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8 The Importance of Oil Price Changes in the 1970s World Inflation

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The increase in the real price of oil during 1973–74 is widely believed to have been a major cause of inflation in the United States and abroad. In part, this belief is based on a partial equilibrium (or adding-up) approach which explains the inflation rate as the weighted sum of the inflation rates of individual goods and services without making due allowance for the general equilibrium effects on factor prices of an increase in the relative price of an imported factor. But arguments acceptable theoretically can be made which attribute inflation—or at least an upward price-level shift—to factors decreasing the real quantity of money demanded or increasing the nominal quantity of money supplied by the central banks. This chapter reports an empirical investigation of the magnitude of these possible effects consistent with general equilibrium.

First, a theoretical analysis of the long-run and short-run effects of an oil price change is presented in section 8.1. It is seen there that the long-run effect on real income and the real quantity of money demanded may be quite small, if not negligible, particularly when real income is measured in terms of real GNP and money is deflated by the corresponding implicit deflator. While this result may be due to the use of a three-factor Cobb-Douglas production function in the context of a neoclassical growth model, it certainly illustrates that a long-run reduction of real GNP of even 1 or 2% is very much an empirical question. Short-run effects on real income and prices associated with shifts in aggregate demand and supply appear to be similar in magnitude to those for the long run. Central banks' reaction to the short-run real-income and inflation effects may offset or reinforce these effects once monetary policy is allowed to be endogenous.

Tests of significance of oil price variables in an extended Lucas-Barro real income equation are reported in section 8.2. The results are mixed and confounded by price control and decontrol programs which were widespread at nearly the same time as the 1973–74 oil price change. Much future work is required to disentangle the effects of these two factors definitively.

Section 8.3 reports simulation experiments on the effects of the 1973–74 oil price change. These experiments are conducted using the Mark IV–FLT Simulation Model presented in chapter 7 above. This model—a simplified version of the Mark III International Transmission Model[1]—is a quarterly macroeconomic model of the United States, United Kingdom, Canada, France, Germany, Italy, Japan, and the Netherlands. In addition to the basic Mark IV–FLT Model, an extended Mark IV–Oil Model is used which incorporates oil price variables in the real-income equations for those five countries for which the variables were found to be significant in section 8.2. 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 simulated using the Mark IV–Oil Model, but the price-control caveat of section 8.2 again applies.

The concluding section summarizes the results of this chapter and suggests areas for future research as international data on the effects of the 1979–80 oil price increase become available.

8.1 Theory

The price level, measured in dollars per basket of goods, is the inverse of the price of money, goods per dollar. So it is convenient to classify the forces determining the price level according to whether they influence the supply of or demand for money.

A standard (long-run) money-demand function explains the real quantity of money demanded m^d by real income y and the nominal interest rate R. The nominal quantity demanded M^d is the product of this real demand and the price level:

$$M^d = m^d(y, R) \cdot P. \tag{8.1}$$

Equating money supply M^s to money demand and solving for the price level,

$$P = \frac{M^s}{m^d(y, R)}. \tag{8.2}$$

That is, the price level equals the ratio of the nominal quantity of money supplied to the real quantity of money demanded.

1. See Chapters 5 and 6 for details.

Although the inflationary impact of an oil price change is generally analyzed given an exogenously determined nominal money supply, this may be misleading or at least counterfactual. That is, to the extent that the oil price change increases the price level and unemployment (at least temporarily) and decreases real income for a given nominal money supply, the inflationary effect would induce central banks to reduce M^s while the recessionary effect tends to increase M^s. Which effect is dominant would depend on the relative weights the individual central bank puts on inflation and unemployment. In addition, other factors—discussed below—may influence central bank policy response to an oil price change. With this warning, let us proceed for now to analyze the effects of an oil price change for an exogenous monetary policy.

8.1.1 Long-Run (Full Employment) Effects

Consider first the long-run effects of an oil price change on real output. For illustrative purposes suppose real output y is produced according to a three-factor Cobb-Douglas production function using domestic capital k, labor ℓ, and imported petroleum ϕ:[2]

$$y = k^{\alpha}\ell^{\beta}\phi^{\gamma}, \tag{8.3}$$

$$\alpha + \beta + \gamma = 1. \tag{8.4}$$

Let us assume that output is produced by competitors who treat all prices as parametric including in particular the real price of oil θ.[3] In equilib-

2. A fuller specification would include a factor $e^{\delta+\tau t}$ on the right-hand side, but it simplifies the notation without loss to choose labor units such that the e^{δ} is eliminated and to incorporate technical progress τ into our measurement of labor in efficiency units. The basic results (8.8) and (8.12) below are stated in Tatom (1979*a*, pp. 10–11) and Rasche and Tatom (1980) starting from the same production function (8.3). Their longest-run results (8.12), however, are derived from the simple assertion that the marginal product of capital is fixed in the long run by supply conditions rather than as the result of a growth analysis as is done below. Their assertion—although it is correct in this case—is generally false. They erroneously interpret the gross "rental price of capital" which is equated to the marginal product of capital as the "relative price of capital" (e.g. Tatom 1979*a*, pp. 10–11) and argue that this will equal its fixed supply price in the long run. In the appendix to Rasche and Tatom (1980), they instead have attempted to relate changes in output to changes in capacity of individual firms, but this seems to ignore the fact that the number of firms is not fixed.

In the main body of the paper, they present evidence supportive of the usage of a Cobb-Douglas production function of this form (8.3). Kopcke (1980) argues that it is improper to include energy as an argument in the aggregate production function since energy is itself an intermediate product produced by capital and labor. This objection does not apply to imported petroleum, which is produced by foreign labor and capital. Care must be taken, as seen below, however, in going from the domestic output concept appropriate to the production function (8.3) to the value-added concept of real GNP. Unfortunately this last step has not been made in the three-factor analyses of the effects of oil price changes.

3. This assumption is arguable also. For example, Phelps (1978) treated the quantity of imported oil ϕ as determined erogenously; the nominal price of oil is assumed fixed by Mork and Hall (1979) and by Berner et al. (1977) in their multicountry model. Rasche and Tatom (1980) argue persuasively that neither of these representations captures the meaning of OPEC's ability to set an optimal real price of oil.

rium, one of the first-order conditions requires that the marginal product of petroleum be equated to its real price:

$$\frac{dy}{d\phi} = \gamma k^{\alpha} \ell^{\beta} \phi^{1-\gamma} = \theta . \tag{8.5}$$

It is straightforward to solve for the equilibrium usage of petroleum as a function of θ, k, and ℓ:

$$\phi = \left(\frac{\gamma}{\theta}\right)^{[1/(\alpha+\beta)]} k^{[\alpha/(\alpha+\beta)]} \ell^{[\beta/(\alpha+\beta)]} \tag{8.6}$$

If we now substitute this equilibrium ϕ into the production function (8.3), we obtain equilibrium real output as a function of the real price of oil and given, fully employed resources of capital and labor:

$$y = \left(\frac{\gamma}{\theta}\right)^{[\gamma/(\alpha+\beta)]} k^{[\alpha/(\alpha+\beta)]} \ell^{[\beta/(\alpha+\beta)]} \tag{8.7}$$

Taking logarithms and differentiating, we find the elasticity of equilibrium output with respect to the real oil price for given capital and labor resources:

$$\left. \frac{d \log y}{d \log \theta} \right|_{k,\ell} = -\frac{\gamma}{\alpha+\beta} \equiv -\frac{\gamma}{1-\gamma} . \tag{8.8}$$

If, for example, γ were on the order of 0.01, a 1% increase in the real oil price would decrease real output by only 0.01% (1 basis point) for given resources and given the assumptions of this illustration.[4]

The full, long-run equilibrium effect would be slightly larger due to a reduction in the steady-state capital-labor ratio for a given growth path of labor. To see this, suppose that saving and investment $\dot{k}$ is a constant fraction σ of domestic factor income:

$$\dot{k} = \sigma(y - \theta\phi) . \tag{8.9}$$

Dividing both sides of (8.9) by k and noting that $y - \theta\phi = (\alpha + \beta)y$,

$$\frac{\dot{k}}{k} = \sigma(\alpha + \beta)\frac{y}{k} . \tag{8.10}$$

Thus the growth rate of capital is a fixed proportion of the output-capital ratio. In view of (8.7), this latter ratio is

4. The value of γ is discussed at some length below. To the extent that capital is in the form of existing machines which cannot be readily modified and which require fixed petroleum inputs, the quasi rents of existing machines will fall without any reduction in output or petroleum usage. A possibly offsetting factor would be the premature obsolescence of machines on which the quasi rents fall below zero. Neither of these factors is operative in full long-run equilibrium discussed immediately below, and the two factors are taken as negligible on net here.

$$\frac{y}{k} = \left(\frac{\gamma}{\theta}\right)^{[\gamma/(\alpha+\beta)]} \left(\frac{\ell}{k}\right)^{[\beta/(\alpha+\beta)]} \tag{8.11}$$

The simple neoclassical growth model can therefore be applied, which, after tedious manipulations, yields the result that

$$\frac{d \log y}{d \log \theta} = -\frac{\gamma}{\beta}. \tag{8.12}$$

This effect, which allows for the (proportionate) reduction in the capital stock, would be about a third larger than that in (8.8) for given resources and a labor share equal to three-quarters of value added. We should note that since income and capital fall proportionately in full steady-state equilibrium, there is no long-run effect on the real interest rate.[5]

A curiosity of national income accounting proves important in applying the analysis to empirical data. Gross national product is a value-added concept so that imported inputs are subtracted from total output to obtain GNP. This works fine for nominal GNP or Q:

$$Q = Py - (P\theta)\phi = P(1 - \gamma)y. \tag{8.13}$$

So nominal GNP is simply the price of output P times real domestic factor income $(1 - \gamma)y$. However, in computing real GNP or q, imported inputs are valued at *base-year* relative prices $\bar{\theta}$:

$$q = y - \bar{\theta}\phi = \left(1 - \frac{\bar{\theta}}{\theta}\gamma\right)y. \tag{8.14}$$

Thus measured real GNP rises relative to factor income $(1 - \gamma)y$ when the real oil price θ is increased. *Nominal* aggregate demand as measured by nominal GNP is not affected since there is an offsetting measurement error in the measured GNP deflator D:

$$D = \frac{Q}{q} = \frac{P(1-\gamma)y}{\left(1 - \frac{\bar{\theta}}{\theta}\gamma\right)y},$$

$$D = \frac{1-\gamma}{1 - \frac{\bar{\theta}}{\theta}\gamma} P, \tag{8.15}$$

We can differentiate (8.14) to find the elasticity of real GNP with respect to the real oil price as

$$\frac{d \log q}{d \log \theta} = \frac{\gamma\bar{\theta}}{\theta - \gamma\bar{\theta}} + \frac{d \log y}{d \log \theta}. \tag{8.16}$$

5. Before capital adjusts, but with resources fully employed, the marginal product of capital $\alpha k^{\alpha-1}\ell^{\beta}\phi^{\gamma}$ falls (slightly) with ϕ and hence so does the real interest rate.

For small changes in θ before the capital stock adjusts,[6]

$$\text{(8.17)} \qquad \left.\frac{d \log q}{d \log \theta}\right|_{k,\ell,\theta=\bar{\theta}} = \frac{\gamma}{1-\gamma} - \frac{\gamma}{1-\gamma} = 0 .$$

Thus we see that in the neighborhood of the original oil price, the output effect is completely masked in measured GNP. However, for large changes in θ relative to $\bar{\theta}$ such as those occurring in 1973–74, there would be a negative effect on measured real GNP.[7] Using Δ for the change relative to base-year prices we have

$$\text{(8.18)} \qquad \Delta \log q = \log\left(\frac{1 - \frac{\bar{\theta}}{\theta}\gamma}{1-\gamma}\right) + \frac{d \log y}{d \log \theta} \log(\theta/\bar{\theta}),$$

where

$$\frac{d \log y}{d \log \theta}$$

is from (8.8) or (8.12) depending on whether or not the capital stock is presumed to have adjusted.[8] Note that the deflator is decreased relative to the price of output by

$$\log\left(\frac{1 - \frac{\bar{\theta}}{\theta}\gamma}{1-\gamma}\right)$$

just as real GNP is increased relative to real factor incomes.

In summary, an increase in the real price of oil is predicted to decrease real output by the logarithmic change times $\gamma/(1-\gamma)$ before capital adjusts or times γ/β when capital is fully adjusted. However, such an oil price change will cause a partially offsetting overstatement of measured real GNP (and understatement of the GNP deflator).

Obviously the values of γ and β are of considerable interest. For current illustrative purposes, only petroleum imports will be considered.[9] To the extent that petroleum imports are for resale to consumers rather than used in production, they have no effect on output or measured GNP (real or nominal). Thus the ratio of the value of petroleum imports to GNP serves as an upper limit on γ. If we use prechange U.S. data, this

6. That is, $\theta \simeq \bar{\theta}$ so that $\gamma\bar{\theta}/(\theta - \gamma\theta) \simeq \gamma/(1-\gamma)$.

7. Although $(d \log q)/(d \log \theta) = 0$ initially as seen in (8.17), as θ increases, the positive RHS term in (8.16) decreases while the negative RHS is unchanged. The negative effect is yet greater if capital is allowed to adjust.

8. Note that the first RHS term in (8.18) is approximately equal (for small γ) to $\gamma(1 - (\bar{\theta}/\theta))$, which illustrates that as θ becomes large the adjustment for imported inputs in measured GNP becomes trivial and all output is included in measured GNP.

9. It is possible to apply the analysis to energy more generally, but the increase in γ is largely offset by a reduced logarithmic change in θ.

upper limit would be about 0.003 for 1970. In 1976, this share had risen to 0.02. This rise in the share could indicate inelastic consumer demand for imported petroleum products, a problem with the Cobb-Douglas production function, or both. So while 0.003 should be an upper limit for γ if the Cobb-Douglas function is correct, 0.02 will also be considered as an upper-upper limit. Finally suppose that $\alpha/(\alpha+\beta)$ and $\beta/(\alpha+\beta)$ have their traditionally estimated values of ¼ and ¾. Then the multiplier $-\gamma/(1-\gamma)$ is -0.003 or -0.020 depending on γ. The corresponding multipliers allowing for capital stock change are -0.004 and -0.027. The real price of a barrel of crude oil increased some 3.57fold from 1973I to 1974I (a logarithmic increase of 1.273). This is surely an upper limit on $\theta/\bar{\theta}$ for all petroleum products. Table 8.1 presents estimates of the maximum effects on output and measured real GNP. We see that the maximum full adjustment effects on real output range from a decrease of 0.5 to 3.5% according to whether one takes a prechange or postchange estimate of γ. For measured real GNP the corresponding decreases are only 0.3 to 2.0%. Even smaller changes correspond to the intermediate period corresponding to full employment of resources but no adjustment of the capital stock.

Rasche and Tatom have long argued for much larger real-income effects of the oil price change. They rely upon regression estimates of the quasi-production function (8.7) and find much larger values of γ than considered here. Part of that difference is illusory: They use a much broader energy price index which has a logarithmic increase of only 0.408 from 1972 to 1974[10] compared to the 1.273 increase for a barrel of oil used here; so the larger elasticity is offset by a lower value of $\log(\theta/\bar{\theta})$. Further they do not take account of the biases in reported real GNP so that their estimates may refer to the output effect rather than the GNP effect. Finally, in their (1980) paper, they report an equation (6) in which they estimate the production function (8.3) directly (after taking logs) and also add $\log\theta$ separately. The estimated γ is 0.05 while the coefficient on $\log\theta$ is -0.07. Using $\gamma = 0.05$, $\beta = 0.70$ (as reported), and $\log(\theta/\bar{\theta}) = 0.408$, we get an output change of -0.0215 with no capital adjustment and of -0.0291 with capital adjustment, which is in the same ball park as the figures in table 8.1. It is the things other than in the production function—captured in the $\log\theta$ coefficient of -0.07—which permit such big estimates. These other things may have to do with cyclical factors, induced monetary policy, or fortuitous removal of price controls at roughly the same time as discussed below. Further the 0.05 estimate of γ may be biased upward if energy usage (relative to capital and labor) serves as an indicator of whether the economy is in a boom or recession. Thus the Rasche and Tatom conclusions may have weak empirical foundations.

10. Rasche and Tatom (1980, table 6).

Table 8.1 Illustrative Calculations of Maximum Long-Run Effect of 1973–74 Real Oil Price Increase

	No Capital Adjustment		Full Capital Adjustment	
	$\gamma = 0.003$	$\gamma = 0.02$	$\gamma = 0.003$	$\gamma = 0.02$
Change in log output ($\Delta \log y$)	−0.0038	−0.0260	−0.0051	−0.0346
Change in measured real GNP ($\Delta \log q$)	−0.0017	−0.0114	−0.0029	−0.0200
Difference ($\Delta \log q - \Delta \log y \equiv \Delta \log P - \Delta \log D$)	0.0022	0.0146	0.0022	0.0146

This exercise has shown that even a huge change in the real price of oil such as in 1973–74 may result in very small if not negligible effects on real output and especially upon measured real GNP. Different assumptions would result in different results, but the model used is surely a standard one in practice. Thus it would appear to be an empirical question as to whether the oil price change had any significant long-run effect on measured real GNP.

We can now return to our original question of the long-run effect of the oil price change on the real quantity of money demanded and hence, given the nominal money supply, on the price level. First, we note that in long-run equilibrium real income is reduced by a constant fraction but the growth rate of real income is reduced only temporarily during the transitional period. Second, we note that the real interest rate is unchanged. Under these conditions, in long-run equilibrium the real and nominal interest rate will be unchanged and the real quantity of money demanded will behave similarly to real income—a downward parallel shift in its growth path. The logarithmic downward shift will equal the elasticity of real money demand with respect to real income times the logarithmic shift in real income. Thus, if this income elasticity is around 1, there will be a long-run increase in the price level equal to the long-run decrease in real income.[11] If during the early part of the adjustment period the price-level effect exceeds this long-run effect, then the inflation rate must be reduced (ceteris paribus) below what it would otherwise be to reach long-run equilibrium.

Two problems may arise in econometric work based on real GNP as

11. A formal solution to this problem is presented in Darby (1979, chapter 5).

measured in the national income accounts. First, the reduction in measured real GNP will understate the output reduction which actually occurs. A second problem arises only if the income elasticity of the demand for money differs significantly from unity: Then the offsetting measurement errors in real GNP and the GNP deflator would cause an apparent shift in the money-demand function equal to the product of the measurement error and the difference of the elasticity from 1. This latter problem is a second-order matter which will not be pursued further in this chapter.

8.1.2 Short-Run Effects

Short-run effects of the 1973–74 oil price shock have been analyzed in terms of induced shifts in aggregate demand and aggregate supply curves under the assumption that nominal wages are predetermined (or at least sticky) in the short run. As with the long-run analysis, the analysis of the short-run effects proceeds on the assumption that the government's monetary and fiscal policy is unaffected by the unexpected oil price increase.

The aggregate demand effects of an oil price shock can be viewed as analogous to that of an increase in taxes.[12] Assume for simplicity that in the short run both producer and consumer demands for imported petroleum are perfectly inelastic. For producers, this means that higher import prices will be paid out of reduced quasi rents, reducing private income. For consumers, higher oil prices would directly reduce expenditures on *other* consumption goods for given private income and these expenditures would be further reduced by the reduction of private income.[13] Thus, at initial levels of real income and interest rates, aggregate expenditures would fall *unless* increased demand for exports by oil exporters equals or exceeds the induced reduction in consumption. When we allow for some elasticity of demand for imported oil and for increased exports of goods to oil producers, the plausible magnitude of these basically distributional effects is sharply reduced and could even be reversed.[14] In what follows, we shall nonetheless consider the possibility of a small decrease in aggregate demand.

The aggregate supply effect would appear more substantial and has been analyzed on varying assumptions by Bruno and Sachs (1979), Hud-

12. This tax analysis is given little if any weight in recent analyses. Rasche and Tatom (1980), for example, term it the "1974 view," and the belief that aggregate demand shifts were important appears to have been an ephemeral phenomenon. It is included here for the sake of completeness.

13. The exact amount of these reductions depends on consumer expectations, but the direction is unambiguous.

14. There is no long-run effect on output or interest rates via this channel unless differences between foreign and domestic propensities to save cause a shift in the domestic investment-output ratio.

son and Jorgenson (1978), Mork and Hall (1979), Norsworthy, Harper, and Kunze (1979), Phelps (1978), and Rasche and Tatom (1977*a*, 1980). Following the latter authors, suppose that the short-run conditions underlying the aggregate supply curve are fixity of the capital stock, the nominal wage W, and the real price of oil. Using the aggregate production function (8.3), one can readily derive output as

$$y = \left(\frac{\gamma}{\theta}\right)^{\gamma/\alpha}\left(\frac{\beta P}{W}\right)^{\beta/\alpha} k. \tag{8.19}$$

On comparing (8.19) and (8.7), we note that for a given price level there is a much greater output effect with nominal wages fixed than when labor is assumed to be at its natural unemployment rate. Specifically

$$\left.\frac{d \log y}{d \log \theta}\right|_{k,W} = -\frac{\gamma}{\alpha} + \frac{\beta}{\alpha}\frac{d \log P}{d \log \theta}. \tag{8.20}$$

Note that the elasticity of the aggregate supply curve is

$$\frac{d \log y}{d \log P} = \frac{\beta}{\alpha}. \tag{8.21}$$

It is convenient to plot aggregate supply and demand curves in terms of log y and log P so that slopes and elasticities have a simple correspondence. The logarithmic aggregate supply curve corresponding to equation (8.19) is

$$\log y = \left[\frac{\beta}{\alpha}\log(\beta/W) + \frac{\gamma}{\alpha}\log \gamma + \log k\right] - \frac{\gamma}{\alpha}\log \theta + \frac{\beta}{\alpha}\log P. \tag{8.22}$$

This is plotted as S in figure 8.1 for given values of k, W, and the base-year relative price of oil $\bar{\theta}$. The slope of S is the inverse (α/β) of the elasticity of aggregate supply. An aggregate demand curve D is also drawn to determine short-run output and the price level, $\bar{y}$ and $\bar{P}$.[15]

As can be seen in equation (8.22) an increase in the real price of oil shifts the aggregate supply curve horizontally by $-(\gamma/\alpha)\log(\theta/\bar{\theta})$, as illustrated in figure 8.2.[16] This can alternatively be described as an upward shift equal to minus the slope of S times the horizontal shift:

$$\left(-\frac{\alpha}{\beta}\right)\left(-\frac{\gamma}{\alpha}\log(\theta/\bar{\theta})\right) = \frac{\gamma}{\beta}\log(\theta/\bar{\theta}). \tag{8.23}$$

15. The aggregate demand curve is derived by solving the IS relation for R and substituting in equation (8.2).

16. A negative sign indicates a shift to the left.

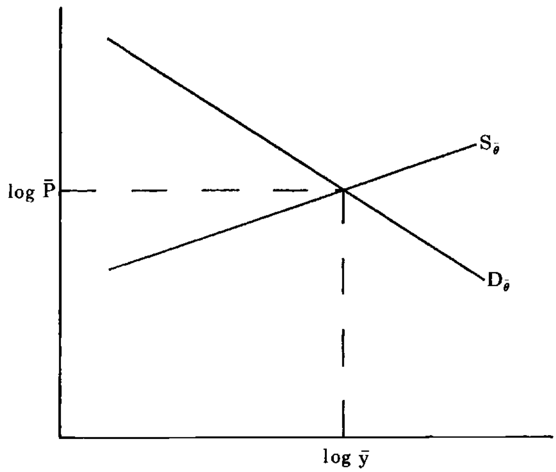

Fig. 8.1 Determination of base output and price level.

If any shift in the aggregate demand curve is negligible, the new equilibrium output and price level are y and P. The short-run displacement in output from that corresponding to the base real oil price $\bar{\theta}$ is

(8.24) $$\Delta \log y = \frac{-1}{\frac{\alpha}{\beta} - \frac{1}{\eta_D}} \frac{\gamma}{\beta} \log(\theta/\bar{\theta}),$$

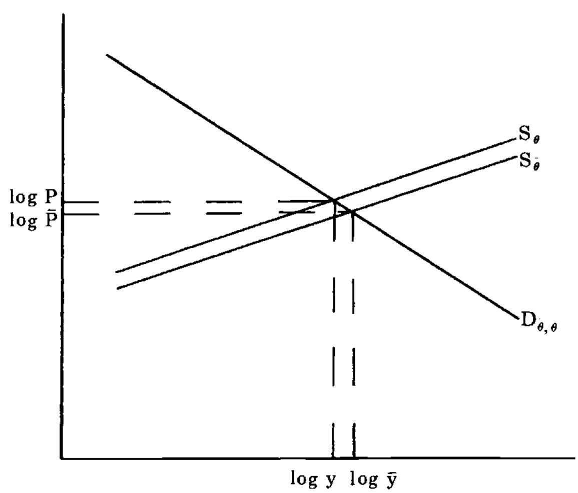

Fig. 8.2 Determination of changes in output and price level from base values with no aggregate-demand shift.

where η_D is the elasticity of the aggregate demand curve so that α/β and $1/\eta_D$ are the slopes of the aggregate supply and demand curves, respectively. Suppose that the aggregate demand curve is unit elastic ($\eta_D = -1$); then

$$\Delta \log y = -\frac{\gamma}{1-\gamma}\log(\theta/\bar{\theta}), \tag{8.25}$$

which is identical to the long-run effect implied by (8.8) before the capital stock adjusts. The increase in the price level,

$$\Delta \log P = \frac{1}{\eta_D}\Delta \log y = \frac{\gamma}{1-\gamma}\log(\theta/\bar{\theta}), \tag{8.26}$$

reduces real wages just sufficiently to maintain employment at the natural level. Thus, in the absence of a shift in the aggregate demand curve, employment rises or falls (and output is greater or less than the given-capital long-run level indicated by (8.25)) according to whether the elasticity of aggregate demand is smaller or greater than 1 in absolute value. If aggregate demand were inelastic, increased employment would lessen the short-run decline in output. In Darby (1976*c*, pp. 161–63) I argued that short-run and hence transitory movements in output will induce much less than proportionate movements in money demand, which suggests that the short-run aggregate demand curve is in fact elastic.[17] This would imply a short-run reduction in employment, which would accentuate the initial fall in output predicted by the full-employment analysis.[18] Once expected nominal wages are reduced, this

17. Purvis (1975) displays the correct formula for η_D, which is

$$\eta_D = \frac{-1}{\dfrac{\partial \log m^d}{\partial \log y} + \psi\dfrac{\partial \log m^d}{\partial \log R}},$$

where ψ is $(d \log R)/(d \log y)$ or the elasticity of the interest rate with respect to output on the IS curve. For a normal negatively sloped IS curve, $\psi(\partial \log m^d)/(\partial \log R)$ will be positive but insufficient to bring the denominator of η_D up to 1 if short-run interest elasticity of money demand is small and the IS curve is rather flat as argued by Hall (1977).

Rasche and Tatom (1980) make a convoluted version of Gamb's error (which Purvis corrected) to conclude that the aggregate demand curve was inelastic. Rather than accept the implication of increased employment, they repeat their (1977*a*) assumption that nominal wages rise freely once the natural unemployment rate is reached. I can see no justification for this appendage to a basic search view of the labor market. It is of course irrelevant if $\eta_D < -1$ or the aggregate demand curve shifts to the left sufficiently to reduce employment despite an inelastic aggregate demand curve.

18. If the elasticity of aggregate demand is less than -1 but greater than $-\beta/(\beta-\alpha)$ (about -1.5), the short-run effect will be greater than the full-employment effect for a given capital stock but less than the long-run effect allowing for capital adjustment. That is, in the absence of significant shifts in aggregate demand, the long-run effects with full capital adjustment such as calculated in table 8.1 exceed the short-run effects unless $\eta_D < -\beta/(\beta-\alpha) \simeq -1.5$.

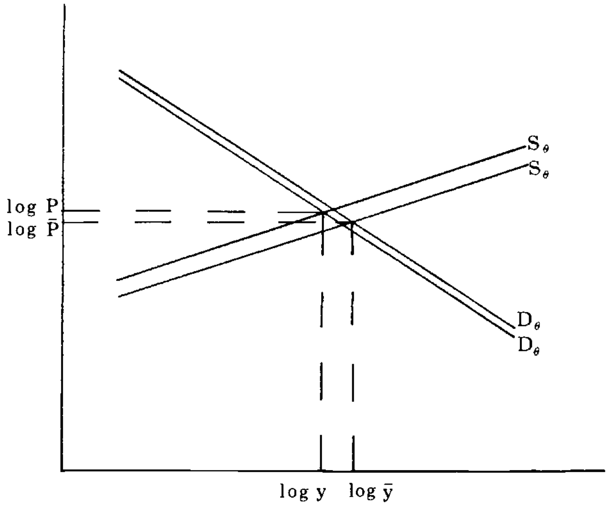

Fig. 8.3 Determination of changes in output and price level from base values with shift in aggregate demand.

difference would disappear. In addition, the aggregate demand curve may shift to the left as previously argued if there is a distributional effect due to faster decreases in consumer spending than increases in oil-exporter spending; this is illustrated in figure 8.3.

Again it must be emphasized that these calculations are only illustrative of the sort of effects which might be expected. If, for example, we assumed partial adjustment of nominal wages to their equilibrium values, the aggregate supply curve would be less elastic and the output change would be more closely tied to the change in the given-capital long-run level of output.[19]

The aggregate demand curve is derived using our price-level equation (8.2) so the short-run price-level effect

$$\text{(8.27)} \qquad \Delta \log P = \frac{1}{\eta_D} \Delta \log y$$

is valid for the short-run period in which IS-LM analysis is applicable. If $-1/\eta_D$ is less than the long-run elasticity of demand for money with respect to output, the short-run increase in the price level would be less than that associated with an equal long-run decrease in output.

Note that the same accounting problem in relating output and the price level to real GNP and the deflator apply in the short run as in the long run.

19. More wage flexibility implies less employment variation, so output would be lower than indicated by equation (8.24) if $\eta_D > -1$ and less if $\eta_D < -1$.

8.1.3 Endogenous Monetary Policy

The time has now come to consider effects of the oil shock upon monetary policy. Suppose that we can write the money supply reaction function of the monetary authorities as

$$\log M = \log M^* + h_y \log(y/y^*) + h_p \log(P/P^*) + \epsilon_M. \tag{8.28}$$

In logarithms, actual money equals expected money as predicted by lagged variables systematically affecting central bank behavior plus negative coefficients times the innovations in output and the price level and a random disturbance.[20] Write the semireduced forms for output and the price level as

$$y = f(k, W, \theta, M, M^*, \epsilon_y), \tag{8.29}$$

$$P = \pi(k, W, \theta, M, M^*, \epsilon_p). \tag{8.30}$$

Denote the real-oil-price and money elasticities of these equations by f_θ, f_M, π_θ, and π_M. Then taking the log changes in equations (8.28) through (8.30) and solving for $\Delta \log M$ yields

$$\Delta \log M = \frac{h_y f_\theta + h_p \pi_\theta}{1 - h_y f_M - h_p \pi_M} \Delta \log \theta. \tag{8.31}$$

We have seen above that f_θ is negative and π_θ is positive while h_y and h_p are both negative. Whether money is increased, decreased, or left unchanged by the central bank depends both on the relative sizes of the output and price effects and on the relative aversion of the central bank to recession and inflation. The denominator of (8.31) allows for attenuation of money changes to the extent that there are within-period (positive) responses in output and prices. Finally, the price-level effect is obtained by substituting (8.31) into the log-change form of (8.30):

$$\Delta \log P = \left(\pi_\theta + \frac{(h_y f_\theta + h_p \pi_\theta)\pi_M}{1 - h_y f_M - h_p \pi_M}\right) \Delta \log \theta. \tag{8.32}$$

Here π_θ is the value of $(\Delta \log P)/(\Delta \log \theta)$ such as is computed in (8.27) for a given nominal money supply and the ratio term is the additional (ambiguously signed) effect due to endogenous nominal money supply changes.

20. The lack of a term in the balance of payments implies that we are dealing with either a reserve country (the U.S.), a freely floating country, or a country which can and does sterilize balance-of-payments effects in the relevant period; see chapter 10. By the time of the first oil shock (1973–74) this is probably a reasonable characterization although current balance-of-payments effects will also be present for some countries in the simulations reported in section 8.3 below.

Simulation experiments which allow for such endogenous movements in the nominal money supply are reported below in section 8.3. It is perhaps understandable why most analyses assume that the ambiguously signed change in nominal money must be negligible and proceed on that basis. One can at least explain the effect if the central bank were to hold money supply unchanged.

8.1.4 Conclusions from Theory

Considering first the results of our analysis conditional upon a given monetary policy, with resources at their natural employment levels, the output elasticity with respect to the real price of oil is $-\gamma/(1-\gamma)$ before capital adjusts and $-\gamma/\beta$ with full capital adjustment. The parameter γ, the value share of oil imports used in producing domestic output, may be quite small, certainly less than 0.02 for the United States, for example. The labor share β is on the order of 0.7 to 0.8, so the long-run elasticities vary from about γ to 1.3γ or 1.4γ. In the short run, unemployment will increase slightly (if aggregate demand is elastic), but the short-run output elasticity seems to lie in the same range as for the long run. The price level is shifted up in the long run by the long-run income elasticity of money demand (around 1) times the output elasticity. In the short run the price level shifts less than in proportion to output since the short-run aggregate demand curve is elastic.

These shifts in the levels of output and prices affect their growth rates only during the transitional period. They may be reinforced or offset by endogenous money supply reactions of the central bank. These reactions depend on the relative aversion of the central bank to decreases in output and increases in prices and so are ambiguous in sign a priori.

Biases in the calculation of real value added imply smaller elasticities in absolute value for real GNP and the implicit price deflator than for real output and the price level. Indeed, an increase in the real oil price of the size which occurred in 1973–74 implies that the logarithmic change in real GNP would be less than half that for output.

8.2 Tests for Structural Change in the Real-Income Equation

The behavior of the real price of oil is dominated by a downward secular trend from the 1950s until the early 1970s as illustrated for the United States in figure 8.4. There was a small upward movement in 1971–72, but the major increase occurred in the second quarter of 1973 and especially the first quarter of 1974. Widespread recessions in 1973–75 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 first of these alternative hypotheses points to the final breakdown

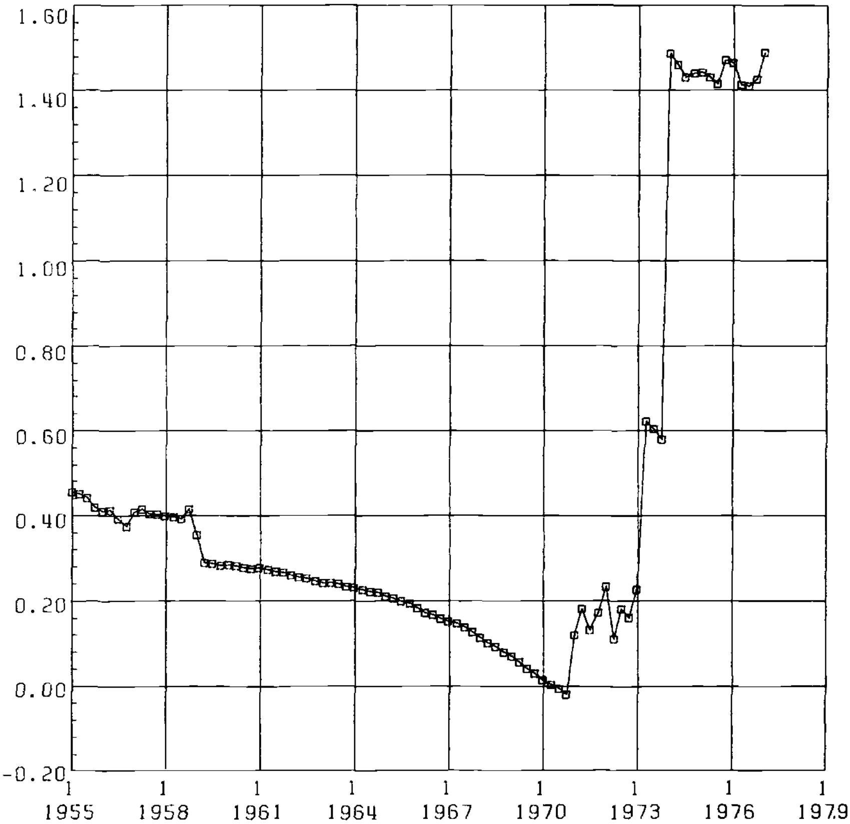

Fig. 8.4 The logarithm of the United States real price of imported oil. Source: The dollar price index of Venezuelan crude oil is taken from various issues of *International Financial Statistics* and rebased to 1.00 in 1970. This is then deflated by the U.S. GNP deflator (1970 = 1.00) to obtain θ ($\theta_{1970} = 1.00$).

of pegged exchange rates in 1973 which permitted (previously) non-reserve 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. Obviously any estimate of the effect of oil price changes must account for the effect of these restrictive monetary shocks.

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 1973–75. Such controls may have caused overstatement of real GNP (and understatement of the GNP deflator) compared to true values.[21] When the controls were relaxed during 1973–75, *measured* real income fell back to its true value giving an illusion of a deeper recession than was actually occurring or the occurrence of a recession when there was none. Although it is possible to develop corrected estimates for real GNP and the deflator using physical unit series such as employment, car-loadings, and components of the industrial production indices, that is a very large job. The present paper will only examine whether estimated effects of oil price changes appear to be larger in those countries with coincident price-control relaxation. If so, future research will be indicated to disentangle these oil and price-control effects.

In examining the empirical data, it is also important to note that the normal or natural growth rate of output has declined generally in the postwar period. In the late 1940s, after a decade and a half of depression and war, the world capital-labor ratio was very low relative to its balanced-growth or steady-state value.[22] As the capital stock approaches its steady-state level, the growth rates of capital and hence real income decline toward their steady-state values. If we were to impose a constant natural growth, a spurious negative coefficient might be estimated for oil to account for slowing growth in the 1970s.

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.[23] 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-expectation/natural-rate approach as

$$(8.33) \qquad \log y_t - \log y_{t-1} = a_1 - a_2(\log y_{t-1} - \log \bar{y}_{t-1}) + \sum_{i=0}^{3} a_{3+i}\hat{M}_{t-i} + \sum_{i=0}^{3} a_{7+i}\hat{g}_{t-i} + \sum_{i=0}^{3} a_{11+i}\hat{x}_{t-i} + \epsilon_t,$$

where the time subscripts are made explicit, $\bar{y}_t$ 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 $\log M_t$, logarithm of real government

21. See Darby (1976*a*, *b*).

22. Even for the relatively unscathed United States, capital grew by only about 0.4% per annum from 1929 through 1948 compared to a normal growth rate of 3.2%; see Christensen and Jorgenson (1978, p. 56). This implies that by 1948 the actual U.S. capital stock was less than 60% of the steady-state capital stock.

23. See chapters 5 and 6 above for a description of the model and chapter 9 below for a detailed analysis of the real-income equations.

expenditures for goods and services, and exports divided by GNP, respectively.[24] 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 as just discussed and for an oil price effect is

$$\log \bar{y}_t = b_1 + b_2 t + b_3 t^2 + b_4 \log \theta_t . \tag{8.34}$$

A positive b_2 and negative b_3 implies a declining natural growth rate. The parameter b_4 estimates the full long-run value of $(d \log y)/(d \log \theta)$. If the expression (8.34) were simply substituted in equation (8.34), 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 analysis of section 8.1 in which it was shown that the short-run effect is similar in magnitude to the long-run effect.[25] So, as with the aggregate demand variables, a four-quarter distributed lag on the first difference of $\log \theta$ is included to capture a rapid short-run adjustment process.

Substituting equation (8.34) in (8.33) and adding the short-run adjustment process yields the estimating equation

$$\begin{aligned} \log y_t = {} & a_1 + a_2(b_1 - b_2) + (1 - a_2)\log y_{t-1} \\ & + a_2 b_2 t + a_2 b_3 (t-1)^2 \\ & + a_2 b_4 \log \theta_{t-1} + \sum_{i=0}^{3} a_{3+i} \hat{M}_{t-i} \\ & + \sum_{i=0}^{3} a_{7+i} \hat{g}_{t-i} + \sum_{i=0}^{3} a_{11+i} \hat{X}_{t-i} \\ & + \sum_{i=1}^{4} c_i (\log \theta_{t+1-i} - \log \theta_{t-i}) + \epsilon_t . \end{aligned} \tag{8.35}$$

This equation has been estimated using the 1957–76 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

24. 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.

25. Immediately after an increase in the real oil price, the capital stock is greater than in full long-run equilibrium while labor utilization is less. The net effect depends on the elasticity η_D of the aggregate demand curve, but approximates the full long-run effect on plausible assumptions.

number of predetermined variables in the model.[26] The coefficients of the aggregate demand variables, not at issue here, are substantially the same as those discussed in chapter 6 above, and so are omitted for the sake of brevity from the present discussion.[27]

The regression results are summarized in table 8.2. The coefficient of log θ_t is negative in every case although only four of the t statistics meet conventional levels of significance. The implicit estimate of the long-run oil effect is reported in the ninth row 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 8.3 indicates the implied long-run reduction in real income for the eight contries based on the 1973I–76IV increase in the real price of oil. Rasche and Tatom (1980, table 7) prepared similar estimates for their model (discussed in section 8.1) on the basis of 1973–77 energy price increases, and those estimates are reported for comparison. Despite some differences in detail, the calculations here tell broadly the same story as those 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: $a_2 b_4 = c_1 = c_2 = c_3 = c_4 = 0$). As reported in table 8.2, only five of the countries have any statistically significant oil effect at the 5% level[28] 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. Further, the significant French effects imply that French income was higher throughout 1973 as a result of rising oil prices and so does not really support the hypothesis.

Since experience indicates that the French, Italian, and Japanese data may be quite unreliable,[29] let us focus on the results for the United States, the 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. In-

26. The only current endogenous variables in equation (8.35) 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.

27. To the extent that 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 those in chapter 6. See also the simulation equation coefficients in section 8.3 below.

28. Only France is significant at the 1% level.

29. See discussions in chapters 3, 6, and 7 above.

terestingly, these three countries with significant F statistics all removed general price controls coincidentally with the 1973–74 oil price increase while Canada and Germany had no price controls during the relevant period.[30] If, as I have argued elsewhere (1976*a*, *b*), 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.

In summary, these empirical results give a rather ambiguous answer to the question of whether a large increase in the real price of oil will reduce real income significantly 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.

8.3 Simulation Experiments

To assess the effects of the 1973–74 oil price increase on real income—and ultimately the price level—we must allow for induced changes in nominal money supplies and real exports aside from any possible direct effects such as examined in section 8.2. 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 Simulation Model described in chapter 7 above.[31] The results of any one simulation model cannot be

30. The United States took the lead in imposing price controls in August 1971, which Darby (1976*a*, *b*) 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 *growth* was overstated from 1971III through 1973I and then understated from 1973II through 1974IV. According to Parkin in Shenoy (1978, pp. 150–51), the United Kingdom followed a similar pattern: controls instituted with a freeze in November 1972 peaked in their effect on the data with the end of stage II in August 1973 and eventually were abandoned entirely after the Conservative loss of February 1974. Shenoy (1978, pp. 132–35) 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. 138–41).

31. The Mark IV Simulation Model is a simplified simulation version of the Mark III International Transmission Model described in chapters 5 and 6 above. 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 in this paper since we are concerned with 1973–74.

Table 8.2 **2SLSPC Regression Estimates of Oil Price Effects in Real-Income Equation (8.35)**

	US	UK	CA	FR	GE	IT	JA	NE
Adjustment coefficient (a_2)	0.180	0.448	0.171	0.613	0.176	0.260	0.206	0.334
	(0.049)	(0.112)	(0.070)	(0.120)	(0.080)	(0.083)	(0.082)	(0.087)
	3.656	3.985	2.446	5.089	2.205	3.127	2.529	3.850
Coefficient of:								
t	0.00196	0.00284	0.00203	0.00892	0.00236	0.00404	0.00485	0.00284
	(0.00058)	(0.00095)	(0.00080)	(0.00173)	(0.00116)	(0.00145)	(0.00179)	(0.00083)
	3.349	2.978	2.529	5.163	2.035	2.785	2.711	3.418
$(t-1)^2 \times 10^{-6\dagger}$	−3.215	2.449	1.293	−1.977	−5.581	−11.474	−2.244	11.646
	(3.389)	(6.089)	(5.283)	(7.316)	(6.748)	(6.440)	(6.043)	(7.465)
	−0.949	0.402	0.245	−0.270	−0.827	−1.782	−0.371	1.560
$\log \theta_{t-1}$	−0.0038	−0.0253	−0.0081	−0.0581	−0.0068	−0.0092	−0.0393	−0.0394
	(0.0052)	(0.0093)	(0.0073)	(0.0168)	(0.015)	(0.0073)	(0.0178)	(0.0138)
	−0.732	−2.717	−1.097	−3.455	−0.456	−1.252	−2.205	−2.862
$\Delta \log \theta_t$	−0.021	−0.047	−0.005	0.038	0.002	0.010	−0.048	−0.027
	(0.011)	(0.018)	(0.016)	(0.021)	(0.026)	(0.014)	(0.018)	(0.016)
	−1.897	−2.602	−0.304	1.823	0.074	0.749	−2.711	−1.672

$\Delta \log \theta_{t-1}$	−0.022	0.025	0.004	0.083	0.013	0.005	0.007	0.035
	(0.011)	(0.017)	(0.015)	(0.026)	(0.020)	(0.015)	(0.020)	(0.019)
	−2.074	1.489	0.273	3.167	0.678	0.333	0.345	1.839
$\Delta \log \theta_{t-2}$	−0.009	0.019	−0.010	0.062	0.022	0.010	0.014	0.018
	(0.010)	(0.016)	(0.015)	(0.024)	(0.019)	(0.015)	(0.018)	(0.018)
	−0.092	1.127	−0.642	2.576	1.187	0.617	0.788	0.967
$\Delta \log \theta_{t-3}$	−0.018	0.007	−0.004	0.009	−0.010	0.001	0.010	0.009
	(0.011)	(0.017)	(0.016)	(0.023)	(0.020)	(0.014)	(0.018)	(0.017)
	−1.650	0.433	−0.260	0.373	−0.492	0.073	0.562	0.534
Long-run oil effect (a_2b_4/a_2)	−0.021	−0.057	−0.047	−0.095	−0.039	−0.035	−0.191	−0.118
$F(5,59)$ statistic§	2.54‡	3.32‡	0.49	4.40#	0.56	0.54	2.27‡	2.38‡
$\bar{R}^2$	0.9984	0.9943	0.9982	0.9976	0.9975	0.9982	0.9994	0.9981
S.E.E.	0.0082	0.0120	0.0121	0.0159	0.0131	0.0120	0.0135	0.0122
h [D-W]††	−0.53	1.10	−3.40	[2.33]	0.26	−2.02	−1.74	1.59

Note. Period: 1971I–76IV. Standard errors are reported in parentheses below coefficient estimates; t statistics are below standard errors. Coefficient estimates for the constant and the aggregate demand shocks ($a_3, \ldots, a_{14}$) are not reported for brevity's sake.

†Note that the coefficients and standard errors in the third row are a multiple 10^6 of those for $(t-1)^2$.

§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 $F > 3.34$.

††The biased Durbin-Watson statistic is reported in square brackets in those cases in which Durbin's h cannot be computed (is imaginary).

Table 8.3 **Implied Estimates of Long-Run Decrease in Real GNP due to 1973I–76IV Increases in Real Price of Oil**

Country	$\frac{d \log q}{d \log \theta}$†	$\log \theta_{1976IV} - \log \theta_{1973I}$	Long-Run Decrease in q§	Rasche-Tatom Long-Run Estimate‡
US	−0.021	1.2119	−2.5%	−7.0%
UK	−0.057	1.2749	−7.3%	−3.5%
CA	−0.047	1.1045	−5.2%	−4.4%
FR	−0.095	1.1477	−10.9%	−4.1%
GE	−0.039	1.1101	−4.3%	−1.9%
IT	−0.035	1.3995	−4.9%	NA
JA	−0.191	1.1402	−21.8%	−17.1%
NE	−0.118	0.9856	−11.6%	NA

†This is the ratio of the estimated values of $a_2 b_4$ to a_2 from table 8.2.
§Product of the previous two columns.
‡From Rasche and Tatom (1980, table 7 for 1973–77 energy-price increases.

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 skepticism, 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 1973I price. The assumed difference in the logarithm of the real price of oil ($\log(\theta/\bar{\theta})$) is plotted in figure 8.5. The dynamic simulations begin in 1973II and continue for six quarters thereafter.[32]

In view of the mixed evidence for direct oil price effects on real income as reported in section 8.2, 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 variables listed in table 8.2 for those five countries for which the oil variables were significant (United States, United Kingdom, France, Japan, and the Netherlands) are added to the real income equations. These five countries are listed with their estimated coefficients in table 8.4. (*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.

32. 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 Mark IV–FLT Model after seven quarters as discussed in chapter 7. 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.

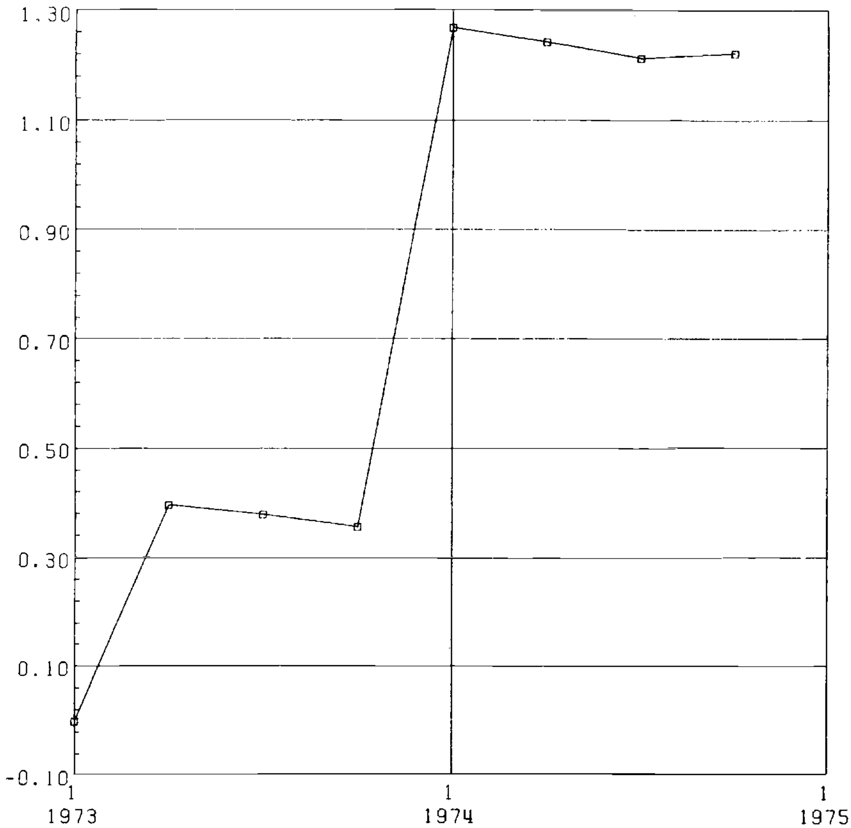

Fig. 8.5 Logarithmic increase in U.S. real price of oil from 1973I.

Figures 8.6 and 8.7 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 8.6 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-1973I price. Figure 8.7 displays the corresponding simulated effects when the Mark IV–Oil Model is used to perform the basic simulations.

Figure 8.6 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.[33] The money

33. Recall that $P = M^s/m^a(y,R)$. Increases in real income tend to raise m^a and hence lower the price level, other things equal. Increases in M^s or in R, on the other hand, tend by themselves to raise the price level.

Table 8.4 **Alternative Real-Income Equations for Mark IV–Oil Model**

a) Equation Form

$$\log y_j = \alpha_{j1} + \alpha_{j2}\log y^P_{j,t-1} + (1-\alpha_{j2})\log y_{j,t-1} + \sum_{i=0}^{3}\alpha_{j,3+i}\hat{M}_{t,t-i}$$
$$+ \sum_{i=0}^{3}\alpha_{j,7+i}\hat{g}_{j,t-i} + \sum_{i=0}^{3}\alpha_{j,11+i}\hat{x}_{j,t-i} + \alpha_{j,20}t + \alpha_{j,21}(t-1)^2$$
$$+ \alpha_{j,22}\log\theta_{j,t-1} + \sum_{i=0}^{3}\alpha_{j,23+i}\log(\theta_{j,t-i}/\theta_{j,j-i-1}) + \epsilon_j$$

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.

b) Coefficients

Coefficient Name	Values by Country (j) US	UK	FR	JA	NE
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
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

Notes. 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 the Netherlands defining their domestic real price of oil as

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

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

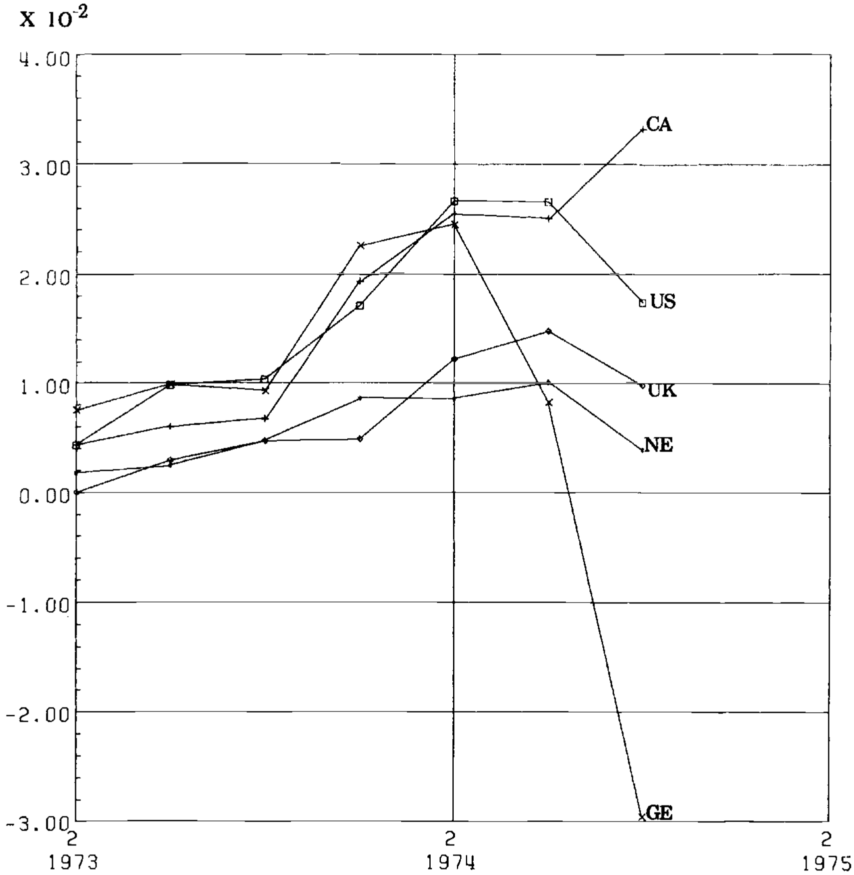

Fig. 8.6 Simulated effects of the 1973–74 increase in the real price of oil using basic Mark IV model.

a) Real income—log y_i

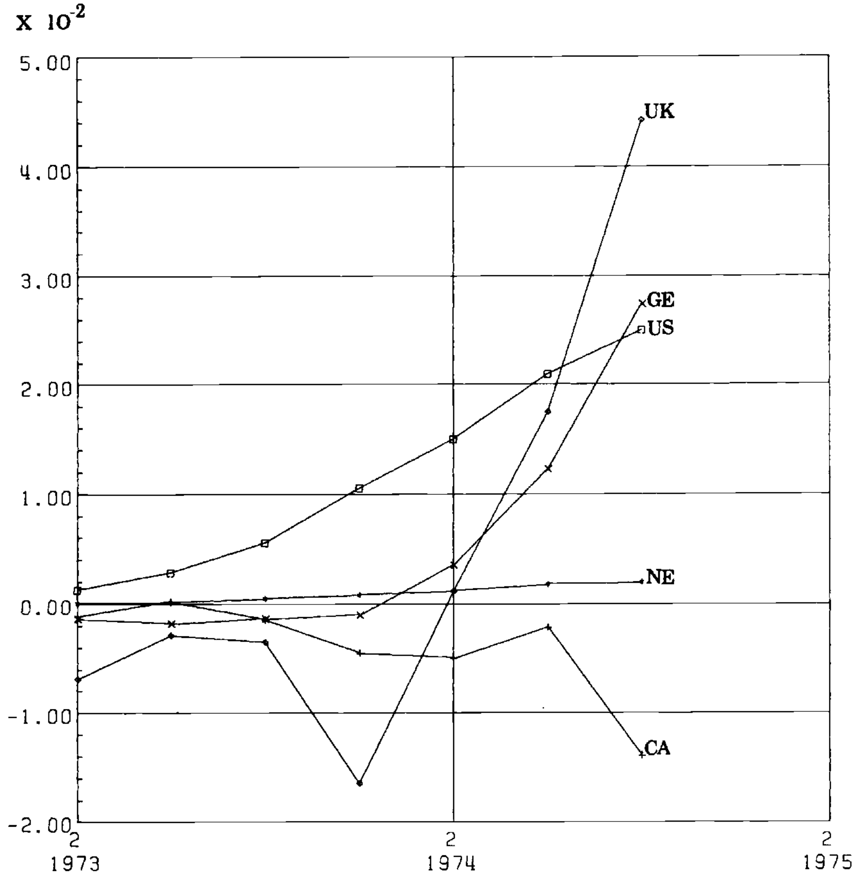

Fig. 8.6 (continued)

b) Price level—log P_i

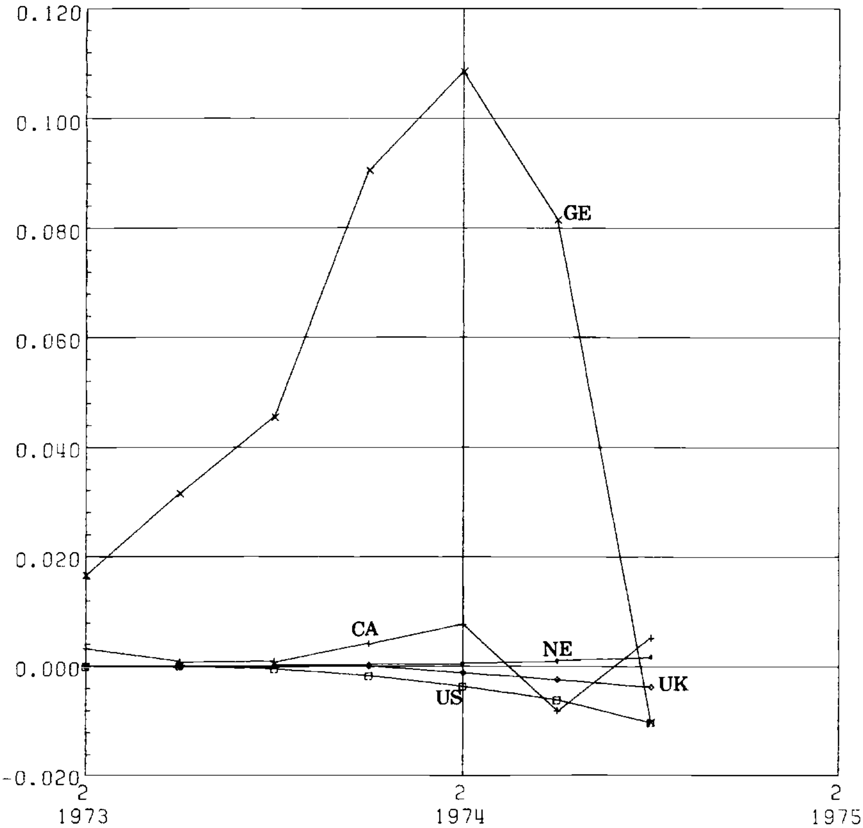

Fig. 8.6 (continued)

c) Nominal money—log M_i

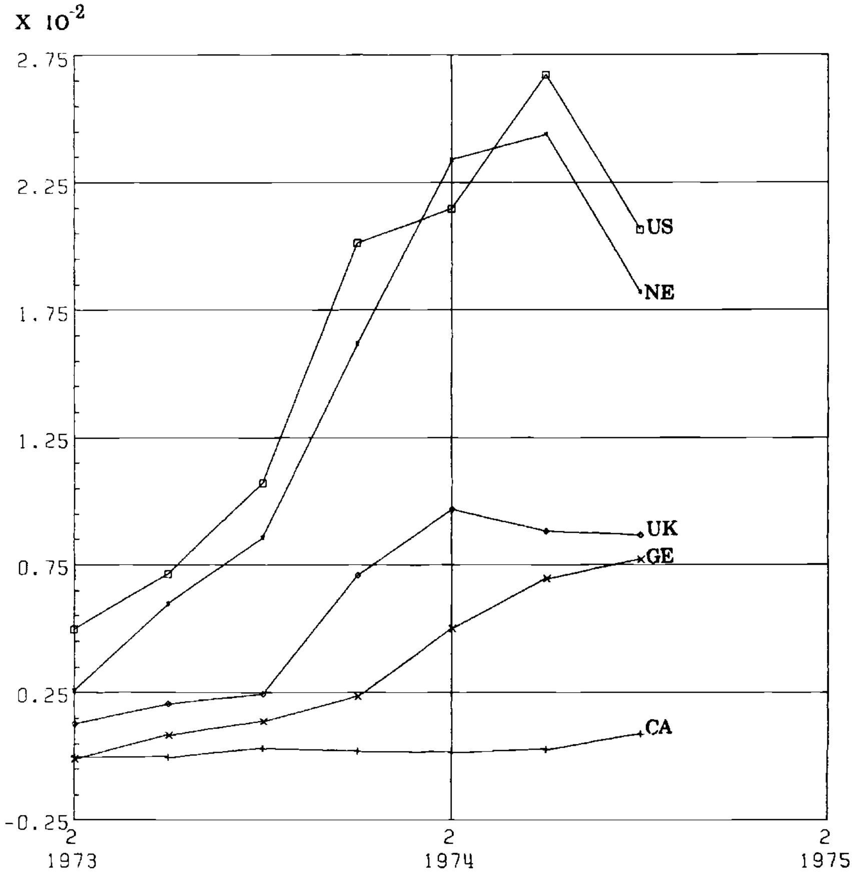

Fig. 8.6 (continued)

d) Short-term interest rate—R_i

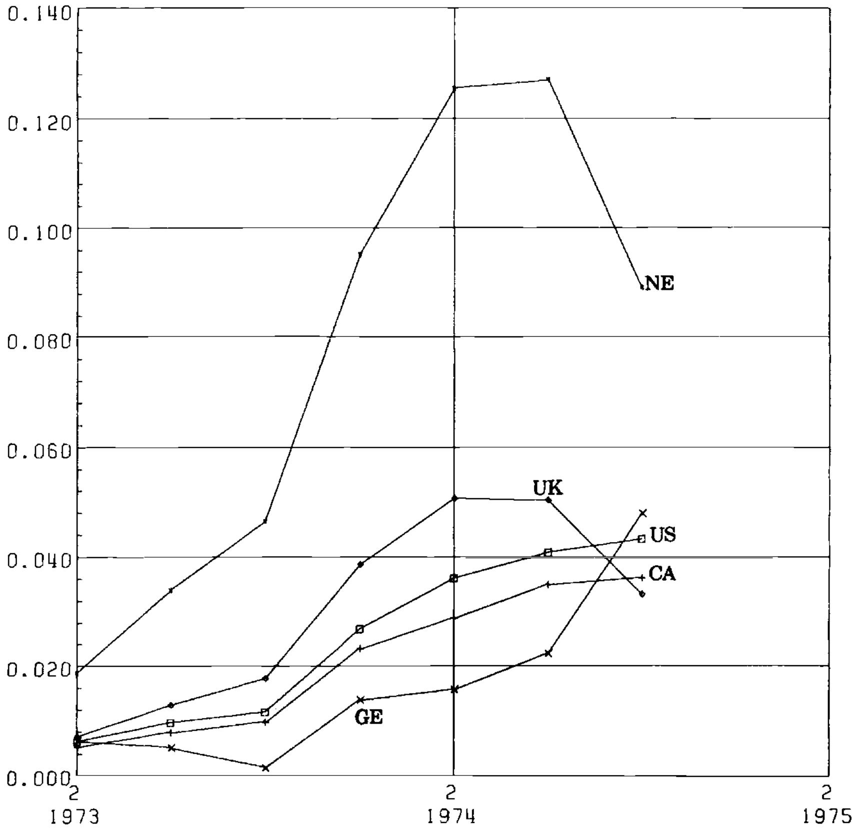

Fig. 8.6 (continued)

e) Scaled exports—$(X/Y)_i$

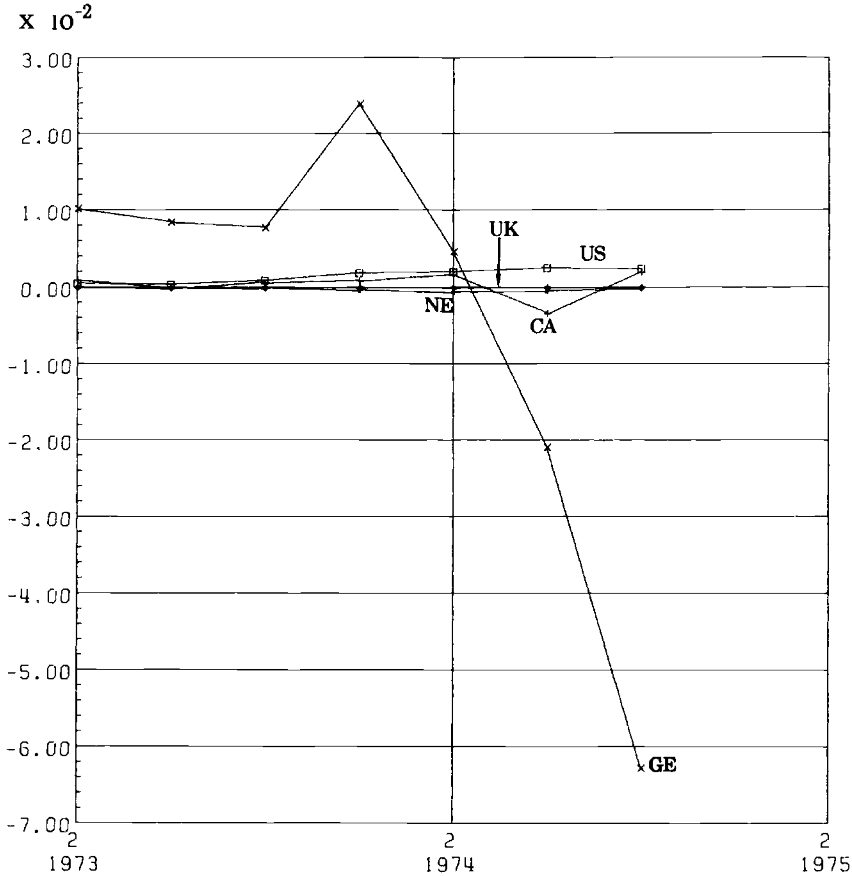

Fig. 8.6 (continued)

f) Scaled balance of payments—$(B/Y)_i$

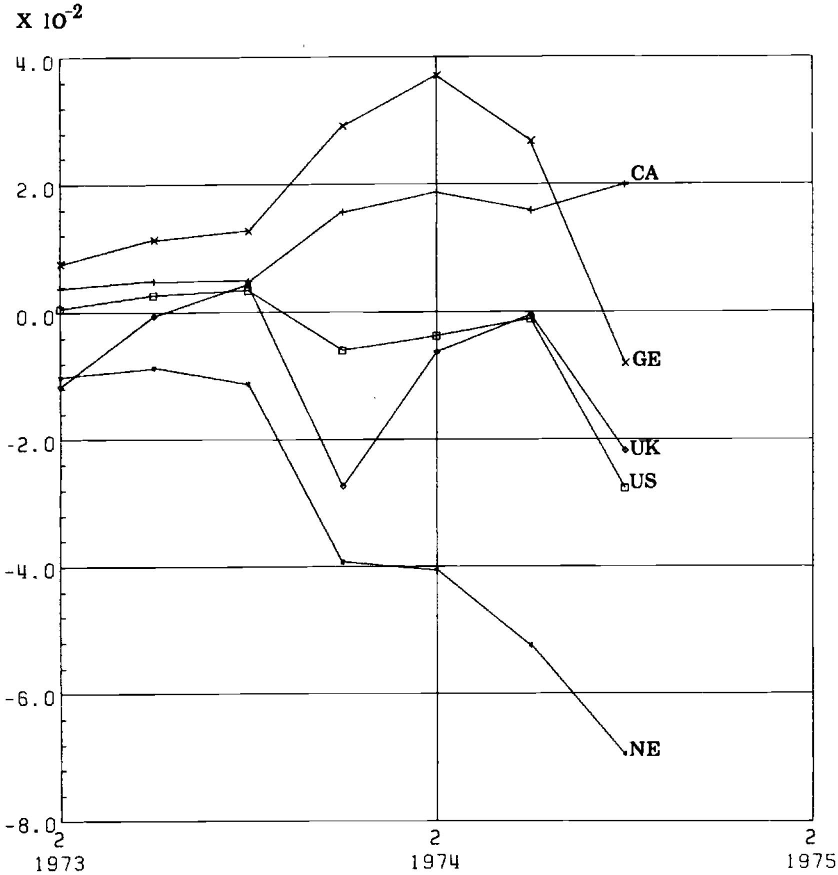

Fig. 8.7 Simulated effects of the 1973–74 increase in the real price of oil using Mark IV oil model.

a) Real income—log y_i

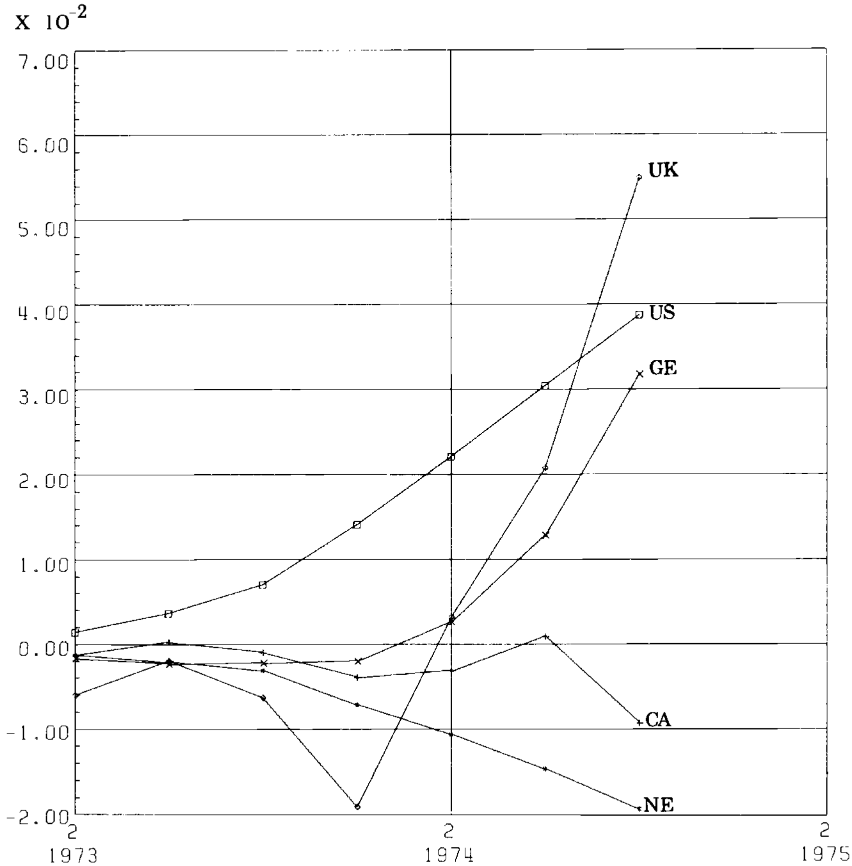

Fig. 8.7 (continued)

b) Price level—log P_i

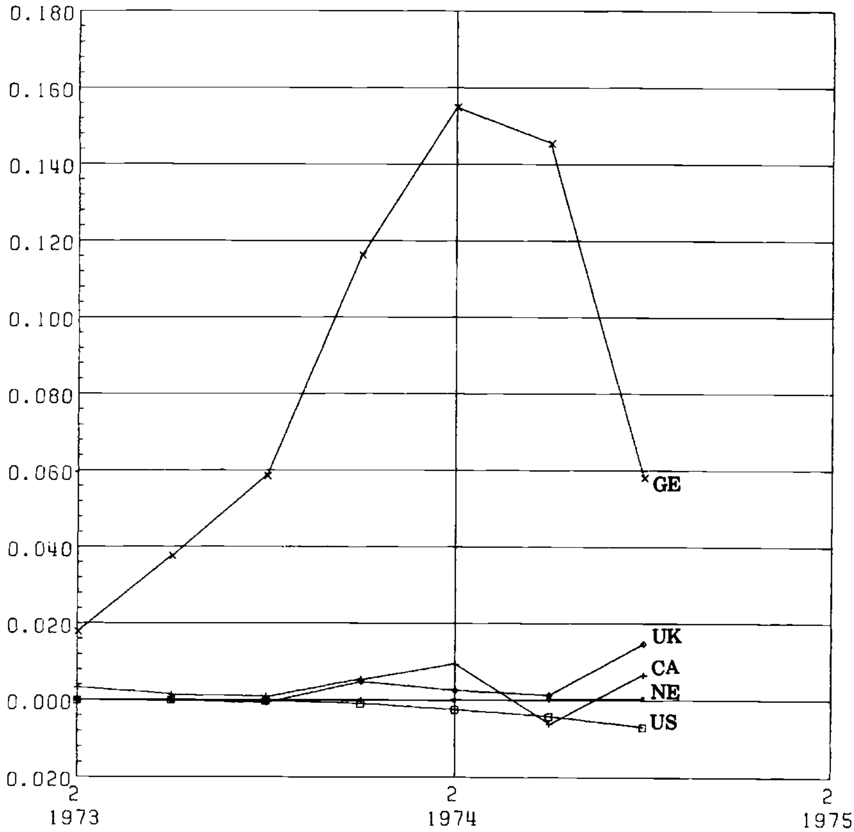

Fig. 8.7 (continued)

c) Nominal money—log M_i

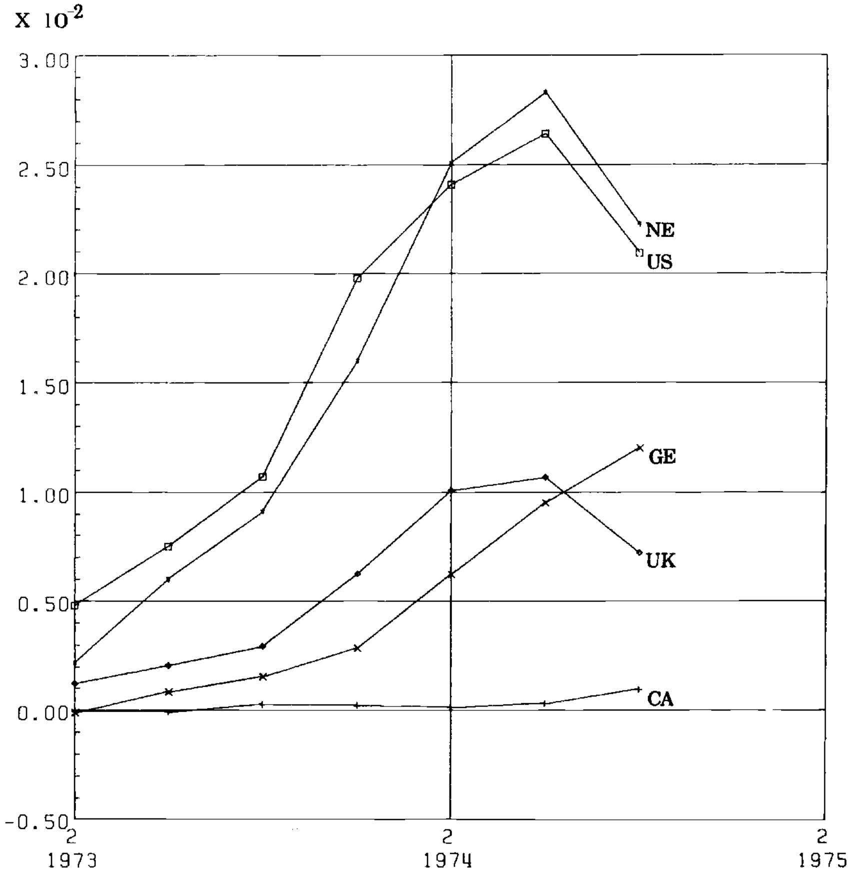

Fig. 8.7 (continued)

d) Short-term interest rate—R_i

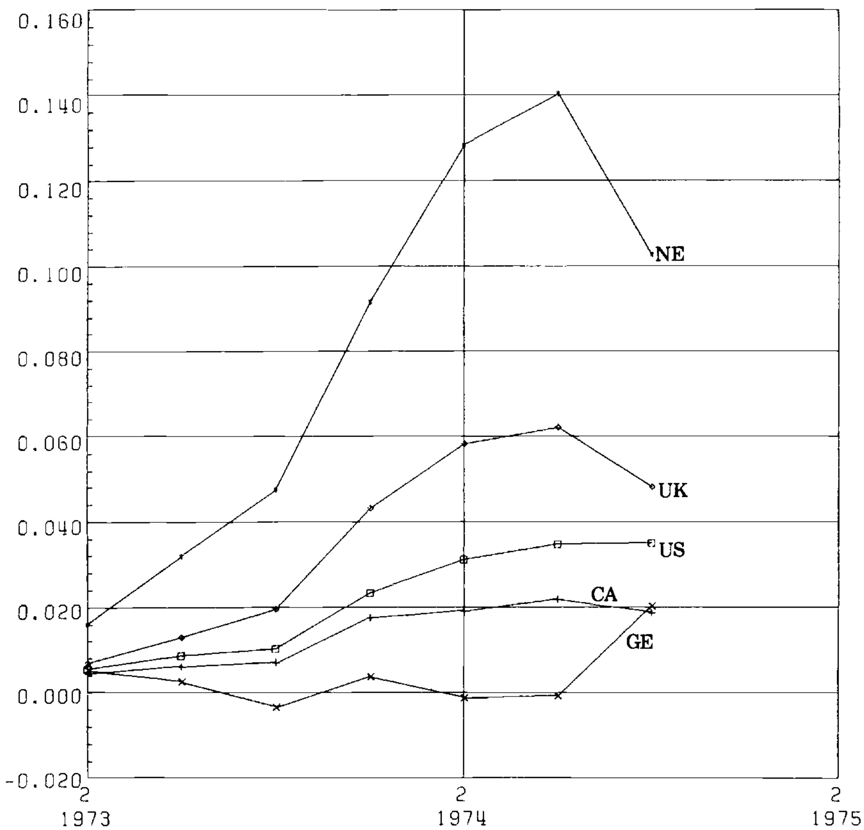

Fig. 8.7 (continued)

e) Scaled exports—$(X/Y)_i$

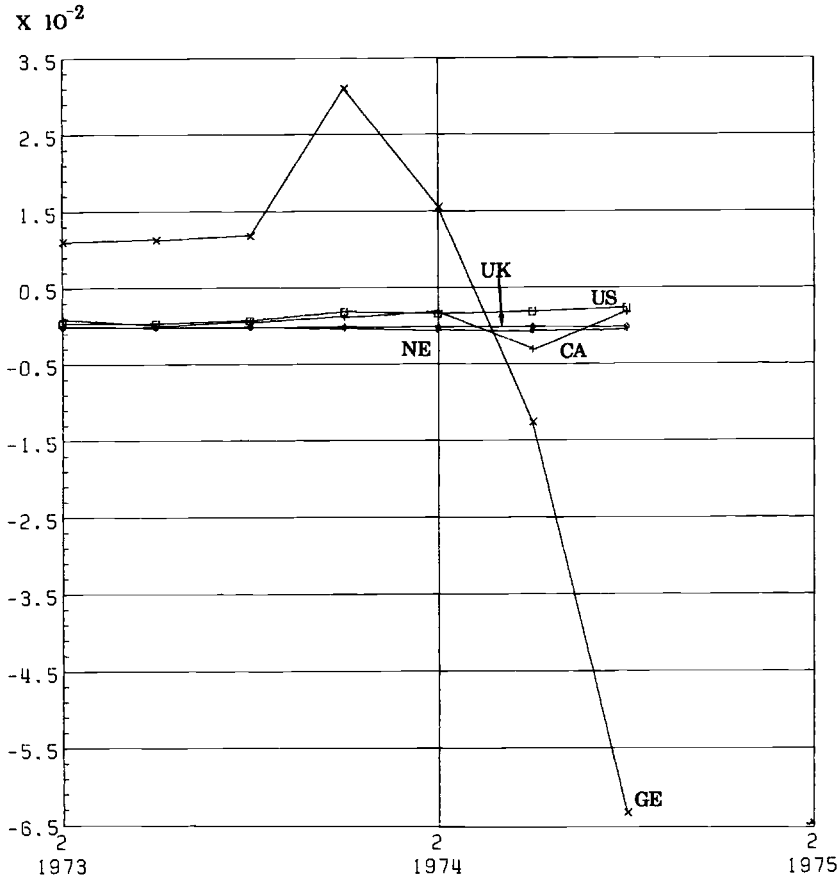

Fig. 8.7 (continued)

f) Scaled balance of payments—$(B/Y)_i$

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 8.7 illustrates just how sensitive the 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.[34] The anomalous 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% 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 1973–74 was identified in section 8.2: 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.

8.4 Conclusions

The effects on real income and the price level of the 1973–74 increases in the real price of oil are subject of strongly held but diverse opinions.[35] Unfortunately the results of this paper indicate that a wide range of opinions is indeed consistent with the data. Perhaps we should not be surprised that with effectively one degree of freedom it is difficult to have much confidence in estimates of both an oil price coefficient and its standard error.

The oil price shock of 1979–80 will provide us data on a second major

34. There is a significant rise in British money because only unemployment and not inflation is important. In the American case these factors are offsetting.

35. Taking two of the best studies for the long-run U.S. real-income effect as examples, Norsworthy, Harper, and Kunze (1979, p. 412) report an average reduction in productivity growth of 0.18% per annum for 1973–78, which implies a total reduction in real income of 0.9%, while Rasche and Tatom (1980), in contrast, as reported in table 8.3, estimate a 7.0% long-run effect.

move in the real price of oil.[36] But these data are unlikely to resolve the empirical question. It seems to me that a more fruitful avenue may be to develop quantitative measures of the biases in official real output data due to price controls and then to see what oil price effects are estimated using these corrected data. This approach is feasible because price controls were generally imposed much before the oil price change. Thus historical relations between labor input, electricity production, carloadings, and other physical unit series can be used to estimate the biases up to the oil price change.

If this chapter has demonstrated that the effects of the real-oil-price increases in 1973–74 remain an open question and thus stimulates research toward answering it, then I will be amply recompensed for having to report such inconclusive conclusions.

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36. When these data for the United States alone were used in Darby (1982), no statistically significant effects of oil prices on real GNP were detected in regressions which also included labor force and price-control variables.

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