THE PRICE OF OIL AND WORLD INFLATION AND RECESSION

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ABSTRACT

Direct real-oil-price effects in an extended Barro-Lucas real income equation are estimated for eight countries. Although statistically significant and substantial direct effects are found for about half the countries, these coincided with countries undergoing price decontrol during 1973-1974. Thus price-control biases in real GNP data provide an alternative explanation for the estimated effects. For American data, no oil-price effects occur in a regression of GNP growth on a price-control and labor-market variables. Simulation experiments in an international model illustrate the wide range of real income and price level effects which are consistent with the data.

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The increase in the real price of oil during 1973-1974 is widely believed to have been a major cause of inflation and recession both in the United States and abroad. This belief is based primarily upon the view that imported oil--or energy more generally--is a third factor in the aggregate production function.[1] Hence an increase in oil's relative price will cause an adverse shift in the aggregate supply curve that produces a higher price level and lower output. Although theoretically consistent, this story requires parameter values which some economists have found implausible.[2] This paper reports new evidence on the empirical importance of the oil-price effects.

Tests of significance of oil-price variables in an extended Lucas-Barro real income equation are conducted for the United States, United Kingdom, Canada, France, Germany, Italy, Japan, and The Netherlands. This approach avoids the potential bias present in direct production function estimates due to short-run increasing returns to scale. The results, reported in Section I, are mixed and confounded by price control and decontrol programs which were widespread at nearly the same time as the 1973-1973 oil-price change. The price-control hypothesis is explored further using the longer and richer American data set; in this one case oil price changes, unlike a price-control variable, are not statistically significant when both appear in a real income equation.

Simulation experiments are performed next to assess the effects on real income and the price level of the 1973-1974 oil price increase. These experiments are conducted using the Mark IV Simulation Model presented in Darby (1982). This model -- a simplified version of the Mark III International Transmission Model[3] -- is a quarterly macroeconometric model of the eight countries examined in Section I. We also use an extended Mark IV-Oil Model that incorporates oil-price variables in the real-income equations for those five countries for which the variables were found to be significant in Section I. Using the basic model, some notable effects are found as a result of induced movements in exports, exchange rates, money supplies, and the like. Stronger effects are obtained using the Mark IV-Oil Model, but the price-control caveat of Section II again applies.

The concluding section summarizes the results of the paper and suggests areas for future research as international data on the effects of the 1979-1980 oil-price increase become available.

I. Estimates of Real-Income Equations

The postwar behavior of the real price of oil is dominated by a downward secular trend from the end of the Korean War until the early 1970s as illustrated for the United States in Figure 1. There was a small upward movement in 1971-1972, but the major increase occurred in the second quarter of 1973 and especially the first quarter of 1974. Widespread recessions in 1973-1975 provide the major empirical evidence in support of a large real-income effect of oil price increases. However, several alternative hypotheses focus on other major events occurring roughly coincidentally. The smaller 1979-1980 oil-price changes provide new evidence on their effects.

The oil story is not the only one which can explain the world inflation and recession of the early 1970s. One of these alternative hypotheses points to the final breakdown of pegged exchange rates in 1973 which permitted (previously) nonreserve countries to regain control of their money supplies and to stop the inflation imported from the United States. In the United States, meanwhile, the Fed reduced money supply growth in mid 1973 and again in mid 1974. The average reduction in the growth rate of the money supply in the eight countries in our sample exceeded 5 percentage points. Normal lagged adjustments would imply accelerating, catch-up inflation coincident with recessions induced by the restrictive monetary shocks.[4]

A second alternative hypothesis points to the widespread adoption of price controls, following the U.S. lead in August 1971, and their subsequent dismantling in the period 1973-1975. Such controls may have caused overstatement of real GNP (and understatement of the GNP deflator) compared to true values.[5] When the controls were relaxed during 1973-1975, <u>measured</u> real income fell back to its true value giving an illusion of a deeper recession (and faster inflation) than was actually occurring or the occurrence of a recession when there was none.

The first alternative hypothesis suggests a possible bias in previous aggregate-production-function based estimates of the real-income effects of oil-price changes. A standard equation is taken from Rasche and Tatom (1981, p. 24):

$$(1) \quad \log y_t = \beta_0 + \beta_1 \log \ell_t + \beta_2 \log k_t + \beta_3 \log \theta_t + \beta_4 t$$

where y_t is real GNP, ℓ_t is labor input, k_t is capital input, θ_t is the real price of imported oil or energy, and t is a time index.[6] In view of the "short-run increasing returns to scale" phenomenon, real output is typically overestimated by ℓ_t and k_t during recessions in standard ($\beta_3 = 0$) production functions. Any variable such as real money balances which serves as a cyclical indicator will thus appear to enter the aggregate production function -- positively if the variable is procyclical and negatively if it is contracyclical. Given the previously noted coincidence of major restrictive monetary shocks with the major increases in oil prices, a negative estimated β_3 value may be wholly or partially spurious. A straightforward way to avoid this bias is to estimate a real income equation of the Barro-Lucas form which integrates the effects of shifts in the aggregate supply and aggregate demand curves. This approach is pursued below.

The second alternative hypothesis raises fundamental questions about the reliability of price-level and deflated data. A full examination is beyond the scope of this paper, but two preliminary checks are reported: (1) We examine whether estimated effects of oil-price changes appear to be larger in those countries with coincident price-control relaxation. (2) Using a fuller data set available only for the United States, we examine whether oil-price changes, a price-control variable, or both best explain real income growth relative to labor market conditions for 1949-1980.

The real GNP equations of the Mark III International Transmission Model provide a convenient starting place for estimating the effect on output of changes in the real price of oil.[7] These equations were derived, following Barro (1978), by combining a standard Lucas (1973) aggregate supply function with an aggregate demand function with nominal money, real government spending, and real exports as arguments. Specifically, they express the rational-expectations/natural-rate approach as

$$(2) \quad \log y_t - \log y_{t-1} = a_1 - a_2(\log y_{t-1} - \log \bar{y}_{t-1}) + \sum_{i=0}^{3} a_{3+i}\hat{M}_{t-i} + \sum_{i=0}^{3} a_{7+i}\hat{g}_{t-i} + \sum_{i=0}^{3} a_{11+i}\hat{x}_{t-i} + \varepsilon_t$$

where $\bar{y}_t$ is the natural-employment level of real output in quarter t, and $\hat{M}_t$, $\hat{g}_t$, and $\hat{x}_t$ are the innovations in the aggregate demand variables (logarithm of nominal money, logarithm of real government expenditures for goods and services, and exports divided by GNP, respectively).[8] Thus in the absence of innovations or stochastic disturbance ε_t, $\log y_t$ adjusts toward its natural level at the rate a_2 per quarter. Innovations in the determinants of aggregate demand affect $\log y_t$ with an unconstrained four-quarter distributed lag to allow for any inventory adjustment lags.

To estimate the effect of the real oil price, it remains to specify $\log \bar{y}_t$ appropriately. A form which allows for both declining natural output growth and for an oil price effect is

$$(3) \quad \log \bar{y}_t = b_1 + b_2 t + b_3 t^2 + b_4 \log \theta_t$$

A positive b_2 and negative b_3 implies a declining natural growth rate.[9] The parameter b_4 estimates the full long-run value of $\frac{d \log y}{d \log \theta}$, the elasticity of real GNP with respect to the real price of oil. If the expression (3) were simply substituted in equation (2), an oil price change would implicitly be assumed to have no immediate effect and then a partial adjustment effect at the rate a_2 per quarter. This is inconsistent with the view of various proponents of the oil story who argue for fast short-run effects on the aggregate supply curve and possibly the aggregate demand curve.[10] It might be argued that innovations rather than changes in log θ_t are appropriate to shifts in aggregate demand, but the distinction is not appropriate since θ_t can be regarded as an asset price.[11] Therefore our estimating equation is obtained by substituting equation (3) in (2) and adding a four-quarter distributed lag on Δ log θ_t to capture a possibly rapid short-run adjustment:

$$(4) \quad \log y_t = a_1 + a_2(b_1 - b_2) + (1 - a_2)\log y_{t-1} + a_2 b_2 t + a_2 b_3 (t-1)^2 + a_2 b_4 \log \theta_{t-1} + \sum_{i=0}^{3} a_{3+i}\hat{M}_{t-i} + \sum_{i=0}^{3} a_{7+i}\hat{g}_{t-i} + \sum_{i=0}^{3} a_{11+i}\hat{X}_{t-i} + \sum_{i=1}^{4} c_i \,\Delta \log \theta_{t+1-i} + \varepsilon_t$$

This equation has been estimated for 1957-1976 using the quarterly data set and instruments for the eight countries in the Mark III International Transmission Model. The regressions are based on the two-stage-least-squares-principal-components (2SLSPC) technique because of the large number of predetermined variables in the model.[12] The coefficients of the aggregate demand variables are not at issue here, are substantially the same as those discussed in Darby and Stockman (1980), and so are omitted for the sake of brevity from the present discussion.[13]

The regression results are summarized in Table 1. The coefficient of log θ_t is negative in every case although only 4 of the t-statistics meet conventional levels of significance. The implicit estimate of the long-run oil effect is reported in the ninth column as ranging from a 2 basis point decrease in real income per percentage point increase in the real price of oil for the U.S. to 19 basis points for Japan. Table 2 indicates the implied long-run reduction in real income for the eight countries based on the 1973I-1976IV increase in the real price of oil. Rasche and Tatom (1981, p. 48) prepared similar estimates for their model based on 1973-1977 energy price increases, and those estimates are reported for comparison. Despite some differences in detail, the calculations here tell broadly the same story as that of Rasche and Tatom. However, this strong story does not do so well under closer examination.

Let us first consider the possibility that the share of imported oil in total output is so small that any effects are in fact negligible. This is tested by computing the F statistic for the hypothesis that all the oil coefficients are zero (H_0: $a_2b_4 = c_1 = c_2 = c_3 = c_4 = 0$). As reported in Table 1, only five of the countries have any statistically significant oil effect at the 5 percent level[14] and for one of these (the United States) the significant response is due to short-run movements which might be related to various panic policy responses, briefly adopted here and abroad, to the temporary OPEC embargo at the end of 1973.[15] Further, the significant French effects imply that French income was higher throughout 1973 as a result of rising oil prices and so does not support the hypothesis.

Since experience indicates that the French, Italian, and Japanese data may be quite unreliable,[16] let us focus on the results for the United States, United Kingdom, Canada, Germany, and the Netherlands. Of these five, the F statistic is insignificant for Canada and Germany and significant for the United States, United Kingdom, and the Netherlands. Interestingly these three countries with significant F statistics all removed general price controls coincidentally with the 1973-1974 oil price increase while Canada and Germany had no price controls during the relevant period.[17] If, as I have argued elsewhere (1976a, 1976b), the decontrol process results in the elimination of overstatement of real GNP built up during the control period, then the spurious drop in reported real GNP relative to true GNP will be captured as part (or all!) of the effect of the coincidental increase in real oil prices. Certainly the pattern of significant oil effects only where simultaneous decontrol occurred strongly indicates the value of research to formulate real GNP estimates unbiased by price-control evasions which overstate quantities and understate prices.

It is possible to run a more direct test between the oil-price and price-control hypotheses using the more complete data set available for the United States. The basic approach is to see whether a price-control variable, oil-price changes, or both enter significantly in a regression of real GNP growth on changes in labor market conditions.

We start with an expanded Okun's Law equation borrowed from a related project on productivity growth:

$$(5) \qquad \Delta \log y_t = h_1 + h_2\, TS_t + h_3\, \Delta u_t + h_4\, \Delta LR_t + h_5\, \Delta \log E_t + h_6\, \Delta \log E_{t-1} + \varepsilon_t$$

where TS_t is a time shift variable equal to 0 before 1965 and 1 otherwise, u_t is the total unemployment rate, LR_t is the layoff rate, and E_t is employment in manufacturing, mining, and construction. The advantage of this equation is that all the right-hand variables are based on counts of individuals and so not subject to possible reporting biases under price controls. The estimated equation for 1949I-1980IV is[18]

$$(6) \qquad \Delta \log y = \underset{(11.47)}{0.0089} - \underset{(-0.83)}{0.0009}\, TS - \underset{(-3.80)}{0.010}\, \Delta u_t - \underset{(-1.77)}{0.004}\, \Delta LR_t$$

$$+ \underset{(4.49)}{0.357}\, \Delta \log E_t - \underset{(-3.39)}{0.218}\, \Delta \log E_{t-1}$$

$$S.E.E. = 0.0060, \quad \bar{R}^2 = 0.714, \quad D\text{-}W = 2.07$$

This regression appears to provide a good empirical representation of the relationship between changes in real GNP and labor market conditions.

To test the price-control hypothesis a simple PC_t variable was created. As discussed in footnote 17, the hypothesis is that prices were systematically and cumulatively understated (and thus real GNP overstated) throughout Phases I and II of the Economic Stabilization Program (1971III - 1973I); these reporting biases were eliminated during Phases III and IV and decontrol (1973II - 1974III). Accordingly the PC_t variable starts at 0 in 1971II, rises smoothly to 1 in 1973I, and then falls smoothly to 0 again in 1974IV.[19] The test equation adds ΔPC_t and a four-quarter distributed lag on $\Delta \log \theta_t$ to equation (5):

$$(7) \quad \Delta \log y_t = h_1 + h_2 TS_t + h_3 \Delta u_t + h_4 \Delta LR_t + h_5 \Delta \log E_t + h_6 \Delta \log E_{t-1} + h_7 \Delta PC_t + \sum_{i=1}^{3} h_{8+i} \Delta \log \theta_{t-i} + \varepsilon_t$$

Table 3 reports test statistics for the coefficients h_7 through h_{11}. Examining the first row of the table, we note that the price-control variable is significant at the 10 percent level,[20] but at that same level of significance we could not reject the hypothesis that $h_8=h_9=h_{10}=h_{11}=0$ or that $h_9=h_{10}=h_{11}=0$ or that $h_8=0$. On line 4 we note that even if we force ΔPC_t out of the regression, we still cannot reject the hypothesis that $h_9=h_{10}=h_{11}=0$, although h_8 might be significantly negative as hypothesized.[21] Line 2 reports the results with both ΔPC_t and $\Delta \log \theta_t$ (but no lagged θ_t's) included and there the price control variable is significant at the 1 percent level while we cannot reject $h_8=0$ even at the 10 percent level. Note that the estimation period includes the real-oil-price increases of 1979 and 1980 which was not possible using the international data set.

While these results are supportive of the hypothesis that oil-price changes had no effect on real GNP, several caveats must be entered: First, we really cannot apply significance tests sequentially as is done implicitly in our discussion. Further, this equation only tests for oil-price effects operating via the aggregate production function; aggregate demand or other effects operating through employment and other labor-market variables may still be present.

Taken as a whole, empirical estimates of real income equations give an ambiguous answer to the question of whether or not a large increase in the real price of oil will reduce significantly real income for given nominal money supplies, real government spending, and real exports. Such a reduction is estimated for half the cases, but this may be a spurious result due to the simultaneous removal of price controls in those countries. For the United States, a direct test favors the price-control hypothesis over the oil-price hypothesis.

II. Simulation Experiments

Direct real-income effects of the type examined in Section I are only one of the ways in which the 1973-1974 oil-price shocks may have influenced world inflation and recession. We must also allow for any induced changes in nominal money supplies, real exports, interest rates, to obtain consistent estimates of the output and price level effects. To take account of these indirect effects, one must resort to a simulation model of some sort, and this section reports results from the Mark IV International Simulation Model described in Darby (1982).[22] The results of any one simulation model cannot be taken too seriously except as they illustrate the possible importance of channels not inconsistent with the data which might otherwise be overlooked. So with a spirit of healthy scepticism, let us turn to the specific experiments.

To assess the effects of the oil price increase we compare the results from simulating the model in one case with the actual real price of oil and in another case with the real price of oil held constant at the 1973 I price. The assumed difference in the logarithm of the real price of oil (log $(\theta_t/\theta_{1973I})$) is plotted in Figure 2. The dynamic simulations begin in 1973 II and continue for six quarters thereafter.[23]

In view of the mixed evidence for direct oil price effects on real income as reported in Section I, the basic Mark IV model does not incorporate such effects. An alternative simulation model, the Mark IV-Oil, was therefore estimated. It differs from the basic Mark IV model only in two ways: (a) The addition to the real income equations of the variables listed in Table 1 above for those 5 countries for which the oil variables were significant (United States, United Kingdom, France, Japan, and the Netherlands). These five equations are listed with their estimated coefficients in Table

4. (b) Corresponding identities are added to define the logarithm of the domestic price of oil as the sum of the logarithms of the dollar price and the purchasing power ratio.

Figures 3 and 4 illustrate the simulation results for the five countries with reliable data. The basic Mark IV model is used to simulate the effects of the oil price increase as displayed in Figure 3 for six major macroeconomic variables for each country. The effect is estimated as the difference between the simulation values based on the actual real price of oil and the values based on a constant post-1973 I price. Figure 4 displays the corresponding simulated effects when the Mark IV-Oil model is used to perform the basic simulations.

Figure 3 illustrates that in the basic model without direct real income effects, real income (panel (a)) generally rises due to increases in export demand (panel (e)). Whether this raises or lowers the price level depends on the simulated movements in interest rates (and so the net change in real money demand) and in the nominal money supply.[24] The money supply movements are generally small except in Germany where strong simulated balance of payments effects cause a sharp but temporary increase in nominal money.

Figure 4 illustrates just how sensitive these results are to the inclusion of direct real-income effects. Notice in panel (a) the considerable real income declines which occur in the three countries (the United States, the United Kingdom, and the Netherlands) with direct real income effects included. For the United States and the United Kingdom, the price level rises due to the lower real income and hence real money demand and, for the U.K. only, due to a rise in nominal money.[25] The anomolous fall in the

Dutch price level occurs because of a perverse, statistically insignificant negative coefficient on transitory income in the money demand equation. For Canada and Germany the results differ little from the basic Mark IV simulations.

These simulation results illustrate the large difference it makes whether or not we take at face value the estimated real-oil-price effects in the real income equations: Real income effects vary from slightly positive to as much as -7 percent by the end of 1974. A smaller variation in simulated price level effects also occurs in the alternative simulations. It is both the sorrow and challenge of our nonexperimental science that other things were not held constant when the oil price change occurred. One factor which may explain the estimated real income effects in 1973-1974 was identified in Section I: the coincidental removal of price controls in those countries for which real effects were found. Only much further research can show whether the large simulated effects in the Mark IV-Oil Model have a basis in reality or are the result of other changes -- such as price decontrol -- occurring in the same period.

III. Conclusions

The effects on real income and the price level of the 1973-1974 increases in the real price of oil are the subject of strongly held but diverse opinions.[26] The results of this paper indicate that a wide range of opinion is indeed consistent with the data. Perhaps we should not be surprised that with effectively one degree of freedom we cannot arrive at firm estimates of both an oil-price coefficient and its standard error.

As consistent international data on 1979-1980 becomes available, some further untangling of the effects of oil-price changes and price controls will be feasible. Alternatively, it may be possible to exploit historical relationships between real GNP and labor inputs or other physical-unit series to obtain quantitative measures of price-control biases in official output and price-level data. Meanwhile, we should not be surprised by diversity but firmness of opinion.

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FOOTNOTES

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[1]Some authors such as Rasche and Tatom (1977, 1981) and Tatom (1979) prefer to use a broad "energy input" as the third factor. Kopcke (1980) points out quite correctly that such a concept is inappropriate to explaining real GNP since most energy is domestically produced using labor and capital. Therefore one must either use a two-sector approach or limit the third factor in the aggregate production function to imported oil. As noted in Darby (1981), this dispute is not an essential one since imported oil prices are nearly collinear with changes in broader energy prices.

[2]See, for example, Tobin (1980) and Darby (1981).

[3]See Darby and Stockman (1980) for details.

[4]See Darby (1976c, 1979).

[5]See Darby (1976a, 1976b).

[6]This is based on a Cobb-Douglas production function and the assumption that competitive producers treat the real oil price as parametric. This permits substitution of the oil price for quantity with the interpretation that $\beta_1 = \frac{\delta_\ell}{1-\delta_o}$, $\beta_2 = \frac{\delta_k}{1-\delta_o}$, and $\beta_3 = \frac{-\delta_o}{1-\delta_o}$ where δ_ℓ, δ_k, and δ_o are the shares of

labor, capital, and oil respectively.

[7]See Darby and Stockman (1980) for a description of the model.

[8]The scaling of exports as a fraction of income rather than in logarithmic terms was done to permit application of the balance-of-payments identity in the model. In the results reported here all the innovations are defined as residuals from optimal ARIMA processes applied to log M_t, log g_t, and $(X/Y)_t$, respectively.

[9]The declining normal or natural growth rate of output generally observed in the postwar period may be attributed to a low capital-labor ratio following 15-odd years of depression and war.

[10]A lengthy summary of these arguments is given in Darby (1981). Aside from any lags due to inventory adjustments, it is possible that the impact effect is very nearly equal to the long-run effect.

[11]Under the usual efficient-markets/rational-expectations assumptions, the real price of oil should evolve following a random walk with drift. The drift term which allows for both the real interest rate and trends in extraction costs will be included in the constant term of the estimating equation.

[12] The only current endogenous variables in equation (4) are $\hat{M}_t$, $\hat{x}_t$, and log θ_t. Time t and government spending shocks are exogenous in the model, but $\hat{M}_t$ and $\hat{x}_t$ are endogenous. The price of oil in base-year dollars is exogenous so log θ_t is exogenous for the U.S. For the other seven countries endogenous movements in the purchasing power ratio make the real price of oil in base-year domestic currency units endogenous, but they are dominated by movements in the U.S. real price.

[13] To the extent these aggregate demand variables were correlated with any significant oil variables added here, their numerical values were of course affected. However, the general pattern and conclusions remained unaltered from the earlier discussion cited in the text.

[14] Only France is significant at the 1 percent level.

[15] Interpreting the coefficient of log θ_{t-1} as proportional to the long-run effect is dependent upon the particular partial adjustment pattern posited in equation (2). An anonymous referee has pointed out that on alternative specifications this coefficient might be termed the total short-run effect.

[16] See discussions in Darby and Stockman (1980) and Darby (1982).

[17] The United States took the lead in imposing price controls in August 1971 which Darby (1976a, 1976b) argues led to an increasing overstatement of real GNP (and understatement of the deflator) through the first quarter of 1973. Controls were then relaxed in phases through the third quarter of 1974 with progressive elimination of overstatement in real GNP. That is, real income <u>growth</u> was overstated from 1971III through 1973I and then understated from 1973II through 1974IV. According to Parkin in Shenoy (1978, pp. 150-151) the United Kingdom followed a similar pattern with controls instituted with a freeze in November 1972, peaking in their effect on the data with the end of Stage II in August 1973, and eventually abandoned entirely after the Conservative loss of February 1974. Shenoy (1978, pp. 132-135) reports a similar albeit more complex pattern for the Netherlands beginning also with a 1972 price freeze. Carr (1976, p. 40) points out that Canada was free of general price controls until October 1975, too late to cause any biases in the oil-price coefficients. West Germany imposed no price controls on the ground that such policies distract attention from the real problems; Shenoy (1978, pp. 138-141).

[18]The t-statistics are reported in parentheses below the estimated coefficients.

[19]Such a simple form might be improved upon, but for current purposes it is preferable for errors in the variables to bias the test against accepting the price-control hypothesis. The estimated value of h_7 is interpreted as the (logarithmic) overstatement of real GNP (understatement of the deflator) in 1973I.

[20]The alternative hypothesis is $h_7>0$, so a one-tailed test is appropriate.

[21]The alternative hypothesis is $h_8<0$, so again a one-tailed test is appropriate.

[22]The Mark IV International Simulation Model is a simplified simulation version of the Mark III International Transmission Model described in Darby and Stockman (1980). The main simplifications involve (1) deletion of insignificant variables except where they are required a priori to permit international transmission and (2) combining variables to reduce multicollinearity where a priori hypotheses on equality of coefficients were not rejected by the data. The resulting model is thus both consistent with the data and tractable for simulation. The Mark IV Model exists in versions corresponding to pegged and floating exchange rates, but only the latter (Mark IV-FLT) is used here since we are concerned with 1973-1974.

[23]In a dynamic simulation, the input series are the exogenous variables plus the initial conditions (endogenous variables at the beginning of the simulation). The values of endogenous variables within the simulation period are assigned their predicted values. Dynamic instabilities become important in the floating version of the Mark IV Model after seven quarters.

These instabilities apparently arise from our inability to eliminate simultaneous equation bias in the short estimation period. Therefore the previous caveat that these results are only illustrative must be reemphasized.

[24]Solving the money-market equilibrium condition yields $P_t = M_t^s/m^d(y_t,R_t)$. That is the price level is the ratio of nominal money supply to real money demand with the latter a function of real income and the nominal interest rate. Increases in real income tend to raise m^d and hence lower the price level, other things equal. Increases in M_t^s or in R_t, on the other hand, tend by themselves to raise the price level.

[25]There is a significant rise in British money because only unemployment and not inflation is important in the estimated central-bank reaction function. In the American case these factors are offsetting.

[26]Taking two of the best studies for the long-run U.S. real-income effect as examples: Nosworthy, Harper, and Kunze (1979, p. 412) report an average reduction in productivity growth of 0.18 percent per annum for 1973-1978 which implies a total reduction in real income of 0.9 percent. By contrast, Rasche and Tatom (1981), as reported in Table 2 above, estimate a 7.0 percent long-run effect.

TABLE 1

2SLSPC Regression Estimates of Oil-Price Effects in Real Income Equation (36)

Country	Adjustment Coefficient a_2	Coefficient Of: t a_2b_2	$(t-1)^2$ $a_2b_3 x10^6$	$\log \theta_{t-1}$ a_2b_4	$\Delta\log \theta_t$ c_1	$\Delta\log \theta_{t-1}$ c_2	$\Delta\log \theta_{t-2}$ c_3	$\Delta\log \theta_{t-3}$ c_4	Long-run Oil Effect a_2b_4/a_2	F(5,59) Statistic	$\bar{R}^2$	S.E.E.	h [D-W]
United States	0.180	0.00196	-3.215	-0.0038	-0.021	-0.022	-0.009	-0.018	-0.021	2.54*	0.9984	0.0082	-0.53
	(0.049)	(0.00058)	(3.389)	(0.0052)	(0.011)	(0.011)	(0.010)	(0.011)					
	3.656	3.349	-0.949	-0.732	-1.897	-2.074	-0.092	-1.650					
United Kingdom	0.448	0.00284	2.449	-0.0253	-0.047	0.025	0.019	0.007	-0.057	3.32*	0.9943	0.0120	1.10
	(0.112)	(0.00095)	(6.089)	(0.0093)	(0.018)	(0.017)	(0.016)	(0.017)					
	3.985	2.978	0.402	-2.717	-2.602	1.489	1.127	0.433					
Canada	0.171	0.00203	1.293	-0.0081	-0.005	0.004	-0.010	-0.004	-0.047	0.49	0.9982	0.0121	-3.40
	(0.070)	(0.00080)	(5.283)	(0.0073)	(0.016)	(0.015)	(0.015)	(0.016)					
	2.446	2.529	0.245	-1.097	-0.304	0.273	-0.642	-0.260					
France	0.613	0.00892	-1.977	-0.0581	0.038	0.083	0.062	0.009	-0.095	4.40**	0.9976	0.0159	[2.33]
	(0.120)	(0.00173)	(7.316)	(0.0168)	(0.021)	(0.026)	(0.024)	(0.023)					
	5.089	5.163	-0.270	-3.455	1.823	3.167	2.576	0.373					
Germany	0.176	0.00236	-5.581	-0.0068	0.002	0.013	0.022	-0.010	-0.039	0.56	0.9975	0.0131	0.26
	(0.080)	(0.00116)	(6.748)	(0.015)	(0.026)	(0.020)	(0.019)	(0.020)					
	2.205	2.035	-0.827	-0.456	0.074	0.678	1.187	-0.492					
Italy	0.260	0.00404	-11.474	-0.0092	0.010	0.005	0.010	0.001	-0.035	0.54	0.9982	0.0120	-2.02
	(0.083)	(0.00145)	(6.440)	(0.0073)	(0.014)	(0.015)	(0.015)	(0.014)					
	3.127	2.785	-1.782	-1.252	0.749	0.333	0.617	0.073					
Japan	0.206	0.00485	-2.244	-0.0393	-0.048	0.007	0.014	0.010	-0.191	2.27*	0.9994	0.0135	-1.74
	(0.082)	(0.00179)	(6.043)	(0.0178)	(0.018)	(0.020)	(0.018)	(0.018)					
	2.529	2.711	-0.371	-2.205	-2.711	0.345	0.788	0.562					
Netherlands	0.334	0.00284	11.646	-0.0394	-0.027	0.035	0.018	0.009	-0.118	2.38*	0.9981	0.0122	1.59
	(0.087)	(0.00083)	(7.465)	(0.0138)	(0.016)	(0.019)	(0.018)	(0.017)					
	3.850	3.418	1.560	-2.862	-1.672	1.839	0.967	0.534					

Notes: 1. **Period: 1957I-1976IV. Standard errors are reported in parenthese below coefficient estimates, t-statistics are below the standard errors. The biased Durbin-Watson statistic is reported in square brackets in those cases in which Durbin's h cannot be computed (is imaginary). Coefficient estimates for the constant and the aggregate demand shocks ($a_3,\ldots,a_{14}$) are not reported for brevity's sake.**

2. **Note that the reported coefficient estimates for t^2 are multiplied by 10^6.**

3. **The F(5,59) statistic is for the test of the hypothesis that $a_2b_4 = c_1 = c_2 = c_3 = c_4 = 0$. The 0.05 significance level (indicated by *) requires F > 2.23. The 0.01 significance level (indicated by **) requires F > 3.34.**

TABLE 2

Implied Estimates of Long-Run Decrease in Real GNP due to 1973I-1976IV Increases in Real Price of Oil

Country	$\frac{d \log q}{d \log \theta}$ [a]	$\log \theta_{1976IV} - \log \theta_{1973I}$	Long-Run Decrease in q [b]	Rasche-Tatom Long-Run Estimate c
United States	-0.021	1.2119	-2.5%	-7.0%
United Kingdom	-0.057	1.2749	-7.3%	-3.5%
Canada	-0.047	1.1045	-5.2%	-4.4%
France	-0.095	1.1477	-10.9%	-4.1%
Germany	-0.039	1.1101	-4.3%	-1.9%
Italy	-0.035	1.3995	-4.9%	NA
Japan	-0.191	1.1402	-21.8%	-17.1%
Netherlands	-0.118	0.9856	-11.6%	NA

Notes: a. This is the ratio of the estimated values of a_2b_4 to a_2 from Table 1.

b. Product of the previous two columns.

c. From Rasche and Tatom (1981, p. 48) for 1973-1977 energy-price increases.

TABLE 3

TEST STATISTICS FOR ALTERNATIVE VERSIONS OF EQUATION (7)

Line Number	Restrictions	S.E.E.	Value & t-stat for h_7	Value & t-stat for h_8	F-stat for $h_8=h_9=h_{10}=h_{11}=0$	F-stat for $h_9=h_{10}=h_{11}=0$
1	none	0.00586	0.01990 (1.472)*	-0.00596 (-1.006)	F(4,117)= 0.604	F(3,117)= 0.446
2	$h_9=h_{10}=h_{11}=0$	0.00582	0.02778 (2.416)***	-0.00589 (-1.050)	--	--
3	$h_8=h_9=h_{10}=h_{11}$	0.00582	0.03123 (2.832)***	--	--	--
4	$h_7=0$	0.00589	--	-0.00819 (-1.424)*	F(4,118)= 2.018*	F(3,118)= 1.614
5	$h_7=h_9=h_{10}=h_{11}=0$	0.00594	--	-0.00975 (-1.780)*	--	--
6	$h_7=h_8=h_9=h_{10}=h_{11}=0$ [equation (6)]	0.00599	--	--	--	--

* Significant at 10 percent level.

** Significant at 5 percent level.

*** Significant at 1 percent level.

TABLE 4

Alternative Real-Income Equations for Mark IV-Oil Model

EQUATION FORM

$$\log y_j = \alpha_{j1} + \alpha_{j2}\log y^P_{j,t-1} + (1-\alpha_{j2})\log y_{j,t-1} + \sum_{i=0}^{3} \alpha_{j,3+i}\hat{M}_{j,t-i}$$

$$+ \sum_{i=0}^{3} \alpha_{j,7+i}\hat{g}_{j,t-i} + \sum_{i=0}^{3} \alpha_{j,11+i}\hat{x}_{j,t-i} + \alpha_{j,20}t$$

$$+ \alpha_{j,21}(t-1)^2 + \alpha_{j,22}\log \theta_{j,t-1} + \sum_{i=0}^{3} \alpha_{j,23+i} \log(\theta_{j,t-i}/\theta_{j,t-i-1}) + \varepsilon_j$$

Note: The country index is j, $\log y^P_j$ is permanent income, and $\log \theta_j \equiv \log P^{RO} + \log P_1 + \log E_j - \log P_j$ where P_1 and P_j are the price levels for the U.S. and country j, respectively, E_j is the exchange rate, and P^{RO} is the index of the real price of a barrel of Venezuelan oil in 1970 U.S. dollars.

COEFFICIENTS

Coefficient Name	Values by Country (j)				
	United States	United Kingdom	France	Japan	Netherlands
α_{j1}	-0.0016	-0.0148	0.0843	0.2338	0.0668
α_{j2}	0.1472	0.4631	0.5351	0.2122	0.2869
α_{j3}	0.8335	-0.1410	-0.2414	--	0.1542
α_{j4}	0.4271	--	--	--	0.0679
α_{j5}	--	--	--	0.2152	-0.0676
α_{j6}	0.9220	--	--	--	-0.1044
α_{j7}	--	0.1464	0.0487	--	0.0625
α_{j8}	0.1320	--	--	--	-0.0239

TABLE 4 (Continued)

Coefficient Name	United States	United Kingdom	France	Japan	Netherlands
α_{j9}	0.0960	0.0959	0.0531	--	0.0222
$\alpha_{j,10}$	0.0852	--	--	-0.0522	0.0398
$\alpha_{j,11}$	1.4624	--	-0.1536	-0.8308	0.0352
$\alpha_{j,12}$	1.0743	0.5147	--	--	-0.0231
$\alpha_{j,13}$	--	--	--	-0.6263	0.1660
$\alpha_{j,14}$	--	--	--	-0.8518	-0.0236
$\alpha_{j,20}$	0.0005	0.0005	0.0007	0.0006	-0.0004
$\alpha_{j,21}$	-0.0000	-0.0000	-0.0000	-0.0000	+0.0000
$\alpha_{j,22}$	0.0003	-0.0188	-0.0447	-0.0351	-0.0307
$\alpha_{j,23}$	-0.0187	-0.0294	0.0089	-0.0481	-0.0269
$\alpha_{j,24}$	-0.0231	0.0236	0.0500	0.0024	0.0257
$\alpha_{j,25}$	-0.0064	0.0213	0.0402	0.0105	0.0096
$\alpha_{j,26}$	-0.0200	0.0073	0.0084	0.0022	0.0032

Note: 1. The Mark IV-Oil Model replaces the real income equations in the Mark IV-FLT Simulation Model with these five equations. The only other changes are the addition of identities for the United Kingdom, France, Japan, and Netherlands defining their domestic real price of oil as

$$\log \theta_j \equiv \log P^{RO} + \log P_1 + \log E_j - \log P_j$$

2. A coefficient for a suppressed variable (t statistic less than 1 in absolute value; α_{j3} through $\alpha_{j,14}$ only) is indicated by --.

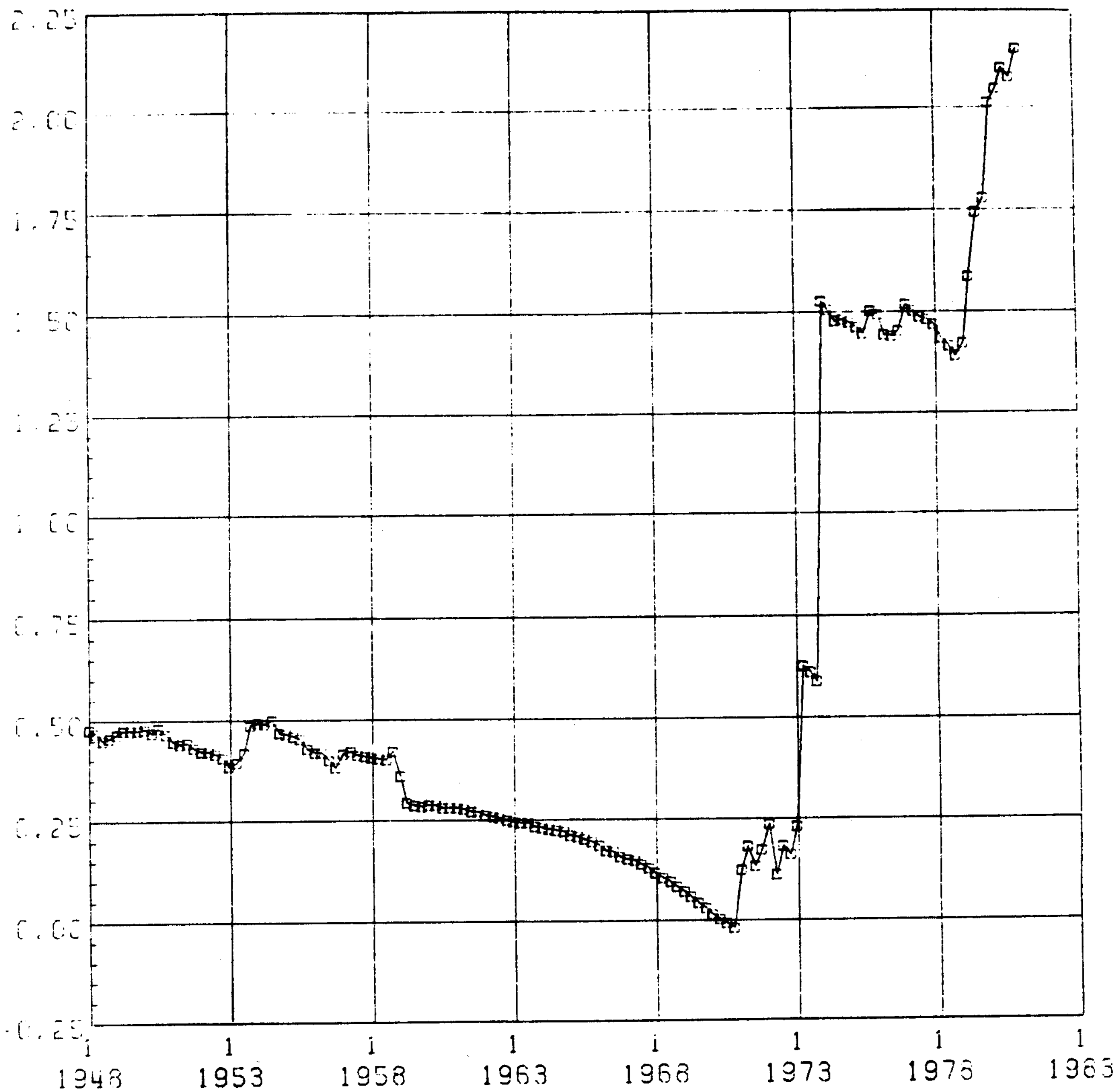


Figure 1

The Logarithm of the United States Real Price of Imported Oil

Source: The dollar price index of Venezuelan crude oil is taken from various issues of <u>International Financial Statistics</u> and rebased to 1.00 in 1970. This is then deflated by the U.S. GNP deflator (1970 = 1.00) to obtain θ (θ_{1970} = 1.00).

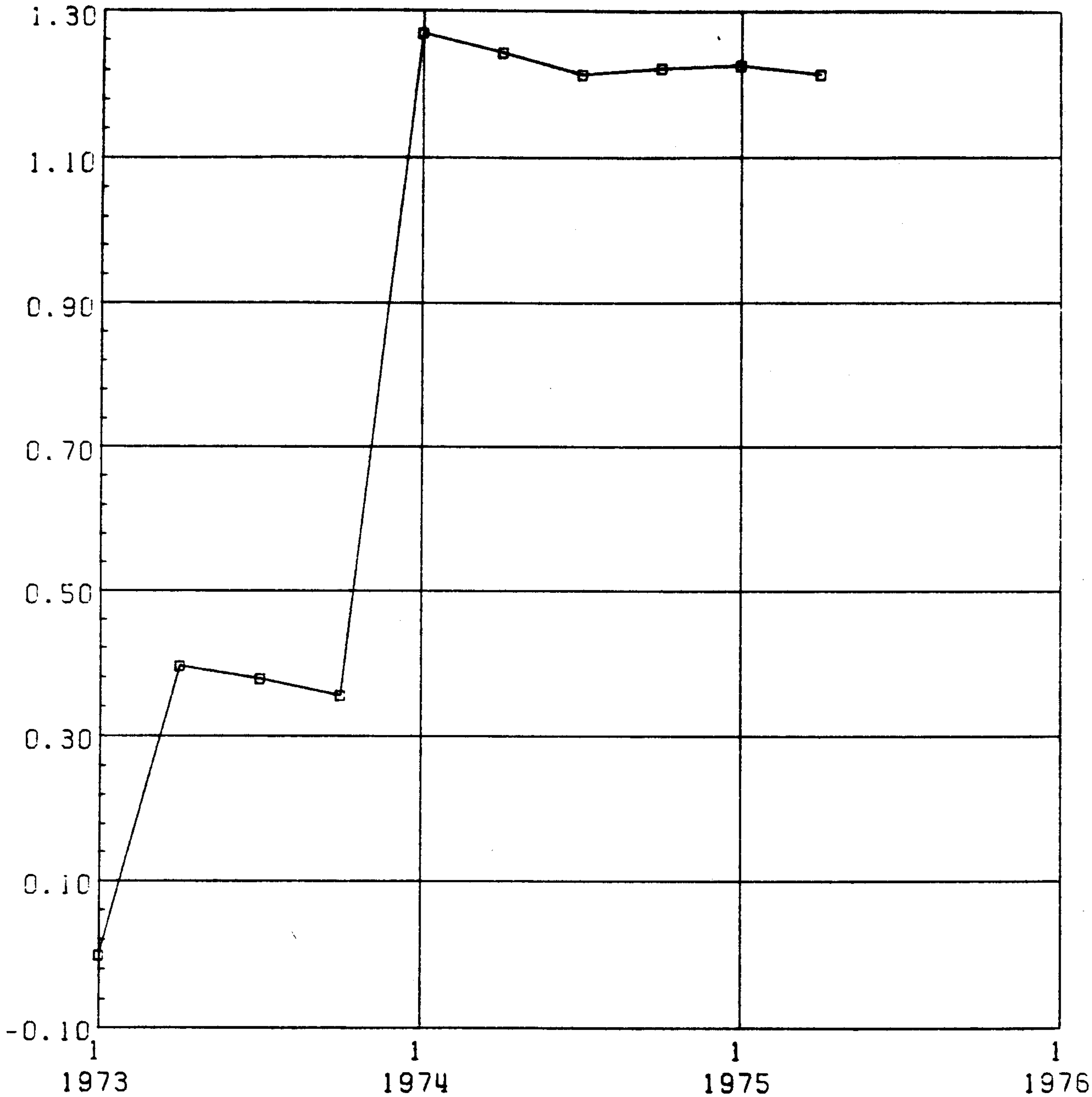
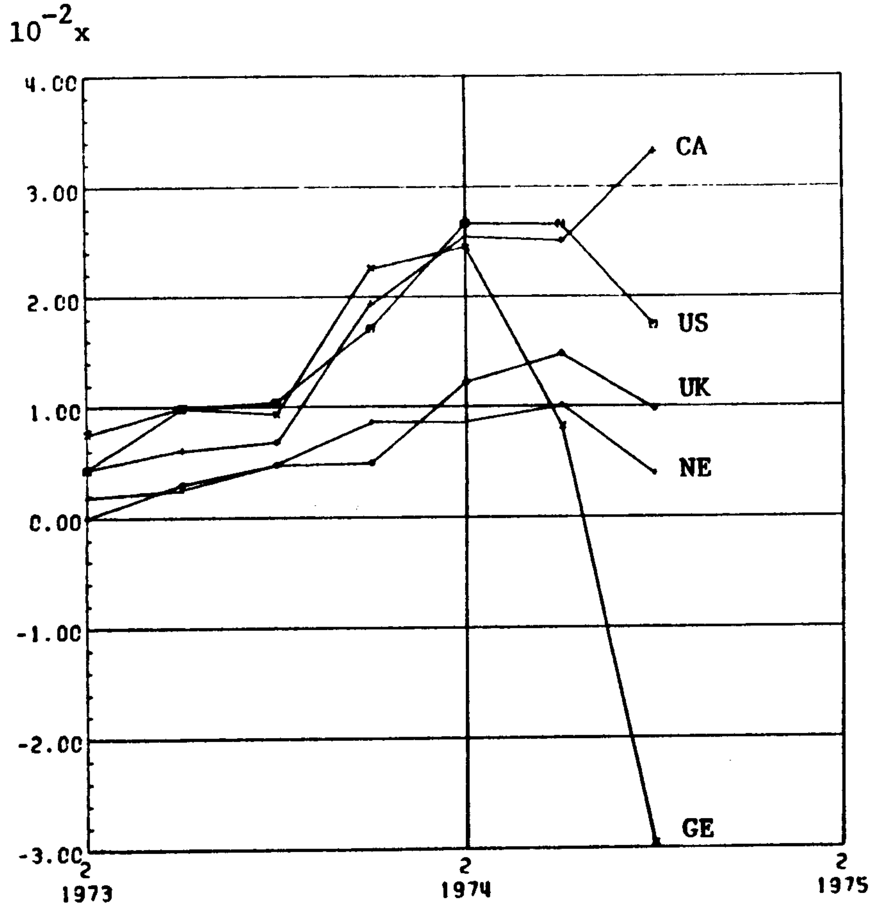


Figure 2

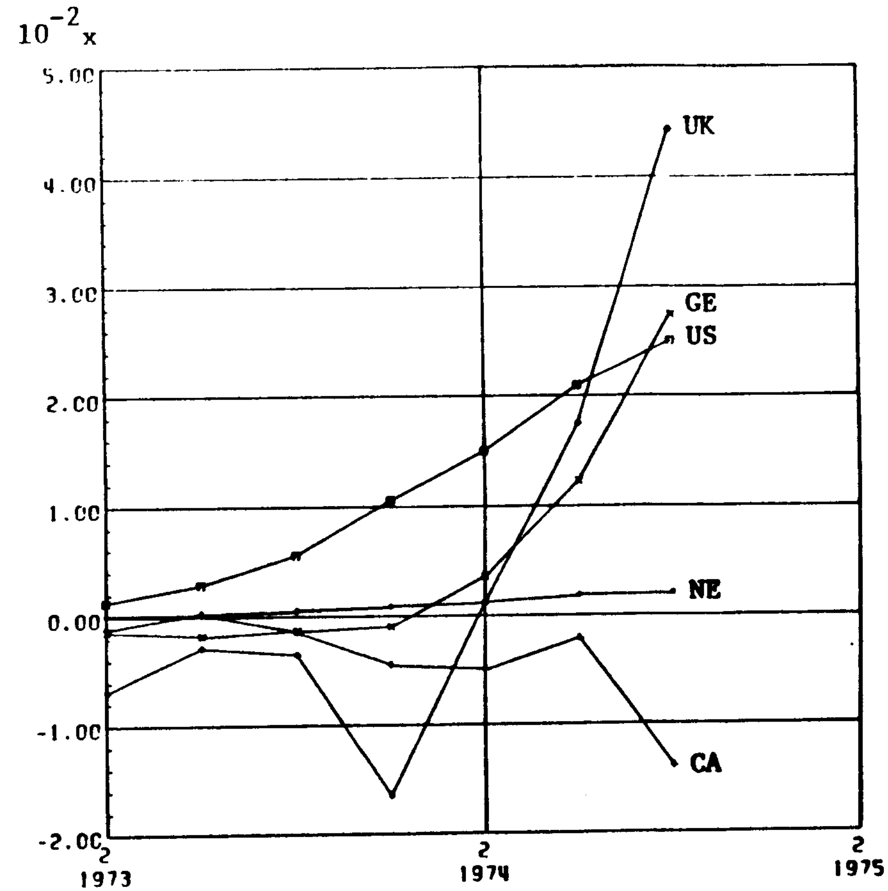
Logarithmic Increase in U.S. Real Price of Oil from 1973 I

FIGURE 3

Simulated Effects of the 1973-1974
Increase in the Real Price of Oil
Using Basic Mark IV Model



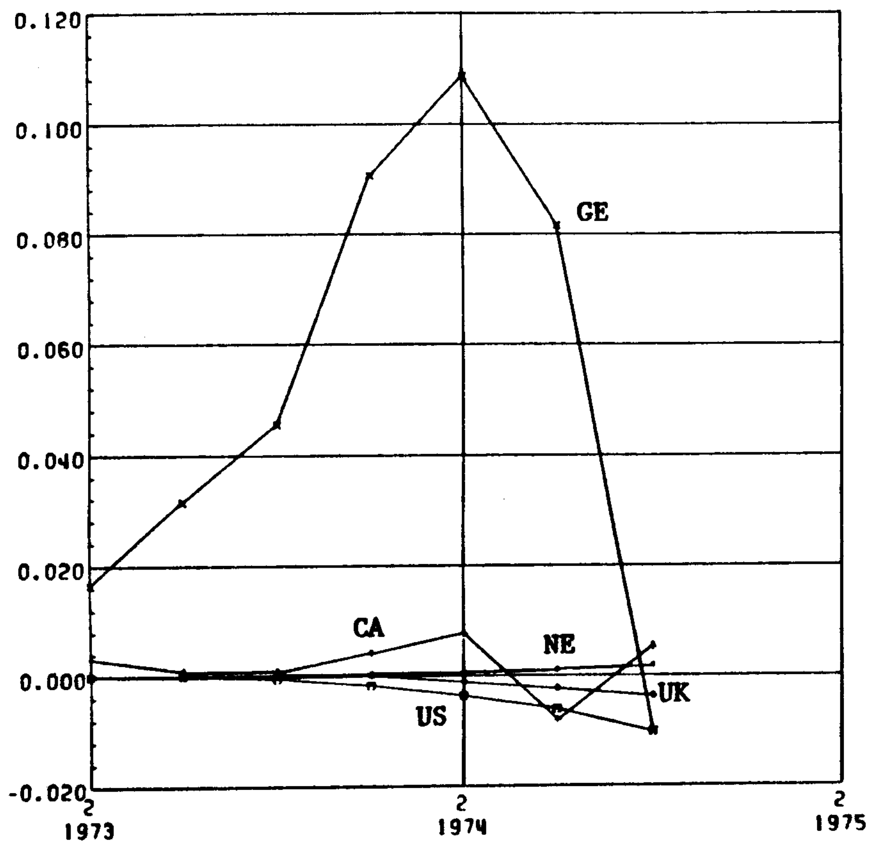
(a) Real Income -- log y_i



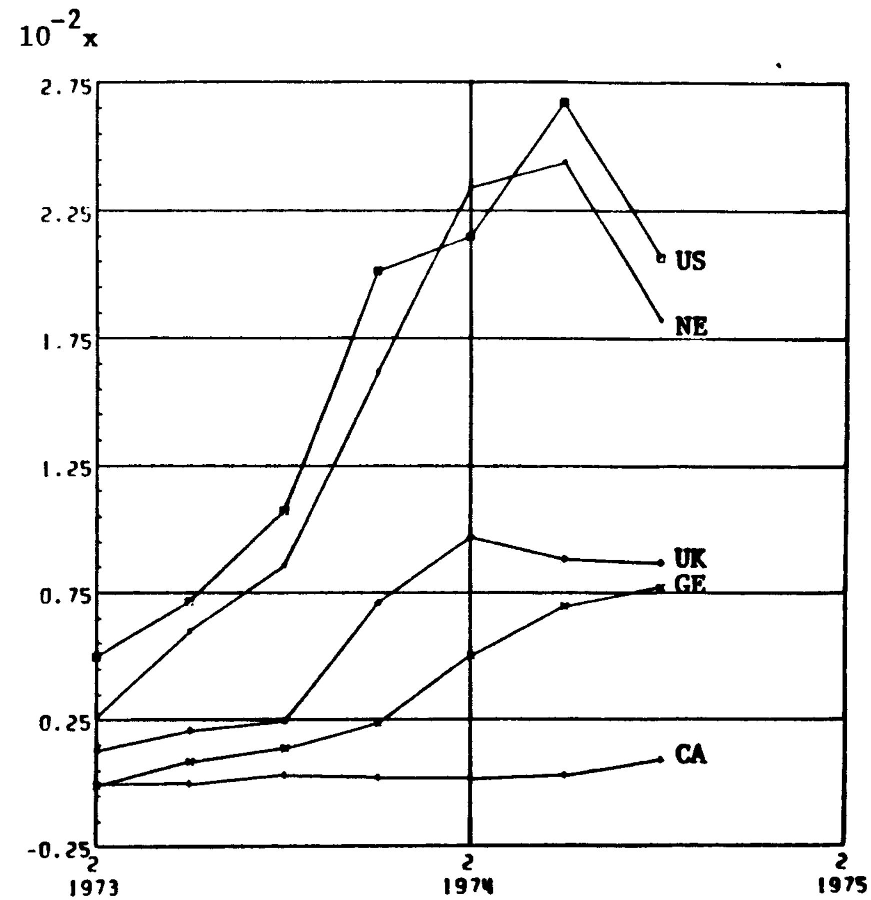
(b) Price Level -- log P_i

Legend
- ▫ United States (US)
- • United Kingdom (UK)
- • Canada (CA)
- × Germany (GE)
- • Netherlands (NE)

FIGURE 3 (Continued)



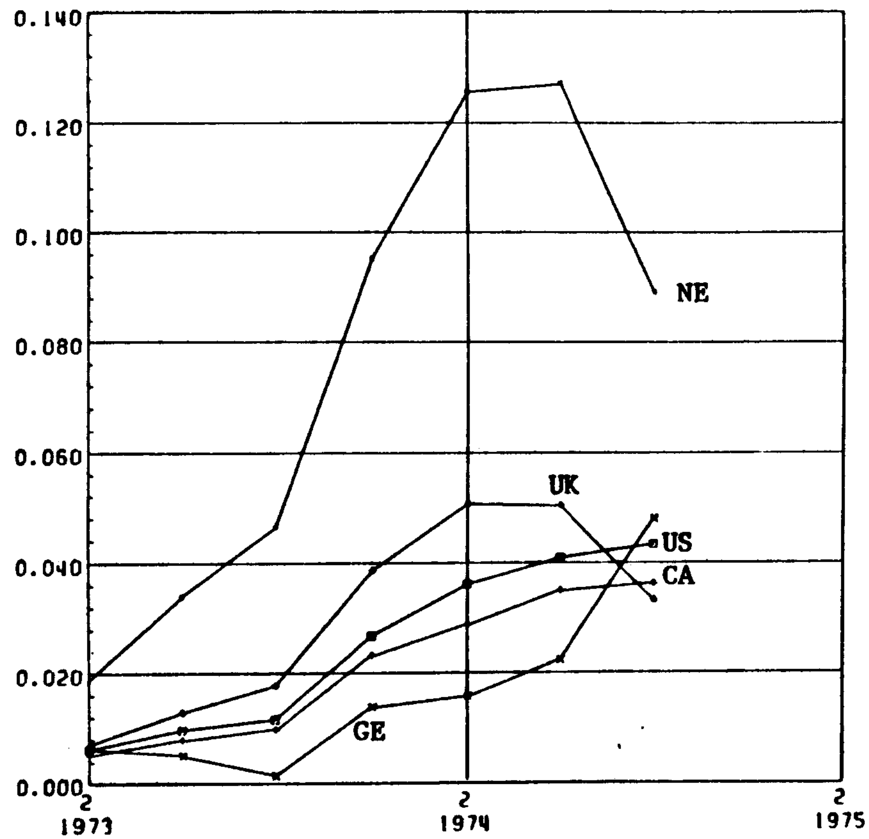
(c) Nominal Money -- log M_1



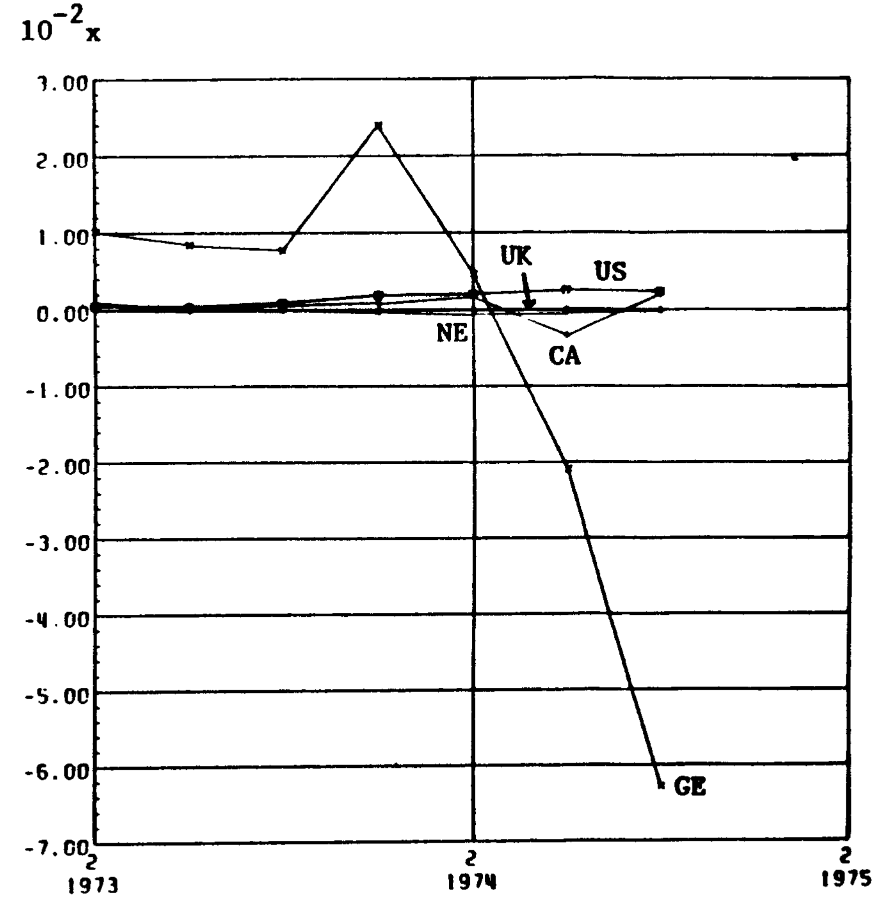
(d) Short-Term Interest Rate -- R_1

Legend
- ▫ United States (US)
- • United Kingdom (UK)
- • Canada (CA)
- × Germany (GE)
- · Netherlands (NE)

FIGURE 3 (Continued)



(e) Scaled Exports — $(X/Y)_1$

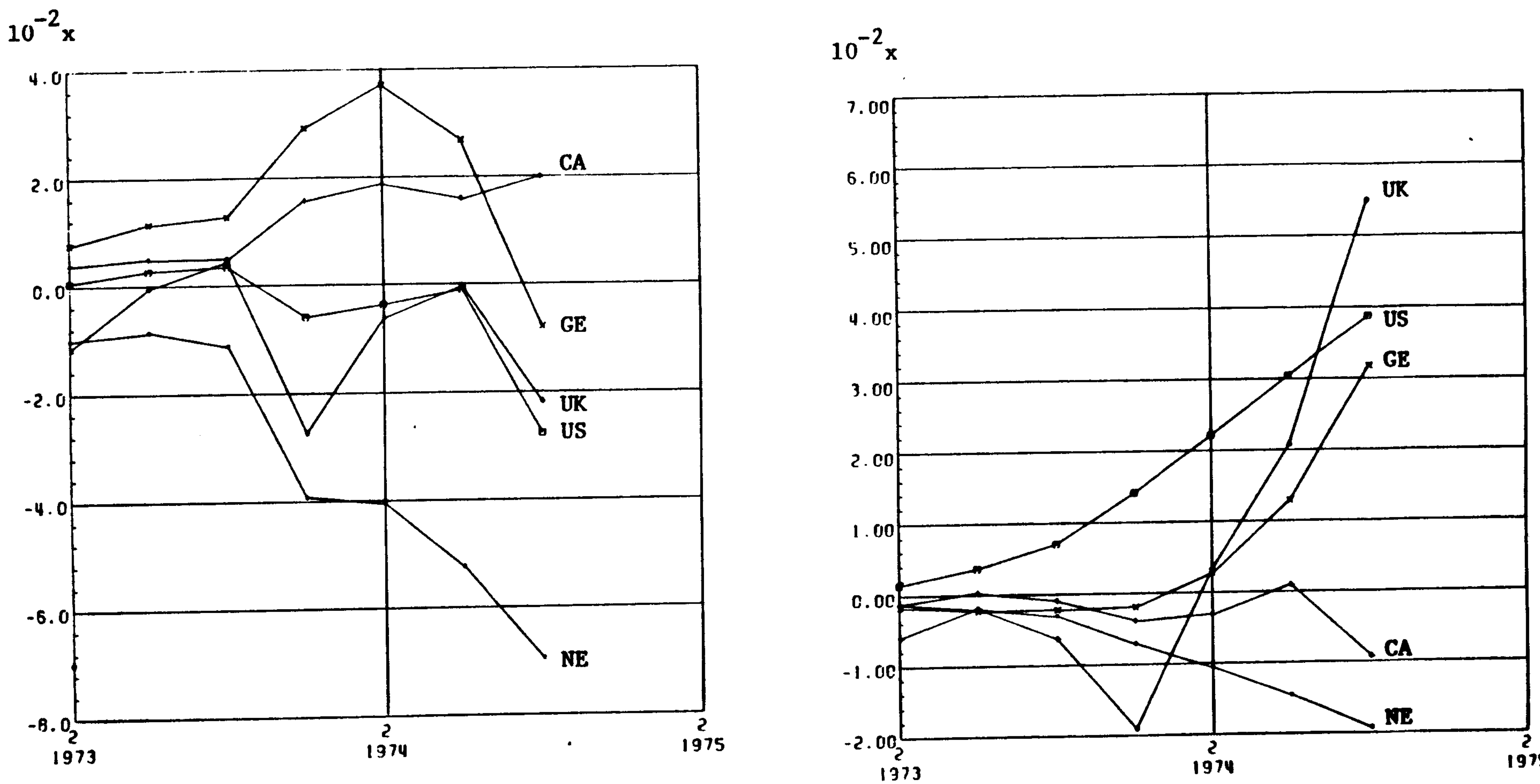


(f) Scaled Balance of Payments — $(B/Y)_1$

Legend
- United States (US)
- United Kingdom (UK)
- Canada (CA)
- Germany (GE)
- Netherlands (NE)

FIGURE 4

Simulated Effects of the 1973-1974
Increase in the Real Price of Oil
Using Mark IV-Oil Model

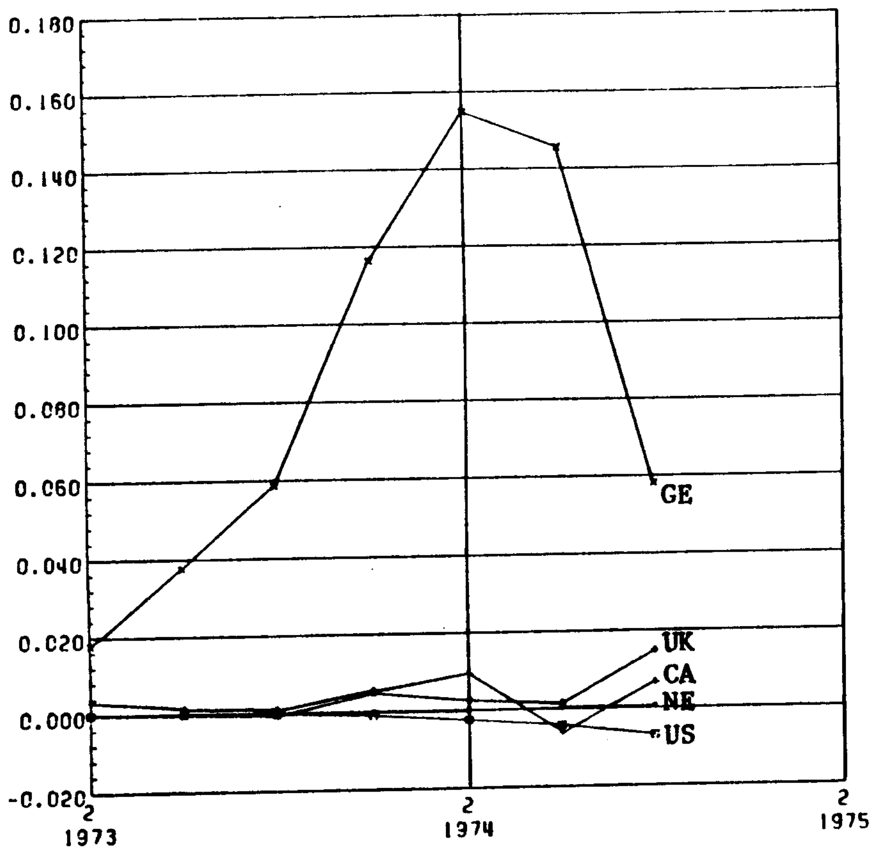


(a) Real Income -- log y_i

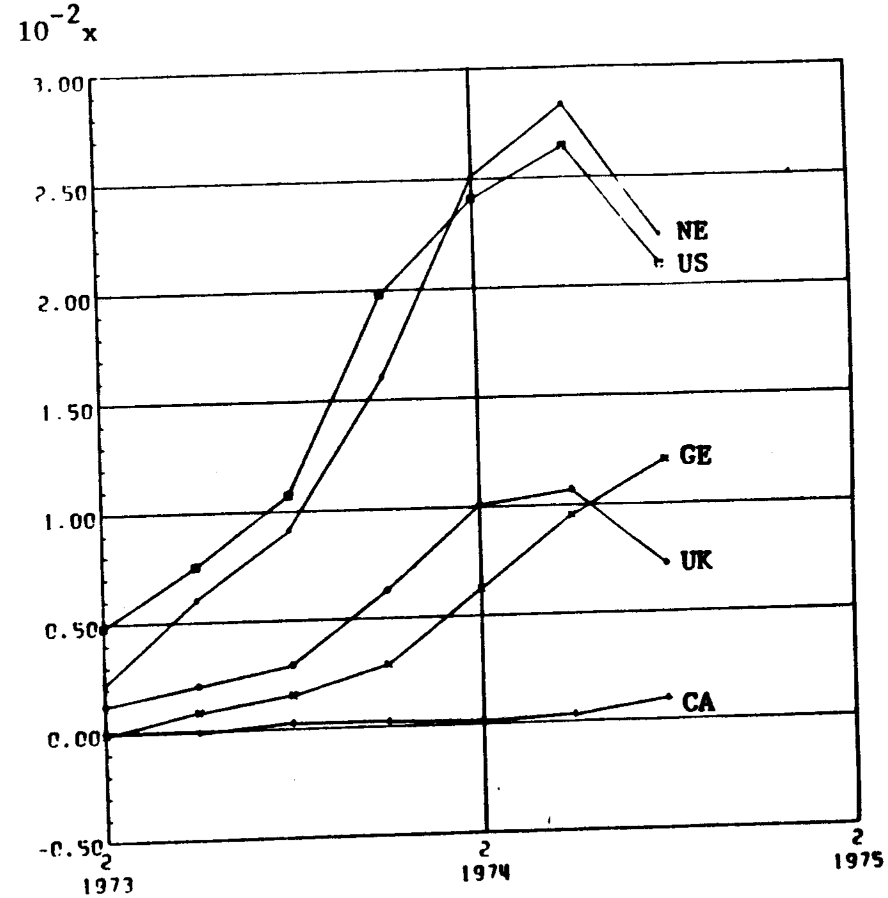
(b) Price Level -- log P_i

Legend
- ▫ United States (US)
- • United Kingdom (UK)
- • Canada (CA)
- × Germany (GE)
- • Netherlands (NE)

FIGURE 4 (Continued)



(c) Nominal Money -- log M_1

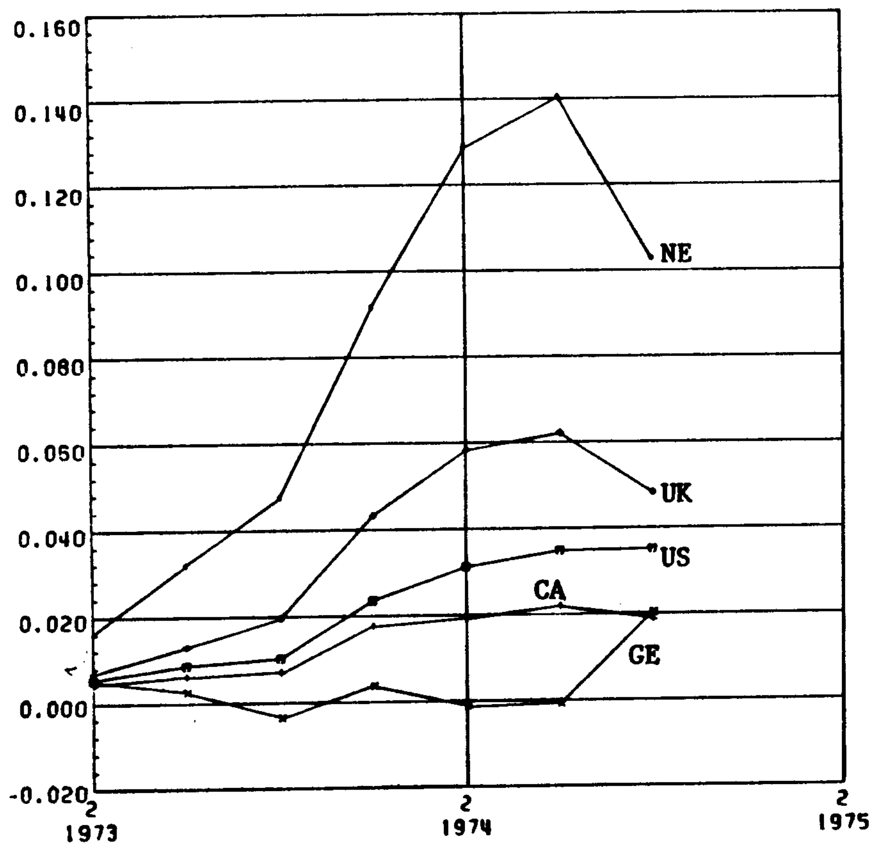


(d) Short-Term Interest Rate -- R_1

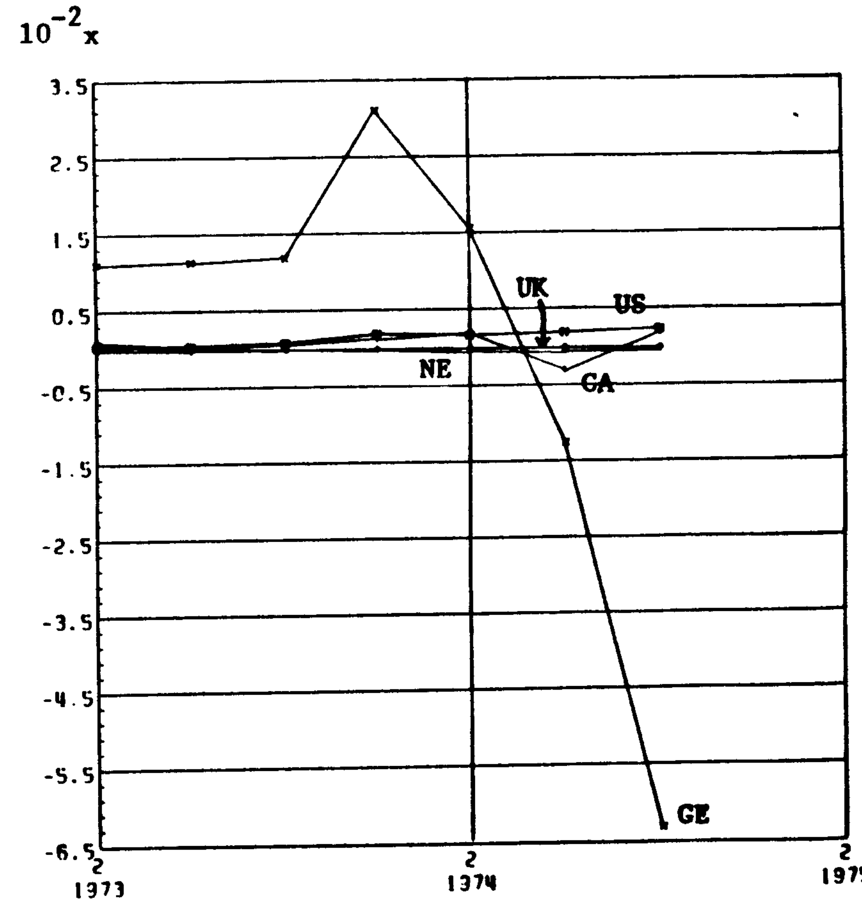
Legend

- United States (US)
- United Kingdom (UK)
- Canada (CA)
- Germany (GE)
- Netherlands (NE)

FIGURE 4 (Continued)



(e) Scaled Exports -- $(X/Y)_1$



(f) Scaled Balance of Payments -- $(B/Y)_1$

Legend
- ¤ United States (US)
- • United Kingdom (UK)
- ⁺ Canada (CA)
- ¤ Germany (GE)
- · Netherlands (NE)