .00544; $\bar{R}^2$ = .975; Durbin-h = -.50; F - statistic for constraint = .062

Proportionate change in implicit price index for output:

$$(3.2)\quad \dot{p}_q = \underset{(12.40)}{-.026725} + \underset{(25.78)}{.80324}\ \dot{W} + \underset{(2.98)}{.087383}\ \dot{p}_e + \underset{(3.52)}{.066412}\ (p_{fx}\ p_{wxq})^{\bullet}$$

$$+ \underset{(3.25)}{.042967}\ \dot{r}_{\ell} + \underset{(4.03)}{.13651}\ \frac{k^*_{ib} - \bar{k}_{ib}}{k^*_{ib}}$$

with cost shares constrained to add to unity.

3SLS 1955 - 1978: s.e.e = .0069; $\bar{R}^2$ = .968; D-W = 1.98;
F - statistic for constraint = .047

Proportionate change in absorption price index:

(3.4) $$\dot{p}_a = .00067021 + .83163\ \dot{p}_q + .16837\ \dot{p}_{mne}$$
$$(.42) \quad (21.90) \quad (4.43)$$

with domestic and import fractions constrained to sum to unity.

3SLS 1955 - 1978: s.e.e. = .0078; $\bar{R}^2$ = .945; D-W = 1.65;
F - statistic for constraint = 12.3

Non-energy exports:

(3.3) $$\ln p_{xne} = .0062945 + .29941 \ln p_{wxg}$$
$$(1.24) \quad (13.08)$$

$$+ .52011 \ln p_q + .42717 \ln p_{fx}$$
$$(19.47) \quad (8.32)$$

OLS 1953 - 1978: s.e.e = .0105; $\bar{R}^2$ = .9986; D-W 1.38

Real GNP:

(3.6) $$y = a + i_{ib} + x_{ne} + x_e - m_{ne} - m_e - M_{id}/p_{mne}$$

Nominal GNP:

(3.7) $$Y = qp_q - M_{id} - m_e p_{me} + T_i$$

4. Balance of payments, capital movements

Net capital inflows, excluding official monetary movements:

(4.1) $$F_i = L_f - L_{f-1} - F_{ireva}$$

or, for the small open economy:

(4.1)' $$F_i = -B + p_{fx}F_{xo}$$

Price of foreign exchange:

(4.3) $$p_{fx} = p_{fx} + .01(-B - F_i + p_{fx}F_{xo})$$

and other formulations discussed in Section 2.

Net liabilities to non-residents:

(4.4)
$$\begin{aligned}
L_f/(V_{kb} + L_b + H) = {} & \underset{(6.68)}{.22662} + \underset{(1.77)}{.15130}(p_{fx} - p_{fx-1}) \\
& + \underset{(5.70)}{1.7840}(r_s - r_{tb2})/100 \\
& + \underset{(4.53)}{.51215}\, L_{f-1}/(V_{kb-1} + L_{b-1} + H_{-1}) \\
& + \underset{(2.61)}{.26357}\, L_{f-2}/(V_{kb-2} + L_{b-2} + H_{-2}) \\
& - \underset{(5.54)}{.54416}(L_b + H)/(V_{kb} + L_b + H) \\
& + \underset{(.79)}{.3583}[p_{xne}(\hat{x}_{ne}-x_{ne}) - p_{mne}(\hat{m}_{ne}-m_{ne})]/(V_{kb} + L_b + H)
\end{aligned}$$

OLS 1955-1978: s.e.e. = .0093; $\overline{R}^2$ = .9195; Durbin-h = 2.28

Net foreign liabilities with small open economy assumption:

(4.4)' $$L_f = L_{f-1} + F_i + F_{ireva}$$

Interest and dividend payments to foreigners (BOP definition):

(4.5) $$M_{id} = \underset{(.41)}{.0722} + \underset{(9.08)}{1.3186}\, r_d \frac{r_\ell}{100} \overline{L}_f$$

$$+ \underset{(1.45)}{.010758}\, (1 - r_d)\, \overline{L}_f$$

OLS 1954 - 1978: s.e.e = .2476; $\overline{R}^2$ = .9646; D-W = 1.21

Balance of trade:

(4.6) $$B = X_{tr} - M_{id} + x_{ne} p_{xne} - m_{ne} p_{mne} + B_e$$

Balance of trade in energy:

(4.9) $$B_e = x_e p_{xe} - m_e p_{me}$$

Retained earnings and revaluation adjustments increasing liabilities to foreigners:

(4.7) $$F_{ireva} = \underset{(7.78)}{-1.2471} + \underset{(69.20)}{1.0283}\, \overline{r}_{vb} (V_{kb} - V_{kb-1})$$

$$+ \underset{(4.35)}{.80392}\, (r_{vb} - r_{vb-1})\, \overline{V}_{kb}$$

OLS 1954 - 1978: s.e.e. .518; $\overline{R}^2$ = .9959; D-W = 1.96

5. Government and Private Finance

Indirect taxes:

(5.1) $$T_i = r_{ti}\ ap_a - G_{fsubo}/1000$$

Direct taxes:

(5.2) $$T_d = \underset{(.02)}{.010735} + \underset{(2.57)}{.15966}(Y - C_{ca} - T_i - WN_e)$$

$$+ \underset{(11.12)}{1.1722}\ r_{tp}(Y - C_{ca} - T_i)$$

OLS 1954 - 1978: s.e.e.= .4806; $\overline{R}^2$ = .9978; D-W = 1.03

where the capital consumption allowance is given by

$$\ln C_{ca} = \underset{(41.76)}{-2.6549} + \underset{(73.43)}{.9971}\ \ln(k_{ne}p_a)$$

OLS 1952 - 1978: s.e.e. = .0469; $\overline{R}^2$ = .9952; D-W = .40

Government bonds:

(5.3) $$L_b = L_{b-1} + gp_a - T_i - T_d + p_{fx}F_{xo} + G_{misc} - H + H_{-1}$$

Demand for high powered money:

(5.4) $$\ln H = \underset{(14.98)}{-2.0472} + \underset{(24.94)}{.89917}\ \ln Y - \underset{(3.01)}{.093672}\ \ln r_s$$

Cochrane-Orcutt 1952 - 1978: s.e.e. = .0292; $\overline{R}^2$ = .9488;
ρ = .837

Corporate taxes:

(5.0) $$T_{cne} = \underset{(2.45)}{-.33843} + \underset{(31.43)}{.2967}(qp_q - ep_e - .08\ k_{ne}p_a - N_eW)$$

OLS 1955 - 1978: s.e.e. = .34; $\bar{R}^2$ = .977; D-W = .86

Business capital and inventories at market value:

(5.6) $$100\ Y_{corp}/V_{kb} = \underset{(1.58)}{-1.3007} + r_\ell + \underset{(2.64)}{.40178}(r_{ep2} - r_{m2})$$

$$- \underset{(4.94)}{.36583}\ \dot{p}_a' + \underset{(4.61)}{.82782}\ \frac{Y_{corp} + \dot{p}_a' V_{kb-1}}{r_\ell L_b/100}$$

where $\dot{p}_a' = 200(p_a - p_{a-1})/(p_a + p_{a-1})$

and $Y_{corp} = qp_q - ep_e - .08\ k_{ne}p_a - N_eW - T_{cne}$

OLS 1955 - 1978: s.e.e. = 1.12; $\bar{R}^2$ = .540; D-W - 1.01

Long-term interest rate:

(5.7) $$r_\ell = \underset{(1.65)}{.21330} + \underset{(10.58)}{.50548}\ r_{\ell-1}$$

$$+ \underset{(4.44)}{.32870}\ r_s + \underset{(2.60)}{.23690}\ r_{m2}$$

OLS 1954 - 1978: s.e.e. = .176; $\bar{R}^2$ = .991; Durbin-h = .197

Private sector wealth:

(5.10) $$V = V_{kb} + L_b + H - L_f$$