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ADJUSTMENT TO EXPECTED AND UNEXPECTED OIL PRICE INCREASES

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ABSTRACT

For oil importers, differences in economic performance after the 1973-74 oil price increase and after the 1979-80 increase can be attributed to a number of factors, including the fact that the 1973-74 oil price increase was unexpected whereas the 1979-80 increase was largely expected.

In this paper, we analyze how an economy's adjustment to expected oil price increases might differ from its adjustment to unexpected increases. By expected oil price increases, we shall mean ones that were anticipated in the past, and by unexpected oil price increases, we shall mean those that were not anticipated in the past but occur unexpectedly in the present. We model this distinction using a three-period model, where the periods are called the past, present and future.

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1. Introduction

For many oil-importing developed economies, the adjustment to the 1973-74 oil price increase and to the 1978-79 increase differed markedly, even though the magnitude of increase relative to the size of their economies was roughly the same in each period.[1] While countries often experienced recession and an acceleration of inflation after each oil price increase, there were noteworthy differences in degree between the two periods. For some, such as Japan, the adverse consequences of the second major oil price increase were much less severe, particularly in the areas of consumer prices, industrial production and employment.[2]

Differences in economic performance in the two periods have been attributed to cyclical factors, industrial restructuring, policy actions, and the willingness of industry and labor to accept the cost of the terms-of-trade decline brought about by higher oil prices.[3] Less attention has been given to the role of expectations as a contributing factor. While there has been some work on the role of expectations in the adjustment process, it has focussed on how adjustment differs when oil price increases are expected to be temporary rather than permanent (e.g. Sachs (1981), Bruno (1982), Svensson and Razin (1982), Svensson (1981), Marion (1981) and Marion and Svensson (1981, 1982)). In comparing the 1973-74 and 1978-79 experience, another distinction merits examination - that between expected and unexpected oil price increases. By <u>expected</u> oil price increases, we shall mean ones that were anticipated in the past, and by <u>unexpected</u> oil price increases, we shall mean those that were not anticipated in the past but occur unexpectedly in the present.[4] The different economic performance after each oil price increase may be due, in part, to the fact that the 1973-74 oil price increase was unexpected, whereas the 1978-79 increase was largely expected.

In this paper, we present a theoretical model which enables us to analyze how an economy's adjustment to expected oil price increases might differ from its adjustment to unexpected increases.

A priori, it seems that with expected oil price increases, the adjustment can start in the past and be spread out over time. With unexpected increases, there can be no adjustment in the past, so all of the adjustment must take place in the present and the future. Nevertheless, while the need to adjust in the present may be larger for unexpected price increases, the capacity to adjust may be less, since we might expect more rigidity and less substitution possibilities in the present in the face of unexpected price increases.

We shall model some of these aspects rigorously in a three-period model, where the periods are called the past, present and future. We shall calculate changes in output, oil imports, consumption, investment, welfare, the trade balance and the current account of a small oil-importing economy when there are present and future oil price increases, in one case when these are anticipated in the past, in the other when they are not.

The following results are derived under the assumption that oil and capital are "cooperative" factors:

First, if wages are flexible and there is full employment, current domestic product falls less for unexpected oil price increases than for expected increases. The reason is that with unexpected oil price increases, firms have no opportunity to reduce past investment and hence they operate in the present with a relatively larger capital stock. This outcome illustrates that firms have less substitution possibilities in the short run.

Both present consumption and investment fall more with unexpected oil price increases, loosely speaking because the necessary downward adjustment of consumption and investment takes place only in the present and future but not in the past.

It follows that unexpected oil price increases cause a smaller deterioration in the trade balance than expected increases. However, they don't necessarily cause a smaller current-account deficit. This is because expected oil price increases stimulate greater saving in the past and hence lead to a larger service-account surplus in the present.

Second, if real wages are predetermined so that full employment results if previous expectations are fulfilled, then full employment will be maintained only for expected oil price increases. For unexpected increases, there will be a fall in present employment if labor and oil are cooperative factors. This drop in employment causes an additional drop in present domestic product. It no longer follows that the fall in present domestic product is unambiguously smaller or that the trade deficit deteriorates less for unexpected oil price increases than for expected increases. In fact, if the employment effect is large enough, the opposite may be true. This case may be more in keeping with the experience of 1973-74, when real-wage adjustment was sluggish.

The paper is organized as follows. Section 2 develops the model. Section 3 compares the economy's response to expected and unexpected oil price increases. Section 4 shows how the comparative results are modified when there are predetermined real wages and the possibility of less than full employment. Section 5 contains concluding remarks and possible extensions.

2. The Model

Consider a small open economy in an intertemporal framework. There are three periods, indexed t = 0, 1 and 2, called the past, present and future, respectively. In each period the economy produces final goods, using domestic capital and labor and an imported intermediate input called oil. There is no domestic oil production. Oil and final goods are traded on the world market in each period at given relative prices. There is a world credit market where the country can borrow and lend at given world rates of interest.

Let the production function in period t be $x^t = f^t(k^t, z^t)$, where x^t is output of final goods, k^t is the capital stock, and z^t is imported oil We suppress the labor input, implicitly assuming full employment of a fixed supply of labor. In Section 4 we relax this assumption in order to deal with predetermined wages and variable employment. We assume that the production function is strictly concave in the two remaining arguments. We define the Domestic Product (DP) function for each period as $Y^t(1, q^t, k^t) = \max\{x^t - q^t z^t: \ x^t = f^t(k^t, z^t)\}$, where q^t is the spot price of oil in terms of final goods in period t. The first argument of the DP function, the price of final goods, is set equal to unity since we shall use final goods as numeraire. The DP function has the standard properties that equilibrium final goods output and oil imports are given by

$$x^t(1, q^t, k^t) = Y_1^t(1, q^t, k^t) \text{ and}$$

(2.1)

$$z^t(1, q^t, k^t) = -Y_q^t(1, q^t, k^t),$$

where Y_1^t and Y_q^t denote the partials of the DP function with respect to the price of final goods and oil, respectively.

Final goods can be invested in period t in order to augment the capital stock in period t + 1, i.e.

(2.2) $$k^{t+1} = k^t + i^t,\ t = 0 \text{ and } 1,$$

where i^t is investment in period t. No investment takes place in the future. Let δ^o denote the present value of past final goods and δ^2 the present value of future goods.[5/] The equilibrium investment levels will maximize the present value of domestic product, net of investment, and hence solve the problem

$$\max\{\delta^o Y^o(1, q^o, k^o) - \delta^o i^o + Y^1(1, q^1, k^o + i^o) - i^1 + \delta^2 Y^2(1, q^2, k^o + i^o + i^1)\}.$$

The maximization gives the first order conditions

(2.3) $$Y_k^1(1, q^1, k^o + i^o) = \delta^o - 1 \text{ and}$$

(2.4) $$\delta^2 Y_k^2(1, q^2, k^i + i^1) = 1,$$

where Y_k^t is the partial of the DP function with respect to the capital stock, i.e. the value of the marginal product of capital.[6/] The solutions to (2.3) and (2.4) give the investment functions $I^t(q^{t+1}, k^t)$ for t = 0 and 1, where we have suppressed the present value factors δ^o and δ^2 since they will be unchanged in the following analysis.

This completes the discussion of the supply side. Let us now deal with demand. With regard to welfare and consumption, the economy is represented by a utility function $U(c^o, c^1, c^2)$, where c^t denotes consumption of final goods in period t. The corresponding (present value) expenditure function is defined as $E(\delta^o, 1, \delta^2, u) = \min\{\delta^o c^o + c^1 + \delta^2 c^2: U(c^o, c^1, c^2) \geq u\}$. Equilibrium consumption is given by

$$c^t = E_t, \quad t = 0, 1 \text{ and } 2, \tag{2.5}$$

where E_t denotes the partial of the expenditure function with respect to the present value price of goods in period t.

The intertemporal budget constraint of the economy can now be expressed as 7/

$$E(\delta^o, 1, \delta^2, u) + \delta^o I^o(q^1, k^o) + I^1(q^2, k^1) = \delta^o Y^o(1, q^o, k^o) + Y^1(1, q^1, k^1) + \delta^2 Y^2(1, q^2, k^2), \tag{2.6}$$

where the capital stocks fulfill

$$k^{t+1} = k^t + I^t(q^{t+1}, k^t) \text{ for } t = 0 \text{ and } 1. \tag{2.7}$$

Equation (2.6) states that the present value of expenditure on consumption and investment equals the present value of domestic product. It can be taken as expressing the welfare level u as an implicit function of the initial capital stock, k^o, the oil prices in the three periods, q^o, q^1 and q^2, and the present value factors, δ^o and δ^1. The level of welfare can be substituted into (2.5) to give the equilibrium levels of consumption. The equilibrium level of final goods output, oil imports and investment are given by (2.1) and the investment functions. Hence for a predetermined past capital stock and exogenously given oil prices and discount factors, the equilibrium of the small open economy is fully determined.

The equilibrium can be interpreted as a perfect foresight equilibrium over time. Equivalently, it can be viewed as a sequence of temporary equilibria, where variables referring to later periods are perfect foresight expectations and plans. We shall examine how the perfect foresight equilibrium varies with a change in oil prices.

First, we consider an initial equilibrium (over time), with given oil prices q^o, q^1 and q^2. Next, we consider the effects of an oil price increase in the present and the future, i.e. a permanent oil price increase, with $dq^1, dq^2 \geq 0$. We assume initially that this oil price increase is anticipated in the past. We analyze how this expected increase changes the endogenous variables relative to the initial equilibrium. In particular, we are interested in how expected oil price increases affect the small economy's welfare and how they change domestic product, oil imports, investment and consumption in the present period. We are also interested in how the present trade balance and current account respond. To calculate these changes, we merely differentiate the equilibrium conditions.

We also wish to compare these changes to those which occur when oil price increases are unexpected, i.e. not anticipated in the past. In this case, agents in the past expect present and future oil prices to equal q^t, $t = 1, 2$. As they enter the present, they learn that $dq^t > 0$, $t = 1, 2$. We represent this case by a temporary equilibrium in the present, conditional upon past values of production, investment and consumption, x^o, i^o, c^o.

We define the conditional expenditure function as $\tilde{E}(1, \delta^2, u; c^o) = \min \{c^1 + \delta^2 c^2: U(c^o, c^1, c^2) \geq u\}$ the minimum present value of present and future consumption required to reach a given welfare level, conditional upon given past consumption. Then the budget constraint for the present and future periods, given the variables in the past, can be written as

$$\tilde{E}(1, \delta^2, u; c^o) + I^1(q^2,k^1) =$$

(2.8) $$Y^1(1, q^1,k^1) + \delta^2 Y^2(1, q^2, k^2) + \delta^o T^o,$$

where

$$k^1 = k^o + I^o \text{ and}$$

$$k^2 = k^1 + I^1(q^2,k^1).$$

It states that the present value of expenditure on consumption and investment in the present and the future equals the present value of present and future domestic product plus $\delta^o T^o$. The term $\delta^o T^o$ is the present value of the past trade balance and is equivalent to the accumulation of net foreign assets at the beginning of the present period plus repatriated interest income.[8/] Given unexpected oil price increases, changes in the endogenous variables relative to the initial equilibrium can now be derived by differentiating the relevant equilibrium conditions.

In the next section, we examine the changes in various endogenous variables for the case where oil prices are expected and for the case where they are not, and we compare the two cases.

3. Expected versus Unexpected Oil Price Increases

In this section, we compare the effects of expected and unexpected oil price increases on domestic product, output, oil imports, investment, welfare and consumption. We also compare their effects on the present trade balance and current account.

Domestic product, output and oil inputs

First, let us compare the response of current domestic product to expected and unexpected oil price increases. Differentiating the DP function, we find that the change in domestic product given an expected increase in oil prices is

$$(3.1)\qquad dY^1 = -z^1 dq^1 + Y^1_k dI^o < 0.$$

The first term on the right-hand side of (3.1) represents a negative oil terms of trade effect. The second term is the effect of a change in past investment on present domestic product, with

$$(3.2)\qquad dI^o = I^o_q dq^1.$$

Assuming that oil and capital are "cooperative" factors,[9] which occurs if $f^t_{kz} > 0$, the partial I^o_q is negative; firms desire a smaller present capital stock in light of higher oil prices and reduce their past investment plans accordingly. The drop in past investment as well as the negative terms of trade effect cause a fall in present domestic product.

The change in current domestic product due to an unexpected oil price increase is

$$(3.3)\qquad d\tilde{Y}^1 = -z^1 dq^1 < 0,$$

where tildes over differentials or partials denote that they are conditional upon given past variables. Now the drop in domestic product is due to the negative terms of trade effect only. Since firms did not anticipate the oil price increase prior to period 1, they had no opportunity to reduce past investment. It follows that the fall in current domestic product is less for unexpected oil price increases, i.e.

(3.4) $dY^1 < d\tilde{Y}^1 < 0.$

Of course, this outcome depends on three factors. First, oil and capital are cooperative inputs, so that firms will reduce past investment if they anticipate oil price increases. Second, firms utilize the entire inherited capital stock in production even if for unexpected oil price increases the _ex post_ marginal product of capital, Y_k^1, is less than the real interest rate, r^o. Since firms have already purchased the present capital stock, they will find it optimal to fully utilize it as long as its marginal product is positive.[10/] Third, full employment of labor is maintained. In Section 4 we find that pre-set wage contracts introduce employment effects which modify the outcome in (3.4).

We next compare the responses of current output and oil inputs to expected and unexpected oil price increases. From (2.1) we get the change in present output and oil inputs given an expected oil price increase:

(3.5) $$dx^1 = x_q^1 dq^1 + x_k^1 dI^o < 0, \text{ and}$$

$$dz^1 = z_q^1 dq^1 + z_k^1 dI^o < 0.$$

The first term on the right-hand side of each equation represents the negative substitution effect of higher oil prices.[11/] The second term is the negative effect of lower past investment.

When oil price increases are unexpected, there is no change in past investment. The fall in present output and oil inputs reflects only the negative substitution effect, with

$$(3.6) \qquad d\tilde{x}^1 = x_q^1 dq^1 < 0, \text{ and}$$

$$d\tilde{z}^1 = z_q^1 dq^1 < 0.$$

Although firms find themselves in the present period with more capital than they would have liked had they known of the forthcoming oil price increases, they nevertheless find it optimal to utilize it fully. Therefore they end up producing relatively more output and using relatively more oil inputs in the present when oil price increase are unexpected. Essentially firms have less room for substitution in the present, given the capital stock inherited from the past.

Investment

For expected oil price increases, the change in present investment is

$$(3.7) \qquad dI^1 = I_q^1 dq^2 + I_k^1 dk^1 = I_q^1 dq^2 - dI^o \gtrless 0.$$

The first term represents the change in present investment due to an increase in future oil prices. When oil and capital are cooperative in future production, firms will desire a smaller future capital stock and so invest less today; $I_q^1 dq^2 < 0$. The second term represents an increase in present investment due to an increase in present oil prices. Since the increase in present oil prices lowers past investment but does not change the optimal future capital stock, it leads to an equal and offsetting change in present investment, i.e. $I_k^1 = -1$. It appears that present investment may either increase or decrease in response to expected oil price increases. Of course, on net, investment falls over the past and present, since $dI^o + dI^1 < 0$, and the smaller the adjustment in the past, the more likely that investment will have to fall in the present.

For unexpected oil price increases, the change in present investment is

$$(3.8) \qquad d\tilde{I}^1 = I_q^1 dq^2 < 0.$$

Present investment unambiguously falls. There is no offsetting change in past investment, in contrast to the case with expected oil price increases.

Comparing (3.7) and (3.8) we see that if present investment falls in both cases, it falls relatively less when oil prices are expected. This is because firms can react to expected increases by spreading the drop in investment spending over the past and present. With unexpected oil price increases, firms must make all of the adjustment in the present.

Welfare

We now compare the welfare effects of expected and unexpected oil price increases. Differentiating (2.6) and making use of (2.1), (2.3)-(2.5) and (2.7), we get du, the change in welfare for an expected oil price increase. We find that

$$(3.9) \qquad E_u du = -z^1 dq^1 - \delta^2 z^2 dq^2 < 0,$$

where E_u is the partial of the expenditure function with respect to the welfare level and represents the inverse of the marginal utility of wealth. Equation (3.9) indicates that the small country faces a negative oil terms of trade effect in the present and in the future and consequently suffers a welfare loss when oil prices increase.

The change in welfare brought about by an unexpected oil price increase, $d\tilde{u}$, can be calculated by differentiating (2.8), which gives

$$\tilde{E}_u d\tilde{u} = -z^1 dq^1 - \delta^2 z^2 dq^2 < 0. \tag{3.10}$$

As before, the welfare effect consists of the oil terms of trade effects, although the inverse of the marginal utility of wealth is evaluated conditional upon a given past consumption. It turns out that the inverse is the same in both cases, i.e. $E_u = \tilde{E}_u$,[12/] so the first-order effects on welfare are the same for expected and unexpected oil price increases. That is,

$$du = d\tilde{u} < 0. \tag{3.11}$$

The second-order effects on welfare are different, of course, and inclusion of the second-order effects would make the total welfare loss from unexpected oil price increases larger than for expected oil price increases. However, taking these second-order effects into account would not change qualitatively any of our comparative results. Thus we limit ourselves to first-order effects in the analysis.[13/]

Consumption

When oil price increases are expected, the change in present consumption is

$$dc^1 = C_W^1 E_u du < 0, \tag{3.12}$$

which is equal to the welfare effect (3.9) times the marginal propensity to consume present goods out of wealth.[14/] Since oil prices reduce welfare, they lower present consumption.

For unexpected oil price increases, we find

$$(3.13) \qquad d\tilde{c}^1 = \tilde{C}_W^1\tilde{E}_u d\tilde{u} < 0.$$

Comparing (3.13) with (3.12) and recalling that $E_u du = \tilde{E}_u d\tilde{u}$, we find that

$$(3.14) \qquad d\tilde{c}^1 - dc^1 = (\tilde{C}_W^1 - C_W^1)E_u du.$$

In the absence of any particular reason for households to favor consumption in any one period over any other, the conditional marginal propensity to consumer should be larger than the unconditional since with the former, households had no opportunity to adjust their spending in the past. [15] It follows that $\tilde{C}_W^1 > C_W^1$ and the fall in consumption is greater for unexpected oil price increases. Although we shall take this to be the case, the opposite outcome is certainly plausible. For instance, if consumption adjusts with some inertia, then the fall in present consumption could be less with unexpected oil price increases.

The Trade Balance and the Current Account

Since we have already compared the effects of expected and unexpected oil price increases on domestic product, investment and consumption, it is a straightforward exercise to compare their effects on the present trade balance and current account.

The present trade balance is simply

$$(3.15) \qquad T^1 = Y^1 - E_1 - I^1 = x^1 - q^1 z^1 - c^1 - i^1,$$

the difference between domestic product and expenditure on consumption and investment. [16]

If we add to both sides of (3.15) net interest income from abroad earned during the past, r^oT^o, we get the present current account,

$$(3.16) \qquad b^1 = T^1 + r^oT^o = [(x^1 - q^1z^1 + r^oT^o) - c^1] - i^1,$$

which is the difference between national product, $x^1 - q^1z^1 + r^oT^o$, and absorption, $c^1 + i^1$, or equivalently, the difference between national saving $[(x^1 - q^1z^1 + r^oT^o) - c^1]$ and investment, i^1.

To calculate the change in the present trade balance when there are expected oil price increases, we differentiate (3.15). We get

$$(3.17) \qquad dT^1 = dY^1 - dE_1 - dI^1,$$

where dY^1, dE_1 and dI^1 are given by (3.1), (3.12) and (3.7), respectively. Expected oil price increases reduce present domestic product, which worsens the trade balance, but they also reduce present consumption and may, under previously specified circumstances, reduce investment as well. Any drop in absorption improves the trade balance.[17/]

For unexpected oil price increases, we again differentiate (3.15) in order to calculate the trade balance response,

$$(3.18) \qquad d\tilde{T}^1 = d\tilde{Y}^1 - d\tilde{E}_1 - d\tilde{I}^1,$$

where $d\tilde{Y}^1$, $d\tilde{E}_1$ and $d\tilde{I}^1$ are given by (3.3), (3.13) and (3.8), respectively.

Comparing the trade balance response for expected and unexpected oil price increases, we find that

$$(3.19) \qquad d\tilde{T}^1 - dT^1 = -Y^1_k dI^o - (\tilde{C}^1_W - C^1_W)E_u du - dI^o > 0,$$

Equation (3.19) indicates that, under full employment, the present trade deficit (surplus) is unambiguously smaller (larger) for unexpected oil price increases than for expected oil price increases. The first term on the right-hand side of (3.19) is the investment effect on domestic product. With unexpected oil price increases there is no fall in past investment, so present domestic product is relatively higher. This helps make the trade deficit smaller for unexpected oil price increases. The second and third terms are the consumption and investment effects, respectively, and we have already noted that present consumption and investment fall more for unexpected oil price increases since there was no adjustment in the past. Since unexpected oil price increases reduce domestic product less and reduce absorption more than expected oil price increases, they cause a smaller deterioration in the trade balance.

The same cannot be said for the current account. While unexpected oil price increases cause a smaller deterioration in the trade balance, expected oil price increases generate more improvement in the service account. Therefore unexpected oil price increases may cause either a larger or smaller current-account deficit (surplus) than expected oil price increases.

Specifically, oil price increases which occur in the present and the future have no effect on past output, but if they are expected, they do permit households and firms to begin reducing their consumption and investment in the past. Hence the country saves more in the past and receives a greater inflow of interest income in date 1.[18/] These additional interest income inflows do not take place if oil price increases are unexpected. Comparing the current-account response in the two cases, we find that

$$(3.15) \qquad d\tilde{b}^1 - db^1 = (d\tilde{T}^1 - dT^1) - r^o dT^o \gtrless 0,$$

where $dT^o = -C_W^o E_u du - dI^o > 0$. As (3.15) makes clear, expected oil price increases cause relatively greater trade deficits but relatively greater service-account surpluses, so we cannot say anything definitive about the relative current-account response to expected versus unexpected oil price increases without more information on specific parameter values.

Table 1 summarizes our results. It shows that the small economy responds differently to expected and unexpected oil price increases. All of the comparisons are made on the assumptions that oil and capital are co-operative factors and that labor is fully employed. In the next section, we show how the existence of pre-set wage contracts can modify these results.

Table 1

Impact	Expected	Unexpected
dY^1	– –	–
dx^1	– –	–
dz^1	– –	–
dI^1	–/+	– –
du	–	–
dc^1	–	– –
dT^1	– –/+	–/++
db^1	?	?

4. Predetermined real wages and employment effects

We shall now consider a situation in which a period's real wage is set in the previous period so as to equate expected labor demand to labor supply. This modification does not change our prior analysis concerning the effects of expected oil price increases since full employment of labor results when the previous period's expectations about oil prices are fulfilled. However, for unexpected oil price increases, the predetermined real wage for period 1 ensures full employment only if oil prices are unchanged. When oil prices unexpectedly increase, employment in date 1 falls. This employment effect leads to a greater drop in domestic product, output, oil inputs, welfare and consumption. It is then no longer true that unexpected oil price increases cause a smaller drop in output, oil inputs and the trade balance than do expected increases.

More precisely, let the production function be $x^t = f^t(k^t, \ell^t, z^t)$, where the labor input is explicitly introduced and ℓ^t is the fixed full-employment labor supply. The DP function will be $Y^t(1, q^t, k^t, \ell^t)$ and the real wage in period t, w^t, will be set in period t - 1 so that

$$(4.1) \qquad w^t = Y^t_\ell(1, q^t, k^t, \ell^t),$$

where Y^t_ℓ is the partial of the DP function with respect to the labor input and equal to the demand price for labor. [19] Note that the oil price q^t is now the oil price expected in period t - 1 to rule in period t. Equation (4.1) can be used to solve for the labor input as a function of the other variables, giving the employment function $L^t(1, q^t, k^t, w^t)$. Actual employment in period t is now a function of the actual oil price in period t.

For unexpected oil price increases, the present employment level will fall by

$$(4.2) \qquad d\tilde{\ell}^1 = L^1_q dq^1 < 0,$$

where the partial L^1_q is negative if labor and oil are cooperative factors. [20]

There is no reduction in employment in the future since future oil price increases are anticipated when wage contracts are negotiated in the present.

The employment effect alters the analysis of unexpected oil price increases. For instance, their effect on domestic product is now

$$(4.3) \qquad d\tilde{Y}^1 = -z^1 dq^1 + w^1 d\tilde{\ell}^1 < 0.$$

The drop in domestic product is now larger due to the fall in employment. It no longer follows that domestic product always falls less for unexpected oil price increases than for expected ones.

Analogously, the adjustment of present output and oil inputs for unexpected oil price increases will be

$$(4.4) \qquad d\tilde{x}^1 = x_q^1 dq^1 + x_\ell^1 d\tilde{\ell}^1 < 0 \text{ and}$$

$$d\tilde{z}^1 = z_q^1 dq^1 + z_\ell^1 d\tilde{\ell}^1 < 0,$$

which now take account of employment effects. It doesn't follow that present output and oil inputs fall less for unexpected than for expected oil price increases.

Furthermore, the welfare effect is now [21/]

$$(4.5) \qquad \tilde{E}_u d\tilde{u} = -z^1 dq^1 - \delta^2 z^2 dq^2 + w^1 d\tilde{\ell}^1.$$

The fall in welfare will now be larger for unexpected oil price increases due to the fall in domestic product caused by reduced employment.

It also follows that when wages are predetermined and employment can vary, the trade deficit is no longer unambiguously smaller for unexpected than for expected oil price increases. Unexpected oil prices still reduce present absorption more, but it is not clear whether they now reduce domestic product less than expected oil price increases.

5. Conclusions

We have rigorously modeled the adjustment of a small oil-importing country to expected and unexpected oil price increases. For expected present and future oil price increases - expected in the sense of being anticipated in the past - we have seen that the adjustment of investment and consumption begins in the past, whereas with unexpected oil price increases, all adjustments must take place in the present and future. Regarding output and oil inputs, we have seen that there are less substitution possibilities with unexpected oil price increases than with expected, since firms must operate with a predetermined, larger-than-desired capital stock when faced with unexpected oil price increases. Consequently, output and oil inputs fall less with unexpected oil price increases. However, with predetermined real wages, unexpected oil price increases lead to a fall in employment which adds to the drop in output and oil inputs. With regard to the present trade balance, we have seen that under full employment it deteriorates less for unexpected oil price increases since domestic product falls less and consumption and investment may have to fall more. With predetermined wages, unexpected oil price increases reduce employment and hence cause a greater deterioration in the trade balance. If the employment effect is large enough, unexpected oil price increases can now cause a larger fall in the trade account than expected price increases. With respect to the present current account, we have seen that both under full employment and variable employment the current account balance may change more or less with unexpected oil price increases than with expected increases. But if the employment effect is sufficiently large, unexpected oil price increases will cause the greater deterioration in the current account.

Let us add some qualifications of these results. First, it is clear than an oil-producing economy, or an economy producing investment goods for the (world) oil industry, would react differently, even if it imported some of its oil. The boom in the oil industry or the oil-investment industry brought about by higher oil prices could dominate the fall in output in sectors that use oil as an input only.

Second, we have generally assumed that the present period's marginal propensity to consume conditional upon unchanged past consumption is larger than the unconditional one, which makes present consumption fall more for unexpected oil price increases. If, as previously mentioned, consumption adjusts with some inertia, the present conditional propensity to consume would be smaller than the unconditional one. This ordering would occur if, for instance, household consumption is complementary with some household investment in the previous period, a situation which could be modeled using a consumption technology with a household production function.

Third, with respect to predetermined real wages, we have assumed that the lead time in wage determination is the same as the information lead, so that full employment is maintained for expected oil price increases. If the lead time in wage determination is longer, unemployment would occur with expected oil price increases as well as with unexpected ones. A rigorous analysis would require more periods on continuous time.

Finally, we have modeled a small economy facing given world rates of interest. A world equilibrium analysis with endogenous rates of interest could easily be undertaken along the lines of Marion and

Svensson (1981) in order to examine the general-equilibrium effects of expected vs. unexpected oil price increases. One issue that might be of interest is whether the present rate of interest is depressed more or less by unexpected than expected oil price increases and whether any fall in the rate of interest is temporary or permanent.

Footnotes

We are grateful for comments by participants in an IIES seminar, especially those by Avinash Dixit and Bill Ethier.

1. Following R. Solomon (1980), we may take the size of the OPEC surplus on current account as a measure of the contractionary effect on the rest of the world of an increase in oil prices. The $110 billion increase in the OPEC surplus from 1978-80 was about the same magnitude, relative to the GNP of the industrial world, as the $60 billion increase from 1973 to 1974. Alternatively, one can calculate the percentage increase in the average dollar price of a country's crude oil imports between 1973-75 and between 1978-80 and calculate the increase in a country's petroleum imports as a fraction of GNP to see that for a number of countries, the magnitude of increase was about the same in each period. For a rigorous theoretical analysis of the general equilibrium effects on the rest of the world of oil price increases, see Marion and Svensson (1981).

2. See OECD Economic Surveys (relevant years) and Mahler (1981).

3. See IMF Annual Report (1974 through 1981).

4. The implication is that expectations held in the past are no longer necessarily perfect foresight ones. For another example of an extension of the microeconomic intertemporal approach to a situation with unfulfilled expectations, see Persson and Svensson (1982).

5. Let r^t, t=0, 1, denote the final goods rate of interest between period t and t+1. Then the present value factors δ^o and δ^2

are defined as δ^o=1+r^o and δ^2=1/(1+r^1). Note that δ^o is a "capitalization" factor, whereas δ^2 is a "discount" factor.

6. We disregard any corner solutions. Equation (2.3) says that the value of the present marginal product of capital, Y_k^1, plus the present value of the future marginal product of capital, $\delta^2 Y_k^2=1$, equals the present value of past investment goods, δ^o. Equation (2.4) says that the present value of the future marginal product of capital equals the present value of present investment goods.

7. We assume there is no initial debt at the beginning of period 0.

8. Note that $\delta^o T^o=(1+r^o)T^{\delta}$.

9. This terminology is used in Hebrew, according to Elhanan Helpman. With many capital goods and oil, the definition of cooperation in terms of the signs of the elements of the matrix I_q is not equivalent to the usual definition of complements/substitutes in terms of the cross derivatives of the factor demand functions. With only one capital good and one kind of oil, it is equivalent to positive cross partials of the production function, i.e. $f_{kz}^t > 0$.

10. The capital-labor ratio will be higher for unexpected oil price increases though. One can think of this higher-than-optimal capital-labor ratio as a measure of the underutilization of capital.

11. An oil price increase will reduce oil inputs (the own substitution effect z_q^1 is always non-positive since the DP function is convex in prices). Since the marginal product of oil is positive, final goods output will fall, i.e. $x_q^1 \leq 0$.

12. We have the identity $E(\delta^o, 1, \delta^2, u) \equiv$
$\tilde{E}(1, \delta^2, u; E_o(\delta^o, 1, \delta^2, u)) + \delta^o E_o(\delta^o, 1, \delta^2, u)$. Then

$E_u = \tilde{E}_u + (\partial\tilde{E}/\partial c^o)E_u + \delta^o E_{\hat{o}u}$. But $\partial\tilde{E}/\partial c^o = -\delta^o$, the negative of the demand price for past consumption.

13. As long as the first-order effects are non-zero, they dominate the second-order effects for small oil price changes. For an analysis of both first and second-order welfare effects, see Persson and Svensson (1982).

14. We have $dE_1 = E_{1u}du = (E_{1u}/E_u)(E_u du)$, where $C_W^1 = E_{1u}/E_u$ and $E_u du$ is given by (3.9).

15. Note that the unconditional marginal propensities to consume fulfill $\delta^o C_W^o + C_W^1 + \delta^2 C_W^2 = 1$, whereas the conditional ones obey $\tilde{C}_W^1 + \delta^2 \tilde{C}_W^2 = 1$. If the propensities to consume in periods 1 and 2 are in fixed proportion to each other (C_W^1/C_W^2 = constant), and if consumption in period 0 is normal ($C_W^o > 0$), it follows that $\tilde{C}_W^1 > C_W^1$. This would be the case if the utility function is of the form $U(c^o, c^1, c^2) = g(c^o, h(c^1, c^2))$ where $h(c^1, c^2)$ is homothetic and all goods are normal.

16. Note that $T^1 = Y^1 - (c^1+i^1) = (x^1-c^1-i^1) - q^1z^1$, the value of net exports of final goods minus imports of oil.

17. Note that the partial effect on the present trade balance of past investment magnifies the change in the latter. We have $\partial T^1/\partial I^o = (Y_k^1 + 1) = 1 + r^o > 1$ as long as r^o is positive.

18. We assume that bonds have a one-period maturity.

19. There is no need to negotiate an indexing scheme since agents have subjective certainty about future periods. Moreover, indexing would make no difference since final goods prices are fixed in this analysis.

20. In the simple case with one type of labor and one kind of oil, cooperation is equivalent to having positive cross partials of the production function, $f^t_{\ell z} > 0$.

21. We implicitly assume that leisure does not enter into the utility function. If it does, and if labor supply is endogenous, the expenditure function should be written $E(\delta^o, 1, \delta^2, u; \ell^o, \ell^1, \ell^2)$. The predetermined present wage rate will fulfill $w^1 = \partial E/\partial \ell^1 = Y^1_\ell$, since $\partial E/\partial \ell^1$ is the supply price of present labor. Differentiating the budget constraint for unexpected oil price increases will give $\tilde{E}_u d\tilde{u} = -z^1 dq^1 - \delta^2 z^2 dq^2 + (Y^1_\ell - \partial\tilde{E}/\partial \ell^1) d\tilde{\ell}^1$. But since $\partial\tilde{E}/\partial \ell^1$ will equal $\partial E/\partial \ell^1$, the last term will be zero. Hence, there will be no first order welfare effects of changes in the employment level, since the value of the increased leisure, $(\partial\tilde{E}/\partial \ell^1)(-d\tilde{\ell}^1)$, equals the loss in domestic product, $Y^1_\ell d\tilde{\ell}^1$. Consequently, there would be no additional welfare effects on consumption from the change in employment. There will be substitution effects, $(\partial\tilde{E}_1/\partial \ell^1) d\tilde{\ell}^1$, though, and the effect on domestic product remains.

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