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by

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I. Introduction

Over the two year period beginning in 1980, OPEC's current account surplus is estimated to have declined by $100 billion or more, to about zero in 1982. This sharp decline has been cited as a possible explanation for the equally dramatic increase in real interest rates (as measured by nominal rates minus actual inflation rates) that took place over the same period. It is argued that the disappearance of OPEC's surplus generated upward pressure on real interest rates by inducing an incipient fall in world savings relative to investment. The theoretical and empirical bases for this argument are examined in the present paper.

The paper begins, in section II, with a theoretical analysis of the relationship between OPEC's surplus and real interest rates. The analysis is intended to show that OPEC's surplus and the real interest rate are endogenous variables, and that the observed relationship between the two depends on both the types of shocks impinging on the world economic system and the pattern of economic adjustment to these shocks. The results of this theoretical analysis also indicate that the correlation between OPEC's surplus and real interest rates may be expected to be positive in some circumstances and negative in others.

The relationship between OPEC's surplus and real interest rates is examined quantitatively in Section III, both by reviewing recent data and by running simulations with the Federal Reserve Board staff's Multicountry Model (MCM). The data review considers both the factors underlying the

decline in OPEC's surplus and the relative magnitudes of OPEC and non-OPEC savings and savings rates. The simulation analysis is then employed to assess quantitatively the response of both OPEC's surplus and real interest rates to several exogenous shocks relevant to the time period under consideration.

A summary of the results and some concluding remarks are contained in Section IV.

II. Theoretical Considerations

In analyzing the relationship between OPEC's surplus and real interest rates, it must be recognized that both variables are endogenous in the world economic system and that the relationship between the two depends crucially on the nature of the shocks impinging on that system. As we shall see, theory suggests that the correlation between the surplus and real interest rates can be either positive or negative, depending upon the particular shock involved, and the way in which the structure of the world economy is specified.

The analysis presented in this section is organized as follows: We begin by outlining a simplified general equilibrium framework in which both OPEC's surplus and a (single, world) real interest rate are endogenously determined. For simplicity, the model consists only of OPEC and one large oil consuming region which is referred to as the U.S.[1/] This analytical framework is then used to study the effects of three different disturbances, each of which has been cited as a factor underlying the recent decline in OPEC's surplus or the rise in real interest rates or both. The disturbances include a decrease in the real price of oil, a contractionary monetary policy in the U.S., and an

expansionary fiscal policy in the U.S. Because of the simplicity of the model employed, the analysis excludes any assessment of the dynamic adjustment of OPEC's surplus and real interest rates to the various shocks. This is left to simulation analysis with the MCM in the next section.

To summarize the results, only in one of the cases --that of a monetary contraction -- do we find that OPEC's surplus falls and the real interest rate rises unambiguously. In the case of an oil price decline, the surplus falls but the real interest rate may either rise or fall. And in the case of a fiscal expansion, both the real interest rate and OPEC's surplus rise. We conclude, then, that a fall in OPEC's surplus need not be associated with a rise in real interest rates. In those cases in which it is not, the impact on ex-ante world savings of the fall in OPEC's surplus is more than offset by an increased desire to save on the part of U.S. citizens or their government. A fall in the real interest rate is required to eliminate the incipient excess supply of goods.

II.A. The Model

The one period, discrete time model described in this section is a modification of the framework developed in Canzoneri and Gray (1983). There are two countries, one oil producing country called OPEC and one oil importing country called the U.S. Oil is an intermediate good that is used by the U.S to produce a single consumption good that is consumed in both countries. Labor is the only other variable input employed in the production of the consumption good; it is used in fixed proportions with oil. The nominal wage rate is set contractually at the beginning of each period, introducing the possibility of short run deviations of output from its full employment level. There are two assets in the system: U.S. money

which is held only by U.S. residents, and a real bond[1/] that is held by the residents of both countries. The model includes three exogenous policy variables: the real price of oil, the rate of growth of the U.S. money stock, and the level of U.S. government spending (bond financed). "Shocks" to the model take the form of unanticipated once-and-for-all changes in these three policy variables. Such disturbances cause short run (one period) deviations of output, the price level, the balance of trade, and interest rates from their full equilibrium, flexible wage values.

The model can be summarized as follows:

Notation

Note: With the exception of interest rates, lowercase letters denote the log value of a variable and uppercase letters denote the variable itself.

x	U.S. real output
h	the composite input, consisting of equal numbers of units of labor and oil
l	labor employed in production of x
o	oil employed in production of x
w	U.S. nominal wage rate
p	U.S. price level
q	real price of oil
c	U.S. consumption of x
c^o	OPEC's consumption of x
y^p	U.S. permanent income
y	U.S. current income
b	OPEC's net holdings of bonds issued by U.S. residents or the U.S. government
r	the real interest rate

Notation (continued)

i	the nominal interest rate
g	the level of U.S. government spending on x
m	the U.S. money stock
z	the rate of growth of the U.S. money stock
$\delta(.)$	denotes the deviation of the current value of a variable from its full equilibium value. Thus, for example, δx represents the deviation of the log value of output from the log value of its full equilibrium (or full employment) level. For small changes, δx approximates the percentage deviation of output from it's full equilibrium value.

The Model

Note: The model has been log-linearized around the initial (pre-shock) equilibrium. A bar over a variable indicates its initial equilibrium value. Unless otherwise indicated, Greek letters represent parameters.

(1) $\delta x = (1-\alpha)\delta h$

(2) $\delta h = \delta l = \delta o = -(1/\alpha)[\beta\delta p + (1-\beta)\delta q], \quad \beta = (W/P)L/[(W/P)L + QO]$

(3) $\delta c = \delta y^p - \sigma dr$

(4) $\delta y^p = -(\overline{QO/Y})\delta q - (\overline{rB/Y})\delta b$

(5) $\delta y = (\overline{X/Y})\delta x - (\overline{QO/Y})(\delta q + \delta o) - (\overline{rB/Y})\delta b - (\overline{B/Y})\delta r$

(6) $\delta c^o = 0$

(7) $\delta b = (\overline{Y/B})(\delta c - \delta y) + (\overline{G/B})\delta g$

(8) $\delta x = (\overline{C/X})\delta c + (\overline{C^o/X})\delta c^o + (\overline{G/X})\delta g$

(9) $\delta m^d - \delta p = \mu\delta x - \lambda\delta i$

(10) $\delta i = \delta r + \delta p_{+1} - \delta p$

(11) $\delta m^s = \delta z$

(12) $\delta m^s = \delta m^d$

Equation (1) gives the U.S. production technology. Output of the consumption good is proportional to the amount of the composite input employed in production. One unit of the composite input consists of one unit of labor and one unit of oil, which are used in fixed proportions.

The long-run supply of labor is assumed to be completely inelastic with respect to the real wage. Consequently, the full equilibrium levels of output and employment are the same before and after the oil price shock. In the short-run, however, the amount of labor and oil employed in production is completely demand determined. The underlying assumption here is that the supply of labor is infinitely elastic in the short-run, where the short-run is defined by the length of labor contracts. The derived demand for the composite input, as well as the derived demands for labor and oil, are obtained from the conditions for profit maximization and are given in equation (2). These demands depend on the price of the composite good in terms of the consumption good -- that is, on the sum of the real wage rate and the real price of oil. Since the nominal wage rate is fixed, the real wage rate varies inversely with the U.S. price level. Thus, equation (2) shows these derived demands to be positively related to the U.S. price level and negatively related to the real price of oil.

In equation (3), U.S. demand for the consumption good is written as an increasing function of U.S. permanent income and a decreasing function of the real rate of interest. Permanent income, in turn, is defined to be the level of income expected to prevail in subsequent periods in the

absence of any further shocks to the system. Changes in the model's three policy variables affect permanent income in two ways: Changes in the real price of oil alter the share of U.S. output that goes to OPEC in payment for oil. And changes in any of the three policy variables alter OPEC's net holdings of U.S. bonds, thereby altering the level of U.S. interest payments. Accordingly, equation (4) shows deviations in permanent income to be negatively related to deviations in both the real price of oil and OPEC's net holdings of bonds. Other factors that might be expected to enter into the determination of U.S. permanent income, including U.S. output, U.S. oil imports, and the real interest rate, do not enter equation (4). This is because the full equilibrium values of these variables are assumed to be invariant with respect to the policy variables we consider.[1/] In the short run, however, output, oil imports, and the real interest rate do respond to policy shocks and therefore can influence current income. In equation (5) current income is written as a function of these three variables as well as the real price of oil and OPEC's holdings of U.S. bonds.

A critical feature of the model is the assumption that OPEC is unable immediately to adjust its level of consumption to changes in the level of its permanent income. Specifically, OPEC is assumed to have a short-run marginal propensity to save (out of both current and permanent income) of one. This assumption is captured by equation (6), with short-run deviations in OPEC consumption set equal to zero.

Equation (7) states that OPEC's net accumulation of bonds -- or, equivalently, its current account surplus -- is equal to the sum of U.S. private and public dissaving. Changes in the level of U.S. government spending are assumed to be temporary (one period in duration) and to be

deficit financed. Accordingly, public dissaving is equal to the change in government spending.

Equation (8) is the log deviation form of the goods market equilibrium condition: The supply of output must equal the sum of the demands for output by U.S. residents, the U.S. government, and OPEC.

Equations (9) through (12) describe the U.S. money market. Real money demand is given in equation (9) as a function of real income and the nominal interest rate. The nominal interest rate is given in equation (10) as the sum of the real interest rate plus the expected rate of inflation. U.S. monetary policy takes the form of setting a constant rate of growth, z, of the money stock. The log of the money stock in any period t, then, is given by

$$(13) \quad m_t^s = m_{t-1}^s + z$$

Equation (11) simply restates this relationship in deviation form. Any change in monetary policy -- that is, any change in z -- is assumed to be unexpected and, once it occurs, permanent. Equation (12) state the equilibrium condition for the money market.

The model outlined in equations (1) through (12) above involves expectations of the future price level and policy variables. To complete the model the manner in which agents form their expectations must be specified. It is assumed that agents' expectations are "rational" given their assumptions about U.S. monetary and fiscal policies and OPEC's oil pricing policy. If their views about these policies are correct, then their price predictions will be realized.

II.B. The Response of the Model to Shocks

The solution to our model is summarized below.[1/] (Complete definitions of the coefficients entering the solution are set out in the appendix.) It should be noted that the solution presented here is for the special case in which OPEC's initial (pre shock) bond holdings are set equal to zero. This assumption removes some of the ambiguities associated with the general solution to the model, while leaving intact the results we are concerned with.

(14) $\delta x = -\rho_1 \delta q + \rho_2 \delta z + \rho_3 \delta g$

where $\rho_1, \rho_2, \rho_3 > 0$

(15) $\delta p = \rho_4 \delta q + \rho_5 \delta z + \rho_6 \delta g$

where ρ_4 is unsigned and $\rho_5, \rho_6 > 0$

(16) $\delta r = \rho_7 \delta q - \rho_8 \delta z + \rho_9 \delta g$

where ρ_7 is unsigned and $\rho_8, \rho_9 > 0$

(17) $\delta b = \rho_{10} \delta q + \rho_{11} \delta z + \rho_{12} \delta g$

where ρ_{10} and $\rho_{11}, \rho_{12} > 0$

Here δq, δz, and δg denote unanticipated changes in the real price of oil, U.S. monetary policy, and U.S. fiscal policy. Equations (14) through (17) show the way in which these three policy shocks produce deviations of U.S. output, the U.S. price level, the real interest rate, and OPEC's surplus from their full equilibrium values. The remainder of this section is devoted to interpreting these results. The focus of our discussion will

be on the correlation in the responses of the real interest rate and OPEC's surplus to the three policy disturbances.

A Decline in the Real Price of Oil

Among the consequences we generally expect to observe following a decline in the real price of oil is an increase in output in those countries that import oil and a fall in OPEC's oil revenues. Examination of equation (14) shows that the first of these expectations is confirmed by our model. A fall in the the real price of oil unambiguously raises U.S. output because it lowers the price U.S. firms must pay for the composite input.

On the other hand, OPEC's oil revenues do not necessarily fall with a decline in the price of oil. Under the assumption that OPEC saves all changes in income in the short run, the change in OPEC's oil revenues is equal to the change in its current account surplus, as given by equation (17). From equation (17) we see that the impact of a decline in the price of oil on OPEC's surplus (or, equivalently, its oil revenues) is ambiguous. The reason for this is straigtforward. At an unchanged level of output (and, therefore, oil imports) in the U.S., OPEC's oil earnings would fall as the real price of oil falls. But U.S. output and oil utilization rates rise as the price of oil falls. If they rise by enough, OPEC's total oil revenues will actually increase following an oil price decline. Since it is generally assumed that OPEC is operating in the inelastic portion of its demand curve, we choose to rule out by assumption this latter possibility. Formally, this can be achieved by assuming that α and β are large enough -- that oil is not "too" important in the production process. Thus, we are restricting our attention to only those

cases in which a fall in the real price of oil leads to decline in OPEC's oil revenues and current account surplus.

From equation (16) we see that the effect of a decline in the real price of oil on the real interest rate is ambiguous. Consequently, the correlation between OPEC's current account surplus and the real interest rate following an oil price shock may be either positive or negative. The intuition behind this result is as follows: The real interest rate may be viewed as the price that adjusts to equate the world demand for goods to the world supply of goods. Alternatively, it adjusts to eliminate any incipient excess supply of world saving. If the oil price shock causes an ex ante increase in desired world saving, the real interest rate will fall to eliminate the associated excess demand for goods. If it brings about a decrease in desired world saving, the real interest rate will rise.

Because OPEC's short run marginal propensity to save is equal to one, the decline in its income following a fall in the price of oil results in an equal decline in its desired saving. This, in turn, will lead to a decrease in desired world saving and upward pressure on the real interest rate only if OPEC's reduced desire to save is not fully (or more than fully) matched by an increased desire to save in the United States. An increased desire to save is, however, a likely outcome for the United States. The oil price decline raises current income in the United States above its (new higher) level of permanent income. If consumption depends on permanent income, savings will rise in order to maintain consumption at a level consistent with permanent income. If the increased desire to save by the United States is less than the decreased OPEC desire to save, desired world saving will fall, with consequent upward pressure on the

real interest rate. In this case, a negative correlation between OPEC's surplus and the real interest rate would be observed. However, if the increased desire to save by the United States exceeds the reduction in OPEC's desired savings, the opposite result would hold and a positive correlation would be observed.[1/]

A Contractionary U.S. Monetary Policy

Because nominal wage rates in the U.S. are contractually fixed in the short run, a decrease in the rate of growth of the U.S. money supply raises the U.S. real wage rate by lowering the U.S. price level. (See equation (15).) This, in turn, leads to a fall in current U.S. output, as shown by equation (14). The reduction in U.S. output is accompanied by a fall in U.S. oil imports and, accordingly, OPEC's oil revenues. Because OPEC's short run marginal propensity to save is one, OPEC's saving -- and its current account surplus -- decline by the same amount as the fall in its income. Thus, we see in equation (17) that a U.S. monetary contraction induces OPEC to run a current account deficit.

From equation (16) we see that a U.S. monetary contraction raises the real interest rate. Accordingly, the implied correlation between OPEC's surplus and the real interest rate following a monetary shock is negative. The intuition behind this results is as follows: At an unchanged real interest rate, the U.S. contraction produces a decreased desire to save in both the U.S. and OPEC. For the U.S., this occurs because current income is reduced below permanent income by the monetary disturbance. For OPEC, as already discussed, it is because the reduction in U.S. output is accompanied by a fall in OPEC's oil revenues which, in turn, is fully reflected in a decline in saving. Thus, desired world saving falls following a decline in the real price of oil, and a rise in

the real interest rate is required in order to eliminate the resulting excess demand for goods. In the case of a monetary contraction, then, we expect to observe a negative relationship between OPEC's current account surplus and the real interest rate.

An Expansionary U.S. Fiscal Policy

In our model, an expansionary U.S. fiscal policy takes the form of a temporary increase in U.S. government spending accompanied by the issuing of an equal amount of U.S. government debt. The increase in spending causes a rise in U.S. output, as shown by equation (14). This is accompanied by an increase in U.S. oil imports and, therefore, OPEC's oil revenues. Since OPEC's short run marginal propensity to save is assumed to be equal to one, its savings -- and current account surplus -- rise by the amount of the increase in its income. Thus, we see in equation (17) that a U.S. fiscal expansion induces an OPEC current account surplus.

From equation (16) we see that the fiscal expansion also raises the real interest rate. Accordingly, the implied correlation between OPEC's surplus and the real interest rate is positive. The intuition behind this result is as follows: At an unchanged real interest rate, the fiscal expansion produces an increased desire to save on the part of both U.S. private residents and OPEC. For U.S. residents, this occurs because current income is raised above permanent income by the fiscal disturbance. For OPEC, as discussed above, it is because the increase in U.S. output is accompanied by a rise in OPEC's income which, in turn, is fully reflected in a rise in OPEC's saving. However, there is an offsetting decrease in U.S. government saving equal to the amount of the increase in U.S. government spending. In fact, in the model of this section, the fall in U.S. public saving more than offsets the increased desired saving on the

part of U.S. residents and OPEC.[1/] The result is a decline in desired world saving and a rise in the real interest rate. Thus, in the case of a fiscal expansion, we expect to observe a positive relationship between OPEC's current account surplus and the real interest rate.

III. Empirical Analysis

This section provides a quantitative analysis of the relationship between OPEC's surplus and real interest rates. We begin with a review of recent data on movements in real interest rates, OPEC's surplus and OPEC and world savings rates. We then attempt to gauge the magnitude of the effects of the various shocks discussed in the previous section, using simulations with the MCM.

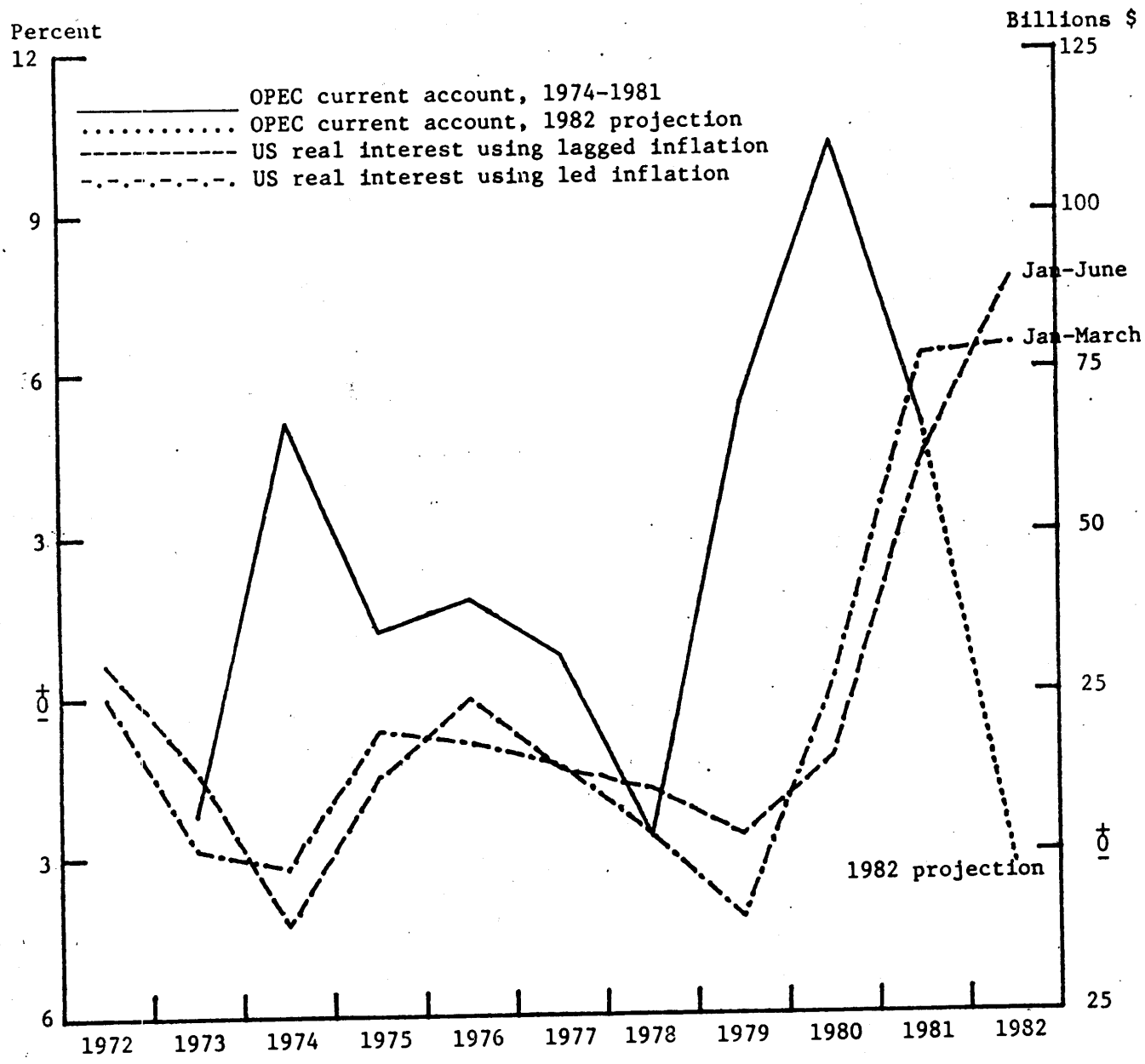
III.A. Data Review

Chart 1 plots OPEC's surplus and the three-month U.S. Treasury bill rate adjusted for both current and realized (led) CPI inflation rates. By either measure, short term real dollar interest rates rose by as much as 10 percentage points between mid-1979 and mid-1982.[2/] This movement was clearly negatively correlated with the sharp decline in OPEC's surplus during 1980-82. These two variables also were negatively correlated during much of 1973-75, following the 1973 oil price shock. However, during much of the latter 1970's the two variables were positively correlated.

Movements in OPEC's surplus over the past decade are analyzed in Table 1. These data show that of the estimated decline of more than $100 billion in OPEC's surplus between 1980 and 1982, about 60% was due to a decline in exports and 40% to a rise in imports and net service payments. This contrasts with the 1974-78 episode, when the disappearance of OPEC's

CHART 1

The OPEC Current Account[1/] and US Real Interest Rates[2/]



1/ Calculation of the current account balance is given in Table 1.

2/ The real interest rates are annual statistics representing the average monthly rate. Monthly real interest rates are calculated as the average market yield of 3-month Treasury bills less the unadjusted CPI inflation rate which is either lagged (over the previous 3 months) or led (over the following 3 months). All data are taken from the FRB macro data base.

TABLE 1

OPEC Current Account [a/]
(billions of U.S. dollars)

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982 [b/]
Exports (f.o.b.)	39.0	117.9	109.6	133.3	146.4	141	214	294	283	231
(oil)	(34.8)	(112.0)	(103.6)	(126.0)	(137.9)	(130)	(201)	(279)	(265)	(211)
(non-oil)	(4.2)	(5.9)	(6.0)	(7.3)	(8.5)	(11)	(13.5)	(15)	(18)	(20)
Imports (f.o.b.)	-20.2	-35.8	-56.2	-68.0	-84.9	-100.5	-101.5	-133	-159	-172
Net Services and Private transfers	-12.2	-14.3	-18.4	-25.3	-30.4	-37.8	-42.3	-50	-57	-61
(receipts)	(4.3)	(8.8)	(12.1)	(14.5)	(18.0)	(21.1)	(24.8)	(34)	(48)	(56)
(payments)	(-16.5)	(-23.1)	(-30.5)	(-39.8)	(-48.4)	(-58.9)	(-67.1)	(-84)	(-105)	(-117)
Balance on Current Account (excluding official transfers)	6.6	67.8	35.0	40.0	31.1	2.7	70.2	111.0	67.0	-2.0
Oil Exports										
Price ($/bbl)	3.22	10.49	11.05	11.74	12.83	12.93	19.00	30.82	34.51	33.07
Volume (mbd)	29.6	29.3	25.7	29.4	29.5	27.5	29.0	24.7	21.0	17.5
				(percentage change from previous year)						
Imports										
Unit Value	23.5	28.0	11.0	0.5	9.0	12	14	12	1	2
Volume	20.3	38.5	41.4	20.4	14.6	5	-12	16	18	6

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a/ Historical data from FRB data bank.

b/ Estimates based on partial monthly trade date for 1982 and projections provided in IMF World Economic Outlook, September 1982, and OECD Economic Outlook, December 1982.

surplus was completely in terms of increased OPEC imports. The decline in exports in 1980-82 was all in terms of volume. While oil prices fell somewhat during the latter part of this period, they were still above their 1980 level in mid-1982. The decline in export volume reflects three factors: 1) reduced consumption in response to higher oil prices (which for convenience, we will refer to as "conservation", 2) increased production elsewhere, and 3) recession in oil consuming countries. The rise in OPEC's imports in 1981 and 1982 was almost all in terms of volume, reflecting a delayed response to the earlier jump in OPEC income. OPEC's import prices (in dollars) rose very little between mid-1980 and mid-1982. The dollar prices of OPEC's imports from countries other than the United States were held down by the substantial appreciation of the dollar during this period.

As discussed in the theoretical section a negative relationship between OPEC's surplus and real interest rates can be expected, under certain conditions, if OPEC's savings rate is greater than savings rates elsewhere. Available data on OPEC and world savings, listed in Table 2, provide evidence that OPEC's savings rate has been greater than those elsewhere. At the time of the 1973-74 oil price shock, OPEC's marginal savings rate appears to have been substantially greater than the aggregate savings rate of the rest of the world. OPEC's savings rate declined sharply during the latter 1970's as its consumption capacity grew, but jumped again with the 1979 oil price hike, to a level well in excess of savings rates in the United States and other OECD countries. OPEC's savings rate may have dropped, of course, as its consumption rose during 1980-82. But as long as it remained above savings rates elsewhere, such factors as rising non-OPEC oil production and conservation will have

TABLE 2

YEAR	OPEC CURRENT ACCOUNT[a/] (Billions of Dollars)	GROSS NATIONAL SAVINGS[b/] (Billions of Dollars)			MARGINAL SAVINGS RATE[d/]		
		OPEC[c/]	OECD	US	OPEC[c/]	OECD	US
1972	NA	12	640	224	.49	.25	.21
1973	6.6	17	822	273	.68	.32	.36
1974	67.8	46	868	278	.81	.13	.05
1975	35.0	49	877	274	.25	.02	-.03
1976	40.0	52	967	310	.22	.27	.22
1977	31.1	58	1104	361	.30	.24	.26
1978	2.7	56	1373	424	-.17	.27	.27
1979	70.2	69	1563	476	.43	.22	.21
1980	111.0	106	1632	473	.65	.10	-.02
1981	67.0	NA	NA	NA	NA	NA	NA
1982	-2.0 (projected)	NA	NA	NA	NA	NA	NA

a/ Calculation of the current account balance is given in Table 1.

b/ Gross national savings is defined as gross domestic investment plus net exports of goods and services. Data for OPEC are compiled from IMF, International Financial Statistics; data for the OECD and the US are taken from OECD, National Accounts 1951-1980, 1982 edition. Data are not available for 1981-82.

c/ OPEC figures include data from Ecuador, Kuwait, Saudi Arabia, and Venezuela. Data are for year-ending December 31 (Equador and Venezuela), year-ending June 30 (Saudi Arabia) or for year-beginning April 1 (Kuwait). Consistent data for other OPEC member countries are not available. Note that these four countries accounted for 58 percent of the OPEC current account on average for the period 1974-1980.

d/ The realized marginal savings rate is defined as the year-to-year change in gross national savings divided by the year-to-year change in nominal GDP.

contributed to a decline in world savings and upward pressure on real interest rates.

However, the magnitude of the shift in world savings associated with these effects may not have been large relative to total world savings. Based on the data in Table 2, even at its peak in 1980 the portion of OPEC savings available for investment elsewhere (OPEC's current account surplus) amounted to only 6 per cent of gross national savings in OECD countries. Over the period 1973-1980 OPEC's surplus averaged about 3-1/2 per cent of OECD savings.

III.B. MCM Simulations

In order to analyze the relationship between OPEC's surplus and real interest rates quantitively, a number of simulations have been run with the MCM. The simulations involve subjecting the MCM to various exogenous shocks. The particular shocks were selected partly on the basis of the statistics presented above, and partly to compliment the theoretical analysis of the previous section.

As noted above, much of the decline in OPEC's surplus during 1980-82 was the result of delayed response to the earlier (1979) price increase, including increased OPEC absorption, reduced oil consumption and increased production in non-OPEC countries. We begin, therefore, with an oil price shock, in order to investigate the subsequent pattern of adjustment of OPEC's surplus and real interest rates. Next we consider two policy shocks similar to those addressed in our theoretical section. One involves a monetary contraction, which has been cited as a factor underlying both the decline in OPEC's surplus (by depressing output in oil consuming countries) and the rise in real interest rates. The other

involves a fiscal expansion, which has been viewed as contributing significantly to the jump in US real interest rates.

The salient features of the version of the MCM used for these simulations are described elsewhere.[1/] We note here only that the MCM differs from the theoretical model outlined in section II in a number of important respects. It contains substantially greater structural detail both in its country coverage and in the specification of goods, money and labor markets within each country. In particular, it allows for lags in the adjustment of demands and supplies to changes in prices in each of the markets. Unlike the theoretical model, goods prices are sticky in the short run and the marginal propesity to consume out of current income is nonzero. Moreover, OPEC's consumption, in particular, responds to changes in its income with a distributed lag, so that OPEC's marginal savings rate, while near 1.0 in the very short run, is closer to zero in the long run.

The greater detail in the MCM comes at the cost of some inconsistency in the treatment of expectations, however. Price expectations are functions of lagged prices in some cases, and static in other cases, rather than rational. This leaves the model open to the Lucas critique, that changes in expectations due to large changes in exogenous variables are not well captured. Moreover, the real interest rate typically is disaggregated into its components, and the estimated response of consumption and invesmtent expenditures to the nominal rate component often differs from the response to the expected inflation component. This makes it difficult to identify a particular real rate that clears the goods market. The simulation results obtained here must therefore be interpreted with caution. In our judgment, the model

nevertheless provides a useful empirical framework for modelling flows of savings between major industrial countries and OPEC and analyzing the dynamics of adjustment to oil shocks.

The results of the simulations are reported in Table 3, which lists the impacts of each shock over a 4-year period on the OPEC current account, the U.S. short-term real interest rate, and an average of short-term real interest rates in the MCM's industrial countries, weighted by GNP shares. The U.S. real interest rate is the three-month Treasury bill rate minus the realized (one-quarter ahead) domestic inflation rate. Foreign real rates were defined analogously, for each of the four non-U.S. MCM countries.

The design of each simulation and the results are summarized below. All of the shocks were started in the first quarter 1979 and run through the fourth quarter 1982. In each of the simulations the money supplies of the MCM countries were held to their historical paths. The paths varied considerably across countries. Most notably, nominal interest rates in countries other than the U.S. were generally less sensitive to the various shocks than U.S. rates.

OPEC Price Increase

This simulation involved comparing the model's prediction of what transpired over the period 1979-82 with its prediction of what would have happened if the 1970-80 oil price increase had not taken place (i.e., holding nominal oil prices to a 5 per cent annual rate of inflation after the fourth quarter of 1978).[1/] The results of this simulation in the short run are consistent with the theoretical analysis of an oil price decline discussed in Section II, given that OPEC's marginal savings rate is substantially above that elsewhere. Following the oil price increase,

Table 3

Results of MCM Simulations

(All shocks begin in 1979 Q1, results expressed as shock minus control)

	1979 Oil Price Shock[a]			U.S. Monetary Shock[b]			U.S. Fiscal Shock[c]		
	OPEC Current Account ($ Billions Annual Rate)	U.S. Real Int. Rate (100 Basis Points)	"World"[d] Real Rate	OPEC Current Account ($ Billions Annual Rate)	U.S. Real Int. Rate (100 Basis Points)	"World" Real Rate	OPEC Current Account ($ Billions Annual Rate)	U.S. Real Int. Rate (100 Basis Points)	"World" Real Rate
1979 Q1	6.3	-.9	-1.2	-.2	1.3	.5	1.6	0	0
Q2	35.8	-1.5	-2.0	-.4	2.2	1.0	1.9	.8	.4
Q3	60.7	-3.0	-3.5	-1.2	2.7	1.2	2.6	1.6	.8
Q4	79.2	-2.3	-3.1	-2.6	3.6	1.7	3.1	2.6	1.3
1980 Q1	106.7	-1.9	-3.2	-3.9	3.9	1.9	2.8	3.0	1.4
Q2	102.2	-1.4	-2.6	-4.3	2.7	1.3	1.3	2.0	.9
Q3	99.0	.7	-.7	-4.5	2.4	1.2	.2	1.5	.7
Q4	80.5	.7	-.6	-4.3	3.3	1.7	.4	2.1	1.1
1981 Q1	81.6	.6	-.8	-3.5	4.3	2.2	0	2.0	1.0
Q2	66.9	.7	-.2	-2.4	5.5	2.8	-.1	2.1	1.1
Q3	49.8	2.9	1.2	-2.4	6.4	3.2	-.1	2.2	1.1
Q4	43.1	2.1	.8	-3.2	5.4	2.6	-.3	1.9	1.0
1982 Q1	41.3	2.0	.6	-4.2	5.9	2.9	-.5	2.2	1.2
Q2	22.8	2.7	1.3	-3.9	6.0	3.1	-.5	2.4	1.3
Q3	30.7	1.1	.7	-3.7	4.8	2.4	-.5	1.9	1.0
Q4	26.4	1.5	.6	-3.0	4.5	2.3	-.5	1.5	.8

Notes:

a) Effect of the actual rise in nominal oil prices during 1979-81, compared with the base case of a 5% annual rate of incease.

b) Effect of reducing U.S. M1 growth rate by 1 percent per year.

c) Effect of a sustained increase in the level of government expenditures by an amount equal to 1 percent of GNP in the quarter 1978.

d) Weighted average of real interest rates in the following countries (weights, based on GNP shares, in parentheses):
United States (.51), Japan (.21), Germany (.16), United Kingdom (.07), Canada (.05)

OPEC's current account initially rises substantially and real interest rates fall. After about a year and a half, however, the rise in OPEC's surplus peaks and begins to diminish. This pattern is remarkedly close to the actual pattern that OPEC's surplus followed during 1979-80, as illustrated in Chart 1. Real interest rates reach a low point somewhat earlier (after about three quarters) and then begin to rise. Real interest rates bottom out and begin to rise in advance of the OPEC surplus peak because income (hence savings) in oil consuming countries is falling. The oil price increase reduces U.S. income by nearly 1/2 per cent after one year and 2 per cent after three years.

OPEC's surplus declines with the rise in OPEC consumption and the fall in oil consumption elsewhere. This reduces ex-ante world savings, which along with the continued recession in industrial countries, further stimulates the rise in real interest rates. The total simulated swing in short term real rates amounts to nearly 6 percentage points between mid-1979 and mid-1981 for the United States and slightly less for the MCM countries combined.[1/] This movement amounts to somewhat more than one-half of the actual swing in short term rates observed during that period. In 1982, the simulation results show a continued fall in OPEC's surplus but at a rate that is less than what is estimated actually to have occurred. This is due, at least in part, to the fact that oil production in non-OPEC countries was held fixed throughout the simulation experiment. Toward the end of the simulation period, both the decline in income in non-OPEC countries and the rise in real interest rates (relative to the historical control) are diminishing noticeably.

The simulated response of real interest rates to an oil price increase depends critically on the stance of monetary policy following the

disturbance. To see this, it is useful to trace through the behavior of inflation and nominal interest rates in this simulation and note the sensitivity of the results to the maintained assumptions about monetary policy. Domestic inflation rises fairly steadily following the oil price shock, reaching a peak of about 3 per cent above control by the fourth quarter of 1979, and then declines, eventually falling below the historical rate for a time as the oil price shock works through the goods and labor markets in the model. The decline is abetted by the recession that is also induced by the oil price shock. Nominal interest rates rise with the price-induced rise in nominal domestic expenditures, which stimulate demand for money. The rise in nominal rates varies across countries, depending upon the stance of monetary policy. It is greatest in the United States, where money is assumed to be least accommodating. Had a more accommodating monetary policy been assumed, the simulation would have shown a smaller initial rise in nominal U.S. interest rates and a higher response of domestic inflation. On balance the level of real interest rates would have been somewhat lower during the period of dynamic adjustment to the oil price shock. This lower level of real rates during the adjustment period would have been associated with a less pronounced decline in U.S. income and saving.

U.S. Monetary Contraction

This shock involved a sustained exogenous 1 per cent reduction in the rate of growth of the U.S. money stock (M1). The effect is eventually to raise U.S. short-term nominal interest rates by about 500 basis points in order to reduce money demand and equilibrate the money market. With prices adjusting slowly, measured real interest rates rise by a similar amount in the near term. (The movement in "world" real rates principally

reflects the U.S. rate; real rates in other MCM countries move relatively little.) The rise in the interest rate depresses domestic expenditure and output, reducing the demand for oil. OPEC's surplus falls, but by less than $5 billion. The relatively large impact on real interest rates and small impact on OPEC's surplus suggests that the monetary shock significantly affects real interest rates independently of its impact on OPEC's surplus.

U.S. Fiscal Expansion

This shock was a sustained increase in real government spending equal to 1 per cent of GNP in the first quarter of 1979, with the money supply treated exogenously.[1/] Consistent with the theoretical discussion in Section II, this shock generates a positive correlation between OPEC's surplus and real interest rates. The fiscal expansion initially stimulates U.S. income and imports of oil, which also raises OPEC's exports and current account surplus. U.S. real interest rates rise by 200-300 basis points, however, partly because of money market effects (increased demand in the face of unchanged supply), and partly because of an ex-ante decline in private world saving (crowding-out effects of increased government deficit). The reader may note that OPEC's surplus evenually turns negative. This is simply an artifact of the model's dynamic adjustment pattern; convergence to the steady state is not monotonic. The point of this simulation is to illustrate that real interest rates could have been influenced significantly by factors other than those underlying the decline in OPEC's surplus.

IV. Summary and Conclusions

We have analyzed the relationship between the recent decline in OPEC's surplus and the rise in real interest rates both theoretically and empirically. In the theoretical analysis it was shown that under some conditions a decline in OPEC's surplus can lead to a fall in world savings and, ceteris paribus, a rise in real interest rates. A higher ex-ante savings rate in OPEC than elsewhere was a necessary condition for this result. However, it was also noted that both the surplus and interest rates are endogenous variables that reflect the influences of other variables, and that in some cases a positive correlation can be expected, even if OPEC's savings rate exceeds the rest of the world's.

A review of recent data suggested that OPEC's savings rate has exceeded that in OECD countries, on average. We also analyzed the recent decline in OPEC's surplus, finding that it reflected rises in OPEC absorption and non-OPEC oil production and declines in world oil consumption. It was reasoned that these factors represented to a significant extent continuing adjustments to the 1979 OPEC price hike. In addition, we noted that recession in industrial countries, which contributed to the decline in oil consumption, could have been induced as much by a shift in economic policy in oil consuming countries as by the oil price shock.

An effort was then made to quantify these relationships using simulations with the MCM. In simulating the 1979 oil price shock, OPEC's surplus was observed to rise sharply after the shock, and then fall, about in line with the actual movement in the surplus over this period. Real interest rates initially fell and then rose noticably as both OPEC's surplus and income in oil consuming countries fell. This swing in real

rates was equivalent to more than half of the actual increase during 1980-1982. The simulated rise in real interest rates was more pronounced in countries that maintained relatively tight monetary policies in the face of the oil price shock. Next we simulated shifts in monetary and fiscal policy. These shocks had small impacts on OPEC's surplus, but large near term effects on real interest rates, principally through channels other than the shift in OPEC's surplus.

Based on this analysis we conclude that the change in OPEC's surplus was not the ultimate casual factor underlying the rise in real interest rates in 1980-82. However, the relationship between the two variables during 1980-82 was more than a chance correlation. Movements in both variables to a considerable extent reflected the continuing pattern of adjustment of the world economy to the 1979 oil price shock. It also seems likely that a tightening of U.S. monetary policy and easing of U.S. fiscal policy contributed significantly to the rise in real rates, at least in the United States, quite independently of movements in OPEC's surplus.

Footnotes

*/ The views presented here are the authors and do not necessarily represent the views of the Federal Reserve Board or its staff. Lois Stekler, Ralph Tryon, John Underwood and Julie Withers contributed significantly to the work presented here. We are also indebted to Cathy Crosby, John E. Keniley and Caryl McNeilly for their able research assistance. Any errors that remain are our own.

2.1/ The model presented in this section is a modification of the model developed in Canzoneri and Gray (1983). Their framework includes two oil-importing countries rather than the one oil-importing country of the present paper. In addition, consumption depends on permanent income in the present paper, while in Canzoneri and Gray the consumption of the two oil-importing countries depends on current income.

4.1/ This real bond pays a variable rate of interest; it is like a savings account that pays a real return that is adjusted each period to equal the return on newly issued bonds.

7.1/ The long run supply of labor is assumed to be completely inelastic with respect to the real wage rate. Consequently, the amount of labor and oil employed in production (recall that labor and oil are used in fixed proportions) is fixed in the long run. Since none of the three disturbances we consider affect the production function, the long run equilibrium level of output is invariant in this model. Similarly, the long run equilibrium real interest rate is that rate which equates demand for the consumption good to the economy's permanent income. In the absence of permanent changes in government spending, this rate is a constant in our model.

9.1/ The solution of equations (1) through (12) of the text requires calculating the one period ahead expectation of the U.S. price level. This expectation appears in equation (10) as a determinent of the nominal interest rate. To find δp_{-1}, we begin by substituting equations (9), (10), and (11) into (12) and updating the result by one period.

$$\delta m^s_{+1} - \delta p_{+1} = \mu \delta x_{+1} - \lambda \delta r - \lambda(\delta p_{+2} - \delta p_{+1})$$

As already noted, δx and δr are expected to be equal to zero in the post shock equilbrium. The term $(\delta p_{+2} - \delta p_{+1})$ is simply the change in the expected rate of inflation in the post shock equilbrium, which is simply equal to the change in the rate of growth of money, or δz. The term δm^s_{+1} is the deviation of the money stock in the post shock period from the value it would have assumed in the absence of shocks. Since the post shock period is the second period in which altered money growth rate is applicable, this term is equal to $2\delta z$. Substituting these values into the equation above and simplifying gives

$$\delta p_{+1} = (2+\lambda)\delta z$$

Once this equation is substituted into equation (10) of the text, the solution of the model is a matter of straightforward algebra.

12.1/ Note that U.S. savings can fall more than OPEC's rises even with a lower savings rate in the U.S. because U.S. savings falls due to the decline in U.S. output as well as the transfer to OPEC.

14.1/ This result is unambiguous because the marginal propensity to consume out of current output in our model is zero. This, in turn, is due to the assumption that the marginal propensity to consume out of current income is zero for both OPEC and the U.S. At an unchanged price level and real interest rate, then, the increase in government spending will generate an equal increase in demand for U.S. output (the simple government spending multiplier is unity). This excess demand will be met only in part by an increase in output, all of which will be saved. Accordingly, if the real interest rate is held constant, the increased private saving generated by this fiscal disturbance is less than the decreased saving of the government. It follows that the real interest rate must rise in order to equilibrate the goods market.

14.2/ Both of the measures of real interest rates we employ are only proxies for actual "real" interest rates. In principle, the real interest rate should be measured as the nominal rate minus the expected future rate of inflation. To the extent that expectations were either realized or influenced primarily by current inflation, the error in these proxies is likely to have been small.

17.1/ See Tryon (1983) and Hooper and Tryon (1982).

18.1/ OPEC's average contract price rose fairly steadily from about $13 dollars per barrel in the fourth quarter of 1978 to $30 per barrel in the second quarter of 1980. By the fourth quarter of 1981 it had reached $34.50 per barrel.

19.1/ The five main industrial countries that are modelled explicitly in the MCM are Canada, Germany, Japan, the United Kingdom, and the United States. In addition, the MCM includes abbreviated sectors for OPEC and the ROW.

21.1/ In our theoretical analysis, we consider a temporary fiscal shock that persists for only one period. One period in our theoretical model, however, corresponds to the duration of a "typical" labor contract. The typical union contract in the U.S. runs for approximately 2 years, or eight periods in the quarterly MCM model. For our purposes, then, subjecting the MCM to a sustained fiscal disturbance approximates the theoretical fiscal exercise carried out in section II.

Appendix

Definitions of the Coefficients Entering Equations (14) Through (17)

Note: These coefficients apply to the special case in which the pre shock level of OPEC's bond holdings is zero.

$$\rho_1 = (1/\Delta)\{\beta\lambda\overline{QO}(1-\alpha) + (1+\lambda)(1-\alpha)(1-\beta)(1-\bar{r})\sigma\bar{Y}\}$$

$$\rho_2 = (1/\Delta)\{\beta(1-\alpha)(1+\lambda)^2(1-\bar{r})\sigma\bar{Y}\}$$

$$\rho_3 = (1/\Delta)\{\beta\lambda(1-\alpha)(1-\bar{r})\bar{G}\}$$

$$\rho_4 = (1/\Delta)\{(1-\alpha-\beta)\lambda\overline{QO} + \mu(1-\alpha)(1-\beta)(1-\bar{r})\sigma\bar{Y}\}$$

$$\rho_5 = (1/\Delta)\{\alpha(1+\lambda)^2(1-\bar{r})\sigma\bar{Y}\}$$

$$\rho_6 = (1/\Delta)\{\alpha\lambda(1-\bar{r})\bar{G}\}$$

$$\rho_7 = (1/\Delta)\{\overline{QO}[(1+\lambda)(1-\alpha-\bar{r}\beta) - \mu\beta(1-\alpha)]\}$$

$$\rho_8 = (1/\Delta)\{\beta(1-\alpha)(1+\lambda)^2(1-\bar{r}\beta)\bar{X}\}$$

$$\rho_9 = (1/\Delta)\{(1-\bar{r})\bar{G}[(\mu\beta(1-\alpha) + (1+\lambda)\alpha]\}$$

$$\rho_{10} = (1/\Delta)\{\sigma\bar{Y}[(1+\lambda)(1-\alpha-\bar{r}\beta) - \mu\beta(1-\alpha)] + \beta^2(1-\alpha)\lambda\bar{X} + \beta(1+\lambda)(1-\bar{r})\sigma\bar{Y}\}$$

$$\rho_{11} = (1/\Delta)(1/\overline{Y^{\sigma}})\{\beta(1-\alpha)(1-\beta)(1+\lambda)^2\sigma\overline{XY}\}$$

$$\rho_{12} = (1/\Delta)(1/\overline{Y^{\sigma}})\{\beta(1-\alpha)(1-\beta)\lambda\overline{GX}\}$$

where $\Delta = (1-r)\sigma\bar{Y}[\mu\beta(1-\alpha) + (1+\lambda)] + \beta(1-\alpha)\lambda(1-r\beta)\bar{X}$

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