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Oil and the Macroeconomy since World War II

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All but one of the U.S. recessions since World War II have been preceded, typically with a lag of around three-fourths of a year, by a dramatic increase in the price of crude petroleum. This does not mean that oil shocks caused these recessions. Evidence is presented, however, that even over the period 1948–72 this correlation is statistically significant and nonspurious, supporting the proposition that oil shocks were a contributing factor in at least some of the U.S. recessions prior to 1972. By extension, energy price increases may account for much of post-OPEC macroeconomic performance.

I. Introduction

The poor performance of the U.S. economy since 1973 is well documented:

1. The rate of growth of real GNP has fallen from an average of 4.0 percent during 1960–72 to 2.4 percent for 1973–81.
2. The 7.6 percent average inflation rate during 1973–81 was more than double the 3.1 percent realized for 1960–72.
3. The *average* unemployment rate over 1973–81 of 6.7 percent was higher than in any year between 1948 and 1972 with the single exception of the recession of 1958.

This paper is drawn from chap. 2 of my Ph.D. dissertation at the University of California, Berkeley. Earlier versions of this paper were presented at the NBER/NSF Time Series Conference in San Diego, March 13, 1981, and at the NBER Conference on Inflation and Business Fluctuations, April 30–May 1, 1982, Cambridge, Massachusetts. In addition to the helpful suggestions of my adviser, James Pierce, I am indebted to the many individuals whose comments and criticisms have helped sharpen the focus of this inquiry, including Allen Berger, Roger Craine, William Dickens, Charles Engel, Robert Engle, Marjorie Flavin, Richard Gilbert, Donald Nichols, Michael Riordan, Thomas Rothenberg, Christopher Sims, and the editors of this *Journal*.

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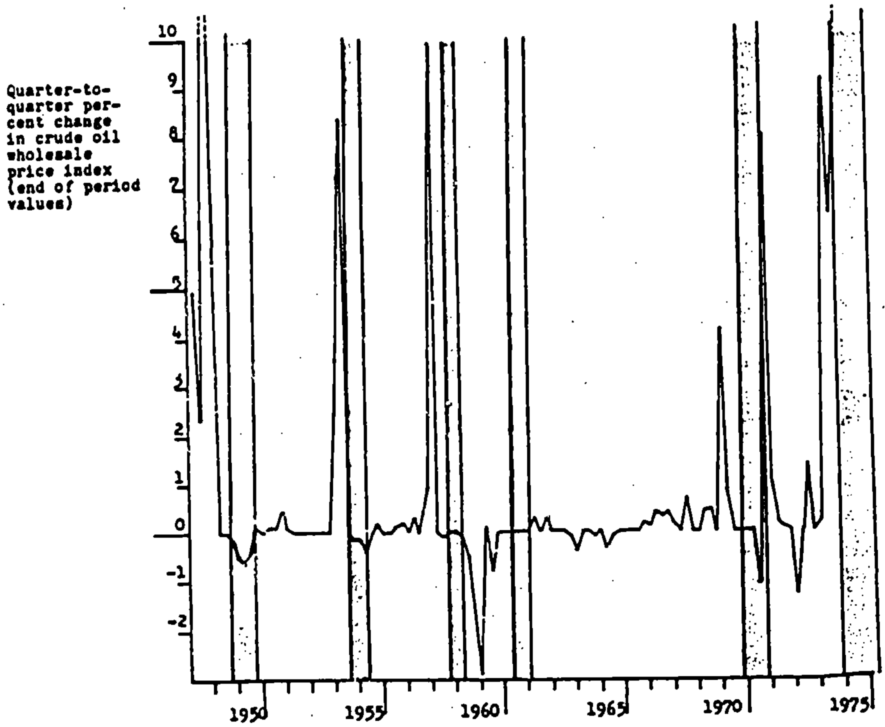

FIG. 1.—Changes in crude oil prices (solid lines) and U.S. recessions (shaded areas), 1947–75.

This decade of stagnating economic performance coincided with a period of rapidly rising energy prices and recurrent disruptions in petroleum supply, by the end of which the real price of energy had doubled its level of 1972. Not only has there been a secular correlation between energy and output over the last decade, there has been a cyclical correlation as well. Oil price increases and reports of heating oil shortages in early 1973 were followed by the onset of recession the subsequent winter. The sharp OPEC price increases of 1974:1 were likewise followed a year later by the dramatic output drop of 1975:1. And the gasoline shortages and price increases of 1979:2 in the wake of the Iranian revolution preceded the business cycle peak of 1980:1, just as the 1980:4–1981:1 oil price increases associated with the Iran-Iraq war and U.S. decontrol preceded the business cycle peak of 1981:3.

Figure 1 indicates that the cyclical tendency manifest over the last decade for oil price increases to be followed by recessions has in fact characterized every recession in the United States since World War II, with the single exception of the recession of 1960–61. The correlation has three possible explanations:

HYPOTHESIS 1: The correlation represents a historical coincidence; that is, the factors truly responsible for recessions just happened to occur at about the same time as the oil price increases.

HYPOTHESIS 2: The correlation results from an endogenous explanatory variable; that is, there is some third set of influences that in fact caused both the oil price increases and the recessions.

HYPOTHESIS 3: At least some of the recessions in the United States prior to 1973 were causally influenced by an exogenous increase in the price of crude petroleum.

Tests of hypothesis 1 are relatively uncontroversial; provided one attends with due care to issues of stochastic specification and data-instigated hypotheses, hypothesis 1 can be investigated through a straightforward application of traditional tests for absence of statistical correlation. More subtle is hypothesis 2, which I have investigated through two complementary methodologies, the first focusing on institutional and historical detail and the second on statistical evidence. In a separate paper (Hamilton 1982*a*) I have examined the specific historical events and institutions responsible for petroleum prices over this period. I argued that the discrete, dramatic pattern of crude oil price changes in figure 1 is explained by the specific regulatory structure of the oil industry over 1948–72. Each month the Texas Railroad Commission (TRC), and other state regulatory agencies like it, would forecast demand for petroleum for the subsequent month and would set allowable production levels for wells in the state to meet this demand. As a consequence, much of the cyclically endogenous component of petroleum demand showed up as a regulatory shift in quantities, not prices.[1] On the other hand, the TRC's sympathies were clearly with the producers it was meant to regulate, and the commission was generally unwilling or unable to accommodate sudden disruptions in supply, preferring instead to exploit these events to realize the dramatic price increases of figure 1.

The particular historical events behind such disruptions are summarized in table 1. I argued that this list of factors bears little resemblance to the usual enumeration of key business cycle developments, and in particular it seems difficult to claim economic endogeneity for events such as the Iranian nationalization in 1951–52, the Suez crisis of 1956–57, the secular decline in U.S. reserves toward the end of the

[1] This regulatory defense of posted petroleum prices also accounts for the close correspondence between domestic posted and transaction prices. According to Cassady (1954, p. 119), typically only 1 or 2 percent of total domestic crude would trade at premiums or discounts from posted prices and rarely more than 5 or 6 percent. This was not the case for internationally traded oil (see Adelman 1972; "What Price Crude Oil" 1969), whose price was not included in the Wholesale Price Index (WPI0561) on which my statistical results are based. See Hamilton (1982*a*) for further discussion.

TABLE 1

PRINCIPAL CAUSES OF CRUDE OIL PRICE INCREASES, 1947–81

Oil Price Episode	Principal Factors
1947–48	Previous investment in production and transportation capacity inadequate to meet postwar needs; decreased coal production resulting from shorter work week; European reconstruction
1952–53	Iranian nationalization; strikes by oil, coal, and steel workers; import posture of Texas Railroad Commission
1956–57	Suez crisis
1969	Secular decline in U.S. reserves; strikes by oil workers
1970	Rupture of trans-Arabian pipeline; Libyan production cutbacks; coal price increases (strikes by coal workers; increased coal exports; environmental legislation)
1973–74	Stagnating U.S. production; OPEC embargo
1978–79	Iranian revolution
1980–81	Iran-Iraq war; removal of U.S. price controls

SOURCE.—Hamilton (1982*a*).

1960s, the 1970 rupture of the trans-Arabian pipeline, the 1973–74 OPEC embargo, the 1979 Iranian revolution, and the 1980 Iran-Iraq war. My conclusion was that the regulatory environment thus acted to filter out many of the economically endogenous influences on petroleum demand and supply, with the result that the particular timing of changes in nominal crude oil prices reflects largely exogenous developments specific to the petroleum sector.

The second method by which I have sought to test for the endogeneity of crude oil prices is based on the suggestion of Granger (1969). The institutional perspective described above motivates the maintained null hypothesis of strict econometric exogeneity of crude oil prices. This hypothesis has the statistically refutable implication that no other series should "Granger-cause" oil prices. More loosely, I would further assert that if instead hypothesis 2 is true—that is, if some third set of variables in fact caused both the oil price increases and the recessions—then one should be able to identify unusual behavior in some of the key macro series in evidence *prior* to the oil price increases, which could have contributed significantly to the prediction of subsequent changes in oil prices.

A number of asymptotically equivalent tests have been proposed for assessing such a contribution to prediction. Monte Carlo studies by Geweke, Meese, and Dent (1979) and Nelson and Schwert (1979) suggest that the best approach may be to perform ordinary least squares on

$$z_t = a_0 + a_1 z_{t-1} + \ldots + a_q z_{t-q} + b_1 x_{t-1} + \ldots + b_q x_{t-q} + e_t \quad (1)$$

and test whether x is statistically informative about future z in the form of the restriction $b_1 = \ldots = b_q = 0$. For example, if z represents oil prices and x some other macro variable or set of macro variables suspected of causing oil prices, then I would regard failure to reject the null hypothesis H_0: $b_1 = \ldots = b_q = 0$ as failure to find evidence of unusual behavior in these macro variables prior to the oil price episode and thus as undermining the proposition that some third key influence was common to both the oil price increases and the subsequent recessions. On the other hand, if we perform a parallel test, letting z in equation (1) be the macro series and x oil prices, then I shall regard rejection of H_0 as evidence against the assertion that the correlation between oil prices and real output is just a coincidence.

Limitations of such "causality" tests are well known. The finding "x does not Granger-cause z" is neither necessary nor sufficient for a least-squares regression of x on past x and past and present z to yield consistent estimates of the parameters, nor does the statistical assertion "x Granger-causes z" say anything about x forcing or producing z in the sense that we might normally use the word "cause."[2] I argue instead that the combined discovery that "oil is statistically informative about future x" and "x is not statistically informative about future oil," if found for a variety of scalar and vector candidates for x, would indicate that (1) the correlation between oil and macro variables is not just a coincidence, and (2) no evidence could be found that the oil price increases would have been predicted on the basis of what was happening in the macroeconomy up until that time. Such a finding, in conjunction with the historical analysis of the apparently exogenous causes of oil price increases, could then establish the case for seeking a causal interpretation of the pattern in figure 1.

II. The Role of Oil in a Simple Macroeconomic Model

As a starting point for this analysis, I examine the role of oil in a version of the six-variable system which Sims (1980*b*) presented as a compact approximation to macroeconomic reality. This system includes two output variables (real GNP and unemployment), three price variables (implicit price deflator for nonfarm business income, hourly compensation per worker, and import prices), and a single series M1 to represent the financial sector. My analysis also addresses two possible sources of nonstationarity. First, oil prices have obviously been determined under a radically different institutional regime since 1973 than before. Restricting the analysis to the period prior to 1973

[2] Jacobs, Leamer, and Ward 1979; Geweke 1980. Some of the obvious criticisms of such tests were anticipated by Sims (1972, 1977).

TABLE 2

BIVARIATE GRANGER-CAUSALITY TESTS FOR SIX VARIABLES IN SIMS'S (1980b) SYSTEM VERSUS CHANGES IN OIL PRICES

Null Hypothesis	$q = 4, T = 95$ (t = 1949:2–1972:4) $F(4,86)$	(p-value)	$q = 8, T = 91$ (t = 1950:2–1972:4) $F(8,74)$	(p-value)
Real GNP: $y_t = \log(GNP72_t/GNP72_{t-1})$:				
H_1: $y \nrightarrow o$	.58	(.68)	.71	(.68)
H_2: $o \nrightarrow y$	5.55	(.0005)	3.28	(.003)
Unemployment: $u_t = RUNS_t$:				
H_3: $u \nrightarrow o$	2.06	(.09)	1.48	(.18)
H_4: $o \nrightarrow u$	3.79	(.007)	3.08	(.005)
U.S. prices: $p_t = \log(PYNDOMNF_t/PYNDOMNF_{t-1})$:				
H_5: $p \nrightarrow o$	2.01	(.10)	1.54	(.16)
H_6: $o \nrightarrow p$	.40	(.81)	.31	(.96)
Wages: $w_t = \log(JRWSSNF_t/JRWSSNF_{t-1})$:				
H_7: $w \nrightarrow o$	1.92	(.11)	1.46	(.19)
H_8: $o \nrightarrow w$	1.28	(.28)	1.32	(.25)
Money: $m_t = \log(MONEYNS_t/MONEYNS_{t-4})$ $- \log(MONEYNS_{t-1}/MONEYNS_{t-5})$:				
H_9: $m \nrightarrow o$	.42	(.79)	.49	(.86)
H_{10}: $o \nrightarrow m$	1.10	(.36)	2.22	(.04)
Import prices: $p_t^m = \log(PM_t/PM_{t-1})$:				
H_{11}: $p^m \nrightarrow o$	.55	(.70)	3.21	(.003)
H_{12}: $o \nrightarrow p^m$	.22	(.93)	.26	(.98)
H_{13}: $p^m \nrightarrow y$	.92	(.46)	1.01	(.44)

avoids this source of nonstationarity[3] and also separates the data that suggested the hypothesis (i.e., post-OPEC experience) from those on which it is to be tested. A second source of nonstationarity is the secular time trend common to many macro series. This was generally treated by first-differencing, and where the autocorrelogram continued to exhibit symptoms of unit seasonal roots, a subsequent fourth difference was taken as well. Results for pre-1973 data of bivariate Granger-causality tests between oil price changes and detrended values of each of Sims's six variables are reported in table 2.[4]

[3] A structural shift in the univariate process for oil prices could change the reduced-form relation between output and oil prices even if the relation between innovations of the two series remained the same. Hence, tests of the null hypothesis that oil prices do not Granger-cause output may have limited power if the sample is nonstationary in this sense. It is also of course possible that OPEC today bases its decisions on U.S. output and prices in a manner which was not the case for oil prices over the period 1948–72, so that tests for other series which lead oil prices might well give different answers under the post-OPEC regime.

[4] Statistics for $x \nrightarrow z$ represent an F-test of $b_1 = \ldots = b_q = 0$ in an OLS estimation of

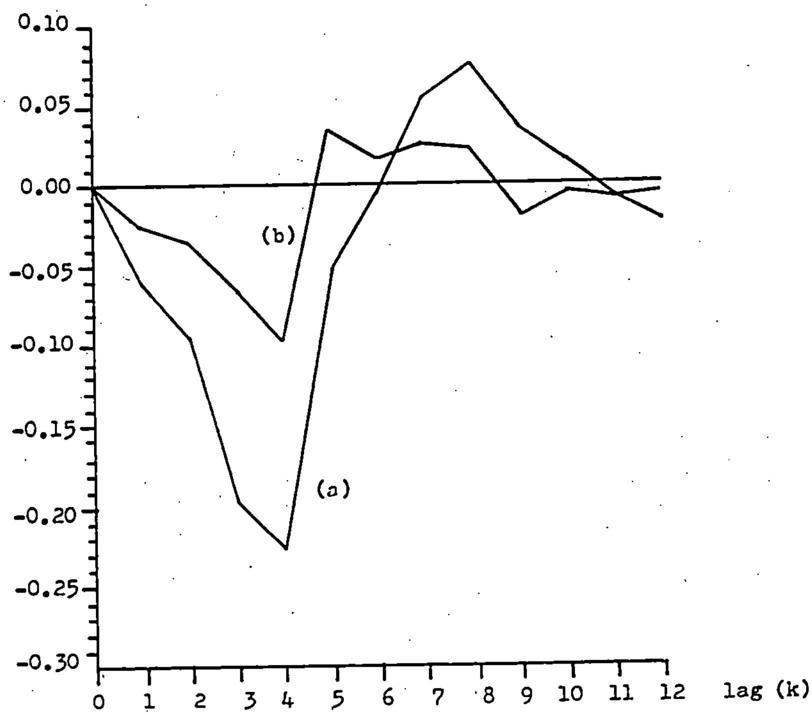

FIG. 2.—"Final form" relation between changes in real GNP and previous changes in oil prices as estimated for (*a*) 1948–72; (*b*) 1973–80.

The failure to reject hypothesis H_1 indicates a lack of evidence of any unusual behavior in real output which could have been used effectively to predict oil price changes over the 1948–72 period. On the other hand, the parallel hypothesis H_2 that oil price changes could not contribute to a prediction of future changes in real GNP can be easily rejected at the .001 level based on a four-lag regression and almost as solidly for an eight-lag regression. Inverting the autoregressive lag polynomial in the bivariate four-lag regression associated with H_2 produces an infinite distributed lag of y on past values of o alone, the coefficients of which are plotted in figure 2*a*: typically, an increase in oil prices was followed 3–4 quarters later by slower output growth, with a recovery beginning after 6–7 quarters.

Results for unemployment, the second output variable in Sims's system, are similar. Unemployment does a modestly better job at predicting oil prices than did real GNP, though the relation is not statisti-

eq. (1), with $q = 4$ and 8 and t running over bounds indicated in column headings. The variable o_t represents first-differenced logs of end-of-quarter values of monthly WPI0561, seasonally unadjusted. All data used in this analysis are published in Hamilton (1982*b*) and are available from the author on request.

cally significant at the .05 level.[5] The test for Granger causality running in the other direction, however, is again unambiguous; clear rejection of hypothesis H_4 at the .01 level casts serious doubt on the proposition that the correlation between oil price changes and future levels of unemployment represents a random coincidence.

Domestic prices (H_5) and wages (H_7) turn out to be no better predictors of oil prices than unemployment; the oil price series is clearly doing something substantially more than just mirroring the behavior of prices generally in the economy. It is also clear from hypothesis H_9 in table 2 that changes in the growth rate of M1, sometimes asserted to be a driving variable in the postwar economy, did not exhibit any unusual behavior prior to the oil price increases. On the other hand, the data warrant rejection based on the eight-lag test of hypothesis H_{10} that money growth rates were themselves unaffected by changes in oil prices. An increase in oil prices tended to be followed for the next year by slower than normal rates of growth of money and by faster than normal rates once the economy started to pull out of recession.

The only one of Sims's six variables to show up as individually statistically significant prior to oil prices is the change in import prices, and here only in the eight-lag regression (hypothesis H_{11} in table 2). Nor do the six variables collectively exhibit statistically unusual behavior in the year prior to the oil price increase (hypothesis H_1 in table 3). However, the F-test is close to the critical value, and in estimating 29 parameters, this latter test is not especially powerful. It might therefore be argued that import prices contributed to a prediction of oil prices in the eight-lag regression of hypothesis H_{11} in table 2 because import prices somehow captured better than the other five series the particular point in a business expansion at which excessive aggregate demand was soon to be manifest in an increase in oil prices. I have tried to test for this possibility using an approach pioneered by Barro (1977). As a first step I constructed a regression equation to predict import price changes according to previous values of each of the six variables in my version of Sims's system:

$$\begin{aligned} p_t^m = a_0 + \mathbf{x}'_{t-1}\mathbf{a}_1 + \mathbf{x}'_{t-2}\mathbf{a}_2 \\ + \ldots + \mathbf{x}'_{t-4}\mathbf{a}_4 + e_t, \end{aligned} \qquad (2)$$

[5] Note that use of the 5 percent level implies that for every 20 independent series tested, one will falsely appear to Granger-cause oil prices. For the large number of series examined in this paper this would seem to stack the odds against the finding of exogeneity. An alternative to classical hypothesis testing is to interpret the F-tests as a purely descriptive statistic of the usefulness of the variable in predicting oil prices. Specifying a critical value of 5 percent is equivalent to requiring the four parameters estimated for an added variable to increase the R^2 by .10 over a four-lag autoregression for oil prices.

TABLE 3

Multivariate Granger-Causality Tests

H_1: $y, u, p, w, m, p^m \nrightarrow o$
t = 1949:2–1972:4, 4 lags each variable
$F(4,66) = 1.61$, $p = .065$

H_2: $o \nrightarrow y$ given past y, u, p, w, m, p^m
t = 1949:2–1972:4, 4 lags each variable
$F(4,66) = 6.03$, $p = .0003$

H_3: $o \nrightarrow u$ given past y, u, p, w, m, p^m
t = 1949:2–1972:4, 4 lags each variable
$F(4,66) = 3.99$, $p = .006$

H_4: $o \nrightarrow y$ given past y, p^m
t = 1950:2–1972:4, 8 lags each variable
$F(8,66) = 3.45$, $p = .002$

H_5: $o \nrightarrow y$ given past y, s
t = 1950:2–1972:4, 8 lags each variable
$F(8,66) = 3.18$, $p = .004$

H_6: $o \nrightarrow y$ given past y, p'
t = 1950:2–1972:4, 8 lags each variable
$F(8,66) = 3.34$, $p = .003$

H_7: $o \nrightarrow y$ given past y, p^m, s, p'
t = 1949:2–1972:4, 4 lags each variable
$F(4,74) = 3.39$, $p = .013$

where $\mathbf{x}_t' = (y_t, u_t, p_t, w_t, m_t, p_t^m)$. I then interpreted the fitted values of this equation $\hat{p}_t^m$ as that component of import price changes which was most clearly endogenous with respect to the business cycle. The second step was to compare these fitted values $\hat{p}_t^m$ with the estimated residuals $p_t^m - \hat{p}_t^m$ in terms of their ability to explain future changes in oil prices:[6]

$$\begin{aligned} o_t = b_0 &+ b_1 o_{t-1} + b_2 o_{t-2} + \dots \\ &+ b_8 o_{t-8} + c_1 \hat{p}_{t-1}^m + \dots + c_8 \hat{p}_{t-8}^m \\ &+ d_1(p_{t-1}^m - \hat{p}_{t-1}^m) + \dots + d_8(p_{t-8}^m - \hat{p}_{t-8}^m) \\ &+ v_t. \end{aligned} \tag{3}$$

The null hypothesis that the influence of import prices on oil prices appears solely because import prices are proxying the state of the general economy was tested in the form of the restriction $d_1 = \dots = d_8 = 0$. This restriction was found to be inconsistent with OLS on equation (3) for t = 1952:2–1972:4, $F(8,58) = 2.41$, $p = .03$. On the

[6] In this and subsequent "anticipated-unanticipated" tests, the lags were chosen so as to give the strongest prediction of oil prices; hence, lag 8 was chosen in (3) in the light of hypothesis H_{11} in table 2.

other hand, the data fail to reject at the .05 level the null hypothesis that oil prices were influenced only by that part of import price changes which could not have been anticipated on the basis of the earlier state of U.S. prices and output; that is, the data admit the restriction $c_1 = \ldots = c_8 = 0, F(8,58) = 1.78, p = .10$. Moreover, even in a regression of output changes on four lags each of y, u, p, w, m, and p''', lagged oil prices still enter statistically significantly in predictions of output (H_2 in table 3) and unemployment (H_3 in table 3) over this period. I thus conclude that to the extent that oil prices were correlated with previous changes in import prices, this correlation is not attributable to import prices acting as a proxy for the general state of output or prices in the U.S. economy as a whole.

Of course, the possibility remains that import prices were correlated with some other unspecified influences that were in fact true causes of the recessions. There are, however, several reasons for doubting this interpretation as well. (1) Import prices do not themselves Granger-cause output in either the four- or eight-lag regressions (H_{13} in table 2). (2) Those oil price increases anticipated on the basis of an eight-lag regression on past import and oil prices likewise fail to Granger-cause output, $F(4,74) = 1.11, p = .36$. (3) Rather, it is precisely those oil price increases which were unanticipated on the basis of previous import prices which account for the correlation between oil prices and output, $F(4,74) = 3.80, p = .007$. (4) Even with eight lags on import prices and output, lagged oil prices still contribute significantly to a prediction of output (H_4 in table 3). Thus, even though import prices are statistically informative about future oil prices over this period, this correlation is unable to account for that between oil prices and output.

The results of this investigation into the role of oil in Sims's macro model thus suggest that oil price increases over the period 1948–72 tended to be followed by reductions in real GNP growth that would not have been anticipated on the basis of the previous behavior of output, prices, or the money supply. Moreover, this statistical regularity is exceedingly unlikely to have resulted from random correlation between the series, and I have likewise been unable to find any indication that the correlation arises because oil prices were proxying some third macroeconomic influence that was in fact the true cause of the recessions. It is, of course, still possible that the particular series represented in Sims's system may not adequately represent the status of key macro variables. Accordingly, I examine in the next section a number of output, price, and financial variables not included in Sims's system for evidence of a common third factor behind oil prices and recessions during 1948–72.

III. Alternative Indicators of Output, Prices, and Finance

Output

Some may object to the regression of a real on a nominal magnitude. However, nominal GNP is no better a predictor of nominal oil prices than was real GNP (hypothesis 1 in table 4), whereas nominal oil prices still Granger-cause nominal GNP, $F(8,74) = 2.44$, $p = .02$. Note that, apart from the constant term, this latter regression is equivalent to a regression of real GNP on real oil prices.[7]

It is also conceivable that even though oil price increases do not seem to have been preceded by any unusual changes in the flow of output, there could be subtle differences in the composition of this flow between final sales and accumulation of inventories that were important in determining the future course of events. Hypothesis 2 in table 4, however, uncovers no evidence that changes in oil prices were preceded by any changes in the ratio of inventories to final sales. I further observe in hypothesis 3 that the Bureau of Economic Analysis (BEA) index of leading indicators likewise failed to be statistically informative about future oil prices over the 1948–72 period. Capacity utilization rates (hypothesis 4) would surely register an unusual status of aggregate demand, but as with all of the other output measures I have examined, this series contains no useful information about the timing of oil price shocks.

I suggested in table 1 that strikes by oil, coal, and perhaps steel workers were contributing factors in several of the oil price increases. A general increase in strike activity may in turn have reflected a critical state in the business cycle or may itself have played a role in the subsequent recessions. Hypothesis 5 in table 4 confirms that a statistically significant portion of the variance in oil price changes could be accounted for by the ratio of man-days idle due to strikes to total employment. However, the data reject the hypothesis that only those strikes anticipated on the basis of a regression on Sims's six variables are correlated with future oil prices, $F(4,74) = 3.31$, $p = .01$, whereas the data admit the hypothesis that only unanticipated strikes mattered, $F(4,74) = 1.64$, $p = .17$; thus strikes seem not to have been acting as proxy for the general state of the macroeconomy. Moreover, (1) those oil price increases anticipated on the basis of an eight-lag regression on past strikes and oil prices fail to Granger-cause output,

[7] I nevertheless regard H_2 in table 2 as the specification of interest, since (1) the institutional argument is that nominal, not real, oil prices track the historical petroleum shocks and are the exogenous variable belonging in a reduced-form regression, and (2) it is naive to assume that the expected change in the relative shadow price of oil equals the (possibly disequilibrium) market price divided by a contemporaneous price index (see Hamilton 1982*b*).

TABLE 4

MARGINAL SIGNIFICANCE LEVELS FOR REJECTION OF NULL HYPOTHESIS THAT x DOES NOT GRANGER-CAUSE OIL PRICES, FOR x ALTERNATIVE INDICATORS OF OUTPUT, PRICES, AND FINANCE, 1948–72

x	Filter for Stationarity	$F(4,86)$ p-value	$F(8,74)$ p-value
Output:			
1. Nominal GNP	$(1 - L)(1 - L^4)\log$	(.60)	(.50)
2. Inventories/sales	$(1 - L)$	(.58)	(.75)
3. BEA Index of Leading Indicators	$(1 - L)$	(.56)	(.61)
4. FRB Index of Capacity Utilization	1	(.27)	(.33)
5. Strikes	1	(.04)*	(.13)
Prices:			
6. Relative oil prices	1	(.13)	(.18)
7. Wholesale prices	$(1 - L)\log$	(.76)	(.88)
8. Nonferrous metals	$(1 - L)\log$	(.87)	(.45)
9. Iron and steel	$(1 - L)\log$	(.13)	(.12)
10. Farm products	$(1 - L)\log$	(.38)	(.55)
11. Lumber products	$(1 - L)\log$	(.90)	(.42)
12. Coal	$(1 - L)\log$	(.003)**	(.004)**
Finance:			
13. BAA Bond Yields	$(1 - L)$	(.10)	(.55)
14. Dow-Jones Industrial Average	$(1 - L)\log$	(.68)	(.44)

NOTE.—BEA = Bureau of Economic Analysis; FRB = Federal Reserve Board; BAA = a type of rating given to bonds that reflects a company's financial status.
* Statistically significant at 5 percent level.
** Statistically significant at 1 percent level.

$F(4,78) = 1.38$, $p = .25$. (2) By contrast, unanticipated oil prices are statistically informative about future output, $F(4,78) = 5.66$, $p = .005$. (3) Oil price increases are still statistically informative about future output even if lagged strikes are taken into account in the regression (H_5 in table 3). Again, an apparent cause of oil price increases has been found, but, as in the case of import prices, it appears to be a largely exogenous influence and is not amenable to a third-variable interpretation of the oil-output connection.

Prices

While one may argue that the proximate cause of the oil price increases of 1957 was the Texas Railroad Commission's refusal to raise production allowables in the wake of the Suez crisis, it still might be argued that the TRC's desire to see prices rise was in turn conditional on the modest inflation of 1954–56. I have sought evidence of an inflationary "catch-up" effect by regressing oil price changes on the (not detrended) ratio of the crude oil producer price index to that for commodities generally. Hypothesis 6 in table 4 shows that such a variable does a slightly worse job of predicting oil price changes than did simple changes in the implicit business income deflator. While a catch-up phenomenon was surely operative, it seems unable statistically to explain the particular timing of the oil price shocks or, thus, the regularity in the timing between these oil shocks and the subsequent recessions.

Despite the apparent absence of unusual aggregate demand conditions prior to the oil price increases, the concern remains that oil prices increase when economic booms confront inelastic commodity supplies; recessions, for reasons unrelated to the commodity price increases, might then follow booms. The main difficulty with this interpretation, however, is that one should see a pattern similar to that in figure 1 for a variety of price indexes; I am aware of no other series which displays parallel behavior. For example, neither the general wholesale price index, $F(4,86) = 0.47$, $p = .76$, nor that for nonferrous metals, $F(4,86) = 1.04$, $p = .39$, Granger-causes real GNP over this period, and a repetition of the test used to establish the exogeneity of oil prices would lead to the conclusion that increases in nonferrous metals prices could easily be predicted from previous changes in real GNP, $F(4,86) = 4.19$, $p = .004$. I have been unable to find any unusual behavior in the prices of nonferrous metals, iron and steel, farm products, or lumber products prior to the oil price increases (hypotheses 8–11 in table 4). The one price series which I have found to be strongly correlated with future oil price changes is that for coal, which finding again corroborates the historical conclusions of table 1.

I have repeated the anticipated-unanticipated decomposition for this coal-oil relationship. Coal prices again seem not to be proxying the general state of Sims's macroeconomy. On the other hand, both those oil price increases anticipated on the basis of coal prices, $F(4,78) = 3.29$, $p = .02$, and those unanticipated ($p = 6 \times 10^{-5}$) have a statistically significant correlation with future output. Part of the strength of the observed oil-output relation, then, may be attributable to the fact that crude oil price increases reflected broader increases in the relative price of energy generally. Still, coal prices are not by themselves statistically informative about future output, $F(4,86) = 1.42$, $p = .23$; $F(8,72) = 1.30$, $p = .26$; nor does the inclusion of coal prices in any way diminish the statistical contribution of oil prices (H_6 in table 3). Note further that even inclusion of all three of the economic variables associated with oil prices likewise cannot account for the statistical correlation between oil prices and output (H_7 in table 3), despite the fact that these three variables were selected specifically on the basis of their collinearity with oil price changes.

Financial Variables

Sims (1980*a*) has noticed a tendency for postwar recessions to be preceded by an increase in interest rates, which seems to have predated the decline in the rate of growth of the money supply known to be associated with the first stages of an economic downturn. I indeed found a positive correlation between oil price changes and the change in interest rates the previous period, though a test for statistical significance fails to reject the null hypothesis of no relation at the .05 level (hypothesis 13 in table 4), and the correlation is certainly not strong enough to explain the oil-GNP connection. Moreover, oil price increases tended to be followed by dramatic adjustments in the bond markets that would not have been anticipated on the basis of the earlier pattern developing in interest rates, $F(4,86) = 3.80$, $p = .007$. As final evidence against the assertion that some third influence both caused the oil price increases and contained the seeds of an incipient recession, I add the testimony of efficient markets: hypothesis 14 in table 4 shows that if recession was incipient prior to the oil shocks, it was news to Wall Street.

IV. Specification Analysis

Precisely because the visual appearance of figure 1 is so dramatic, oil price changes clearly cannot be presumed to follow a Gaussian process. This has implications both for the probability distribution assumed for regression residuals and for functional form.

The Distribution of Regression Residuals

My maintained hypothesis is that the variance of oil price changes was historically dominated by dramatic, exogenous events. In the regression used to test H_1 in table 2,

$$o_t = a_0 + a_1 o_{t-1} + \ldots + a_8 o_{t-8} + b_1 y_{t-1} + \ldots + b_8 y_{t-8} + e_t. \tag{4}$$

This corresponds to the joint assertion that $b_1 = \ldots = b_8 = 0$ and that e_t follows a highly leptokurtic probability distribution. Accordingly, an F-test could lead to rejection either because $\mathbf{b} \neq \mathbf{0}$ or because the small-sample properties of this test are poor when the e_t are nonnormal.[8] The Lomnicki (1961, p. 59) test for leptokurtosis compares the

[8] Even for normal errors, the F-test is only appropriate asymptotically. The assertion that ratios of sums of squares of highly leptokurtic residuals converge more slowly to the limiting distribution than if the true innovations were Gaussian remains an unproven conjecture of the author.

sample second and fourth moments about the mean (m_2 and m_4) with those expected for a normal distribution. For a white noise Gaussian process, the statistic $L = \sqrt{T}(m_4 m_2^{-2} - 3)/\sqrt{24}$ asymptotically approaches an $N(0, 1)$ distribution. For the residuals of regression 4, $L = 30.04$, and three of the 91 residuals are more than four standard deviations from zero—quite impossible events for a normal variate. Consequently, previously reported p-values associated with other series Granger-causing oil prices might be suspected of misstating the true probability.

By contrast, there is no particular reason to believe that the residuals from regressions in which oil price changes are the independent variable are similarly ill behaved. For example, in the regression associated with H_2 in table 2,

$$\begin{aligned} y_t = a_0 + a_1 y_{t-1} + \ldots + a_8 y_{t-8} \\ + b_1 o_{t-1} + \ldots + b_8 o_{t-8} + u_t, \end{aligned} \tag{5}$$

$L = 1.14$ and only two of these 91 residuals exceed two standard deviations. Thus the specification issue raised in connection with equation (4) seems not to apply to the tests for whether oil prices Granger-cause other macro series.

Geweke (1978, p. 169) suggested that one can exploit this asymmetry in choosing between the Granger (1969) and Sims (1972) versions of these tests. One can thus test for whether output Granger-causes oil prices through a regression in which the latter appears as the independent variable, namely,

$$\begin{aligned} y_t = a_0 + a_1 y_{t-1} + \ldots + a_8 y_{t-8} + b_0 o_t \\ + b_1 o_{t-1} + \ldots + b_8 o_{t-8} + c_1 o_{t+1} \\ + \ldots + c_s o_{t+s} + v_t, \end{aligned} \tag{6}$$

and testing the null hypothesis y does not Granger-cause o in the form of the restriction $c_1 = \ldots = c_s = 0$. Note that the residuals so restricted are essentially identical to the unrestricted residuals in (5), which were already seen to have been compatible with a Gaussian assumption.[9]

I have repeated the key tests for other series Granger-causing oil prices based on equation (6). None of Sims's six variables turn out to be statistically informative about future oil prices based on this specification for either $s = 4$ or $s = 8$, the strongest result coming for the four-lead test for wages predicting oil, $F(4,66) = 2.04$, $p = .10$. In

[9] On either (4) or (6), F-tests are apt to be a similar transformation of the conditional cross-correlation between y_t and o_{t+j} (see Theil 1971, pp. 173–74). Thus, the fact that (6) exists as a well-motivated test helps justify use of standard hypothesis tests on (4).

particular, the earlier finding that import prices were statistically informative about future oil prices cannot be reproduced under this alternative form of the test. On the other hand, the statistical influence of strike activity, $F(4,66) = 3.42$, $p = .01$, and coal prices, $F(4,66) = 5.23$, $p = .001$, on the crude oil price series is reconfirmed under the Sims-Geweke test. The conclusion that oil price increases over the period 1948–72 primarily reflected the influence of economically exogenous events thus appears to be robust with respect to the assumed distribution of regression residuals.

Functional Form and Structural Stability

It is well known that for a multivariate Gaussian process the expectation of one variable conditional on the values of the others is linear in the observed values. Alternatively, one often hopes to approximate an arbitrary function in a neighborhood of the sample mean by a linear relation. However, oil price changes are exceedingly leptokurtic, and the increases of 1974:1 were three times as large as anything observed during 1948–72. Consequently, extrapolation to post-1973 data of a linear relation between oil prices and output estimated over 1948–72 must be regarded with some caution, and indeed the postsample predictions of this relation turn out to be quite poor. An F-test documents a structural change among the nine coefficients of the relation

$$\begin{aligned} y_t = a_0 + a_1 y_{t-1} + \ldots + a_4 y_{t-4} \\ + b_1 o_{t-1} + \ldots + b_4 o_{t-4} + u_t \end{aligned} \tag{7}$$

between the sample periods t = 1949:2–1972:4 and t = 1973:1–1980:3, $F(9,108) = 2.43$, $p = .01$.[10]

Is it possible, then, that the regularity observed in (7) over the period 1948–72 represents a historical aberration which has no relation to events since then? Columns 1 and 2 in table 5 compare the coefficients in (7) estimated separately for t = 1949:2–1972:4 and t = 1973:1–1980:3, while figure 2 compares the final forms associated with each of these separate regressions. The dynamics of the relation in fact appear to be very similar over the two periods, with an increase in oil prices followed for 4 quarters by successively slower rates of growth of real GNP, and then a recovery after 6–7 quarters. Furthermore, the 1973–80 data in themselves warrant clear rejection of the null hypothesis that oil prices did not Granger-cause real GNP during the post-OPEC period (col. 2 in table 5). The impression, then,

[10] See Fisher (1970) for details of the tests invoked for structural change.

TABLE 5

Regression Coefficients Relating y_t to o_t for Indicated Sample Periods, with F-Test That Coefficients on Lagged o_t Are All Zero

	Sample Period*			
Coefficient	1949:2–1972:4 (1)	1973:1–1980:3 (2)	1948:2–1972:4 (3)	1948:2–1980:3 (4)
Constant	.011	.023	.0088	.010
	(.0016)	(.0050)	(.0017)	(.0016)
y_{t-1}	.19	−.20	.30	.21
	(.097)	(.18)	(.10)	(.088)
y_{t-2}	.15	−.064	.10	.16
	(.097)	(.20)	(.11)	(.092)
y_{t-3}	−.049	−.088	−.098	−.081
	(.097)	(.20)	(.10)	(.092)
y_{t-4}	−.28	−.34	−.26	−.25
	(.092)	(.19)	(.10)	(.088)
o_{t-1}	−.061	−.023	−.041	.004
	(.056)	(.028)	(.061)	(.023)
o_{t-2}	−.082	−.038	.019	−.007
	(.056)	(.028)	(.036)	(.021)
o_{t-3}	−.170	−.078	−.057	−.050
	(.057)	(.030)	(.035)	(.021)
o_{t-4}	−.177	−.115	−.047	−.062
	(.059)	(.033)	(.035)	(.021)
F-statistic	$F(4,86)$ = 5.55	$F(4,22)$ = 5.71	$F(4,90)$ = 1.51	$F(4,121)$ = 5.28
p-value	.0005	.003	.21	.0007

Note.—y_t = quarterly changes in log of real GNP; o_t = quarterly changes in nominal end-of-period crude oil prices. SEs of coefficients are in parentheses.
* Bounds on t in regression 7.

is that the separate periods 1948–72 and 1973–80 are each characterized by a statistically significant relation between oil prices and real GNP and that, while this relation manifests similar dynamics across the two periods, a linear approximation to it would lead to a choice of smaller coefficients on oil price increases for the later period.

A similar phenomenon is observed when one includes the volatile oil prices of 1947 (see col. 3 in table 5). Estimation of equation (7) for t = 1948:2–1972:4 again yields substantially lower coefficients on the oil price terms than were obtained for t = 1949:2–1972:4,[11] and indeed the relation between oil prices and output is no longer significant at the .05 level (col. 3 in table 5). A Chow test for structural change confirms that the 1948–72 linear relation does not adequately capture the 1947 experience, $F(4,86) = 5.37$, $p = .0007$. Nevertheless, when one averages in the 1947 experience by estimating

[11] The original investigation started with t = 1949:2, i.e., was restricted to data beginning in 1948:2, since this is the first date for which some of the detrended series were available.

equation (7) for t = 1948:2–1972:4 as though it were a single stable relation, the estimated coefficients have a much better fit to post-1973 experience than did those estimated for t = 1949:2–1972:4, giving rise to a postsample mean squared forecast error of 1.22×10^{-4} for the period 1973:1–1980:3, as opposed to 1.46×10^{-4} for a purely autoregressive relation on y. Likewise, the data fail to reject the null hypothesis of no structural change between this average relation estimated for t = 1948:2–1972:4 and a second regression estimated for t = 1973:1–1980:3, $F(9,112) = 1.27$, $p = .26$.

There are thus at least some aspects of the relation between oil prices and output which are quite similar across the different periods. One might accordingly try to reconcile the two dynamic multipliers illustrated in figure 2 with a single functional form, interpreting the two paths as derivatives averaged over two parts of a nonlinear relation. However, nonlinearity is clearly not the only explanation for the discrepancy. Even though equation (7) may represent a feedback-free reduced-form relation, any changes in the structural equations of the system would of course also change the coefficients in this relation. One obvious candidate for such change is the secular inflation rate, the periods 1947:2–1948:1 and 1973:1–1980:3 being characterized on average by general price increases some five to six times as great as those during 1948:2–1972:4. The same nominal oil price increase could be expected to lead to a smaller output effect during inflationary times than in noninflationary times, and this is exactly what was found in figure 2 and table 5.

There are a number of other factors which could also give rise to instability in a reduced-form relation such as (7). In late 1947 and since 1972, but at no time in between these dates, Texas oil fields were at 100 percent production. Movements in the price of crude would represent fundamentally different signals of supply and demand during the regulatory regime than they would outside it. Likewise, oil price increases have sometimes been accompanied by contemporary accounts of consumer rationing; if oil prices have historically served as a proxy for such quantity constraints, equation (7) would falsely anticipate a contraction in output for an increase in the price of crude that might not have been associated with any physical shortages. Finally, to the extent that a deliberate monetary contraction is part of the sequence of events subsequent to the oil price increases that led to recession, a change in this regime could also alter the effective impact multipliers associated with (7).

V. Conclusions

Seven of the eight postwar recessions in the United States have been preceded by a dramatic increase in the price of crude. What further can be said about this correlation in the light of the econometric evidence presented above?

1. There are few grounds for claiming that the correlation between oil prices and output represents just a statistical coincidence. The evidence since 1973 in itself is sufficient to motivate a suspicion of a systematic relation between oil prices and output, and searching for a similar pattern in a different data set (1948–72) calls for clear rejection of the null hypothesis of no relation at the .01 significance level and, for some tests, at the .001 level. Accordingly, a systematic account of why oil price increases should have been followed 3–4 quarters later by output declines seems to be called for.

2. I find little support for the proposition that over the period 1948–72 some third set of influences was responsible for both the oil price increases and the subsequent recessions. None of the six variables in Sims's (1980*b*) macroeconomic system, singly or collectively, exhibited any unusual behavior in the year prior to the oil price increases that could have been used statistically to predict the oil price episodes, and only import prices, which one might have expected to be the series *least* indicative of endogenous business conditions, were statistically informative about future oil prices based on 8-quarter lags. I further observe that (*a*) this latter correlation seems to be attributable precisely to that component of import price changes that would not have been predicted on the basis of previous changes in U.S. output, prices, or money growth rates; (*b*) it is in fact those oil price changes that would not have been predicted on the basis of previous import price changes that are statistically informative about future output; and (*c*) import prices could not by themselves have been used to predict the subsequent economic downturns. Moreover, the conclusion that import prices over the period 1948–72 were statistically informative about future oil prices was not found to be robust with respect to an alternative specification that perhaps relies on more realistic distributional assumptions. If some third macroeconomic variable was in fact responsible for both the oil price increases and the subsequent recessions, its effect is not apparent in this small version of the macroeconomy.

In searching a variety of other series for evidence of unusual statistical behavior prior to the oil price shocks, I have found that the series most useful in predicting oil prices are, again, least likely to be regarded as key endogenous indicators of economic activity. Inventories, capacity utilization, the Bureau of Economic Analysis (BEA) leading indicator series, interest rates, and the stock market would all have failed to predict the major oil price changes over the period 1948–72. One likewise cannot mimic the oil price–GNP relation using wholesale prices generally, nor could a variety of aggregate or specific commodity price indexes have been used to predict the oil price increases. The two series which I have found to be statistically informative about future oil price changes over this period are (*a*) the aggregate incidence of strike activity and (*b*) coal prices. As in the analysis of import prices, neither of these series could itself have been used to predict the subsequent output declines, and it is again that component of each series that would not have been predicted on the basis of previous macroeconomic activity that is most useful in predicting future oil prices.

This is not to argue that endogenous price, output, or financial variables had no influence on oil prices over the period 1948–72, even though that literal assertion is consistent with all of the hypothesis tests that I have undertaken. Undoubtedly the oil industry and its regulators were conscious of the erosion of the real price of crude effected through inflation and were anxious to make up for this loss at any opportunity. What does seem to be the case, however, is that historically these opportunities derived from events which truly were exogenous with respect to the American economy, such as the nationalization of Iranian assets, the Suez crisis, the secular decline in energy reserves, strikes by oil and coal workers, and other economic developments specific to the energy sector. Insofar as exogenous events of this sort account for the particular timing of oil price increases, the regularity in the timing between oil price increases and the subsequent recessions in turn becomes difficult to attribute to their common dependence on some third set of influences endogenous to the macroeconomy.

If the correlation between oil price increases and real output cannot be explained as just a coincidence or as just another correlation between endogenous macro variables, the case is strengthened for the third interpretation: the timing, magnitude, and/or duration of at least some of the recessions prior to 1973 would have been different had the oil price increase or attendant energy shortages not occurred. This is not to say that oil price increases are either a necessary or a sufficient condition for postwar recessions. In the light of the recession of 1960 and the oil price increases of 1970–71, they are clearly neither. Nor is it to assert that this correlation should be viewed as an immutable structural relation. Changes in expected inflation, the response of monetary policy to oil shocks, or the regime in which oil prices are determined could be expected to give rise to a different dynamic pattern. But what does seem to be true is that the post-OPEC world has more in common with its predecessor than many might suppose. What is needed is not to abandon the demand-oriented interpretation of the fifties and sixties or the supply-oriented approach to the seventies but rather to resynthesize the histories told for both.

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On the macroeconomic effects of energy price shocks

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Energy price shocks are widely believed to have severe macroeconomic effects, although this conclusion is far from unanimous in the economics literature. An analysis of disaggregated industry data for four countries after each energy price shock in the 1970s reinforces doubts about the role of energy in these recessions. There was no similarity in the impact on output and employment across industries between the two recessions, and no consistent relationship between industry activity and energy intensity by industry. In addition, there is no evidence to support either the wage rigidity hypothesis or the capital obsolescence hypothesis as an explanation of the effect of energy price shocks on macroeconomic behavior.

1. Introduction

The effect of energy price shocks on economic stability is uncertain, including the extent to which the two energy price shocks of the 1970s were responsible for causing the two corresponding recessions in most industrial countries. Nevertheless, many countries have adopted costly energy policies that presume that the benefits of avoiding or moderating oil price increases are very large. For example, policy statements by the U.S. Department of Energy (1987, 1988) emphasize the effect of changes in energy prices on the economy as the basis for current energy security policy.[1] One such policy decision was to build a 750 million barrel strategic petroleum reserve, and another was an agreement among 21 members of the Organization for Economic Cooperation and Development to share oil supplies and reduce oil imports in the event of another oil market disruption. Some countries have adopted even more intrusive standby policies for intervening in private markets in an energy crisis.

The close correlation between energy price shocks and reductions in GNP

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[1]U.S. Department of Energy (1988) put the economic costs of the two oil price shocks at $1.2 trillion in lost output in the OECD countries.

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Look at Mark Hooker, → Dartmouth ?

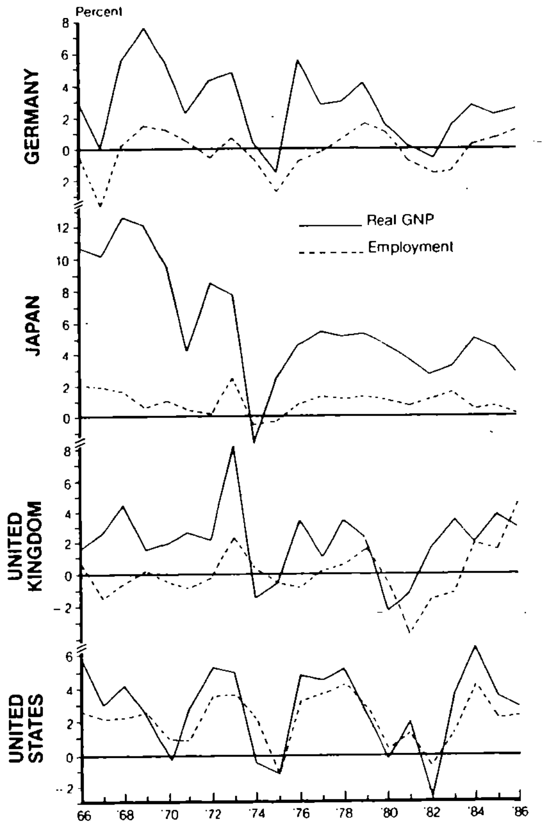

Fig. 1. Annual percentage changes in real GNP and employment: Germany, Japan, the United Kingdom and the United States, 1966–86.
Sources: Various issues of the International Monetary Fund's *International Financial Statistics*, and of OECD's *Labor Force Statistics* and *National Accounts*.

growth rates during the 1970s, as shown in fig. 1 for four countries, is the primary reason that energy is blamed for the worldwide recessions.[2] In addition, many of the prominent macroeconomic models yield estimates that support the view that the losses in GNP due to energy price shocks are very

[2]A time series analysis by Hamilton (1983) supports the hypothesis of energy-induced recessions for the United States, while Burbidge and Harrison (1984) provide similar support for Germany, Japan and the United Kingdom.

large, although the relevant parameters in these models are largely determined by the experience of the 1970s.[3]

At the same time, many economists doubt whether the energy price shocks could be held responsible for such large economic dislocations. As argued early in the debate by Nordhaus (1980), the cost of energy as a share of GNP is too small to account for the large decline in GNP in the United States after 1974 and 1979.[4] Bruno and Sachs (1985) tend to agree with this view and argue that one should look to the dislocations in equilibrium wage rates caused by increases in all raw materials prices as the explanation for worldwide stagflation. Still other economists have preferred to blame the misguided policies of monetary and fiscal authorities for the recessions. According to Sachs (1982), these explanations tend to vary among competing schools of economic thought, with Keynesians arguing that monetary policy was too tight, monetarists arguing that policy was too loose, and rational expectations theorists arguing that policy was too erratic. The unresolved nature of the debate has been summarized recently by Helliwell (1988).

There are other reasons to doubt the role of energy prices in inducing the recessions of the 1970s. One reason is the absence of a positive increase in economic growth following the rapid decline in oil prices at the beginning of 1986. Although the international oil price quickly declined to almost half of its previous level (of about $28), there was no discernible improvement in GNP or aggregate employment in any of the major industrial countries that would mirror the events that occurred after the increases in oil prices in the 1970s.[5]

Another reason for doubting the role of energy prices is the abruptness of the economic downturns that occurred after both energy price shocks in the 1970s. An increase in the price of imported energy will immediately reduce GNP because of the increases in income transferred abroad, but the price increase need not affect gross output and employment if the volume and mix of inputs in production do not change immediately. However, energy consumption as a share of GNP did not decline significantly in any industrial country in 1974–75, and in fact remained fairly stable in the United States until 1980, yet output and employment dropped immediately. Moreover, empirical studies of the slowdown in factor productivity during the 1970s do not point to energy prices as the cause.[6]

[3]A comparison of the results of 14 macroeconomic models is given by Hickman, Huntington and Sweeney (1987).

[4]A contrary point of view is given by Rasche and Tatom (1977, 1981).

[5]Mork (1989) extends Hamilton's (1983) time-series analysis through the 1980s to show that the relationship between energy prices and aggregate output is not symmetric between periods of rising and falling energy prices.

[6]See the analysis by Denison (1979, 1984) and the summary by Wolff (1985). A contrary view that rising energy prices adversely affected factor productivity is given by Jorgenson (1988).

Two possibilities have been offered to explain why energy may be more important to the economy than is indicated by its small cost share, and more immediate in its effect on economic performance than is indicated by the speed of adjustment in energy consumption. One is the induced rise in unemployment when wage rates are rigid (the Bruno–Sachs hypothesis) and the other is a reduction in capital services due to increased obsolescence of the capital stock. A third and related explanation is that energy-induced shifts in the composition of aggregate demand aggravated the problems of adjusting to changes in relative factor prices when wages are sticky and factors are immobile.

This paper reexamines these explanations by using data at the manufacturing industry level of aggregation in four industrial countries – Germany, Japan, the United Kingdom, and the United States – to test the connection between the importance of energy used in production and the behavior of selected industry activity variables. These tests rely entirely on simple bivariate correlations. Of course, more powerful tests of complex hypotheses would require the development of a complete behavioral model of the economy. The objective of this paper is considerably less grandiose by comparison. It is merely to ask whether simple relationships suggested by various hypotheses about the effect of energy prices on the economy hold up, or whether a search for subtle connections is required.

2. Role of energy in production

The direct effect of a change in energy prices on production, and the corresponding indirect effects on the use of labor and capital inputs, may be demonstrated simply by the familiar production function

$$Q = F(K, L, E), \tag{1}$$

where Q is gross output, K is capital inputs, L is labor inputs, and E is energy inputs. Net output is given by

$$Y = Q - P_E E, \tag{2}$$

where P_E is the relative price of energy and the price of output is the numeraire. Substituting (1) into (2) and setting the marginal product of each factor input equal to its price, the effect of a change in the price of energy on net output is given by

$$\frac{\mathrm{d}\ln Y}{\mathrm{d}\ln P_E} = \left[\frac{P_K K}{Y}\right]\frac{\mathrm{d}\ln K}{\mathrm{d}\ln P_E} + \left[\frac{P_L L}{Y}\right]\frac{\mathrm{d}\ln L}{\mathrm{d}\ln P_E} - \left[\frac{P_E E}{Y}\right], \tag{3}$$

where P_K and P_L are the relative prices of capital and labor, respectively. Thus, the effect of an energy price change is given by the cost shares of each factor of production and the substitution effect of the price of energy on the quantity of labor and capital used in production.

The three terms on the right-hand side of eq. (3) summarize the ways that an energy price shock might affect the economy. The third term gives the direct price effect, indicating that net output will decline in relation to the cost share of energy in production because of the additional resources required to pay for intermediate energy inputs. Net output will decline whether the additional resources are used to pay for energy imports or for domestic energy production.

The first and second terms are referred to as the indirect price effects, as determined by the substitution relationships between energy and capital and between energy and labor. Both substitution relationships are normally thought to be positive in a well-functioning economy, in which case substitution away from energy will offset the negative direct effect of an energy price shock. However, in the short-run context of an energy supply disruption both terms could be negative, in which case the indirect effects could exacerbate rather than offset the direct effects. Thus, an energy price shock could be severely damaging to the economy even though the direct impact is small.

The possibility that the substitution effects could be negative has led to two important lines of enquiry in the literature on energy price shocks. One approach, called the rigid wage hypothesis, holds that the labor market may not respond efficiently to an energy price shock. Rigid wages may force employers to reduce employment, and the decline in employment will further reduce output. The second approach, called the capital obsolescence hypothesis, holds that an energy price shock will render part of the capital stock economically obsolete and lead to a decline in the flow of capital services. Again, the negative impact on output will add to the direct effect of an energy price shock.

In the discussion of direct and indirect effects that follows, the production relationships embodied in eqs. (1)–(3) are applied to individual sectors of the economy as well as to aggregate production. Because of wide variations in the relative magnitudes of the cost shares across industries, we should expect to see patterns of output and employment behavior consistent with these hypotheses as a consequence of the energy price shocks experienced in the 1970s.

3. The direct effect of energy price shocks

Assuming for the moment that there are no substitution effects, the direct effect of the energy price shocks in the 1970s would be given by the product of the cost share of energy in GNP and the percentage change in the relative price of energy. Our first task is to show that, whether one looks at aggregate production or disaggregated industry production, the direct effect of the price shocks was small.

Alterman (1985) estimates that the aggregate cost share of energy in the United States was 4.5 percent in 1973 and 7.0 percent in 1979. During 1974, the index of all energy prices in the United States had increased by 97 percent, and during 1979–80 by 75 percent, over the preceding annual levels. Relative to the corresponding increases in the GNP deflator, the energy price increases amounted to 11.1 percent in 1974 and 8.3 percent in 1979–80.

These numbers suggest that higher energy prices could account for a decline in the growth of GNP by 0.72 percent in 1974 and 0.36 percent during 1979–80. Actual GNP declined from a growth rate of 4.5 percent during 1972–73 to −0.8 percent during 1974–75, and from 4.7 percent during 1976–78 to 0.9 percent during 1979–80. Thus, the estimated decline in GNP caused by a rise in energy prices would account for only 14 percent of the first actual decline in growth and only 9.5 percent of the second actual decline.[7] Thus, we may conclude that the direct effect of the energy price shocks on the United States economy was small. Furthermore, since the United States economy uses energy more intensively than the other countries pictured in fig. 1, the direct effect of the price shocks would account for an even smaller share of the slump in economic activity in the three other countries.

While the cost share of energy may be small in aggregate output, energy inputs are of considerable importance to individual sectors of the economy. These sectors, moreover, could be responsible for leading the economy into recession. Thus, it is of interest to see if output declined systematically more in sectors of the economy where energy is used most intensively in production. The same hypothesis may be tested for Germany, Japan, the United Kingdom, and the United States for comparison.

Comparable international data by industrial sector are collected by the United Nations and grouped according to the International Standardized Industrial Classification (ISIC).[8] The three-digit level of aggregation provides the largest number of observations common to the four countries of interest here. Even so, the observations are drawn from the manufacturing sector only because of the lack of detail within countries and lack of comparability across countries in the non-manufacturing sectors. The missing entries in tables 1 and 4 are due to the lack of comparable entries at the three-digit level of aggregation.

[7] Denison (1979) estimates that changes in energy prices explain only 0.35 percent of the loss of output that occurred in 1974.

[8] The data are compiled from country submissions and published in the *Industrial Statistics Yearbook* for years after 1975, and in *Growth of World Industry* for years before 1975.

Percentage changes in industrial production for Germany, Japan, the United Kingdom, and the United States following each of the two oil price shocks are presented in table 1. The changes are calculated over a two year interval to capture lag effects. The preponderance of negative values indicates that the decline in production was pervasive across industries in both shock periods. Consistent with the behavior of aggregate production pictured in fig. 1, where the decline in GNP during 1973–75 was more severe than that during 1978–80 in every country but the United Kingdom than the second recession, more industries experienced a decline in output after the first shock than after the second shock in all countries but the United Kingdom.

However, the two shocks did not always affect the same industries within each country in the same way. Correlations between the percentage changes in industry output in the two time periods yielded coefficients (and corresponding Type I error probabilities) of 0.052 (0.813) for Germany, −0.130 (0.586) for Japan, 0.476 (0.022) for the United Kingdom, and 0.384 (0.071) for the United States. Using the standard 0.05 significance level, only the United Kingdom shows a strong similarity in the way industry output behaved in the two shock periods, while the similarity is weaker in the United States and non-existent in Germany and Japan. If rising energy prices were responsible for the recessions, one might be led to expect more consistency in the effect of energy costs on sectoral output in the two shocks.

Another explanation for the diverse pattern of behavior between the two shocks is plausible. Private agents may be expected to learn from the first shock and be in position to respond differently to the second shock. The differences may be related to investments in energy efficient and fuel-switchable capital stock, closer control over employment production schedules and inventories, and different strategies for passing higher production costs through to consumer prices. It is reasonable to expect that these adjustments would be implemented more aggressively in those industries most affected by the first shock, and could account for the change in pattern of industry response to the second shock. The adjustments would also reduce the severity of the second shock relative to the first, as suggested by the less pervasive decline in output across industries in the second shock.

To test the implication from eq. (3) that the more energy intensive industries should experience systematically larger reductions in output than the less energy intensive industries, rank correlations are calculated between percentage changes in output and energy intensity by industry (see table 3). Energy intensity data (measured in Btu's per dollar of output) are readily available for United States manufacturing industries, but not for the other three countries. Consequently, it is assumed that the industry rankings (though not absolute intensities) in all four countries are the same. The industry rankings for 1973 and 1978 are given in table 2. It will be observed

Table 1

Percentage changes in industrial production by industry in four countries, 1973–75 and 1978–80.[a]

ISIC	Industry	Germany 1973–75	Germany 1978–80	Japan 1973–75	Japan 1978–80	United Kingdom 1973–75	United Kingdom 1978–80	United States 1973–75	United States 1978–80
311	Food	−0.50	2.36	0.50	0.90	−2.83	0.47	1.02	2.16
314	Tobacco	0.51	2.80	4.95	−1.44	−1.92	1.89	0.00	0.47
321	Textiles	−0.59	0.48	−7.63	0.00	−6.90	−9.60	−7.26	0.45
322	Apparel	−0.33	−2.70	−6.90	−0.91	−0.50	−4.72	−4.22	−2.84
323	Leather	−2.83	−3.92	0.51	−1.90	−3.27	−12.89	−2.41	−5.67
324	Footwear	−9.02	−0.52	−0.50	−1.43	−3.27	−7.77	−5.75	0.56
331	Wood	−5.36	1.30	−9.02	−3.24	−9.09	−6.13	−6.75	−1.91
332	Furniture	−5.36	0.89	*	*	*	*	−9.02	−1.89
341	Paper	−6.52	3.72	−7.98	4.47	−10.20	−8.18	−7.63	2.42
342	Printing	−4.95	5.98	*	*	−4.18	0.00	−1.92	3.02
351	Indust. chem.	−5.51	0.41	−7.98	1.63	−6.14	−3.51	−5.36	1.06
352	Other chem.	*	*	−1.46	6.85	2.63	−3.78	1.02	3.86
353	Petrol ref.	−7.63	3.70	−3.70	−2.31	−8.33	−4.25	−1.46	−4.31
355	Rubber	−6.34	2.11	−4.55	10.33	−3.27	−3.91	−6.90	−8.20
361	Pottery	−4.95	1.47	*	*	3.19	−8.55	*	*
362	Glass	−4.55	4.17	−10.91	4.01	−4.55	−4.13	0.51	0.00
369	Other non-met.	−8.71	3.08	*	*	−7.26	−5.38	−7.55	−3.80
371	Steel	−9.02	2.36	−7.98	6.31	−10.94	−16.83	−10.94	−9.32
372	Non-fer. met.	−7.26	3.17	−11.24	2.61	−7.26	−4.67	−13.77	−4.44
381	Metal products	−5.36	4.59	−12.41	0.00	−5.36	−8.25	−6.14	−2.71
382	Machinery	−2.38	5.19	−10.94	11.72	−2.08	−1.04	−3.33	2.81
383	Elect. mach.	−3.70	2.99	−9.02	15.48	−1.92	−9.97	−9.35	4.01
384	Transport eq.	−3.70	0.42	−1.46	11.90	−4.95	−4.50	−9.02	−5.88
385	Other equip.	−3.27	6.48	1.02	22.61	3.19	0.94	−1.94	1.18

[a]* = not available. Entries are for a two-year interval using end-of-year figures.

Sources: United Nations, *The Growth of World Industry* vol. 1 for the years 1973 through 1975, and *Industrial Statistics Yearbook* vol. 1 for the years 1978 through 1980.

Table 2

Rank by energy intensity of United States manufacturing industries in 1973 and 1978.

ISIC	Industry	1973 Rank	1978 Rank
353	Petroleum refinery	1	2
351	Industrial chemicals	2	1
371	Steel	3	3
361	Pottery	4	4
369	Other non-metals	5	5
362	Glass	6	6
341	Paper	7	7
372	Non-ferrous metals	8	8
323	Leather	9	9
352	Other chemicals	10	10
355	Rubber	11	11
331	Wood	12	13
321	Textiles	13	12
311	Food	14	14
381	Metal products	15	15
382	Machinery	16	17
383	Electric machinery	17	18
332	Furniture	18	16
385	Other equipment	19	19
384	Transport equipment	20	21
322	Apparel	21	20
342	Printing	22	22
324	Footwear	23	24
314	Tobacco	24	23

Source: U.S. Department of Commerce, Office of Business Analysis, *National Energy Accounts*. My thanks to Joe Roop for regrouping the data from U.S. SIC categories to International SIC categories.

that there are some slight changes in the rankings between the two energy price shock periods. It should be noted in addition that there are considerable differences in energy intensiveness among the industries. For example, in the United States in 1973, the industries ranked in the top third according to energy intensity consumed on average over 20 times the amount of energy per dollar of output as those ranked in the bottom third.

The rank correlations between energy intensity and industrial production presented in the first two columns of table 3 are mostly negative, in keeping with the view that output declined more in the higher energy intensity industries, but they are not significantly different from zero (i.e., have a Type 1 error less than 0.05) except for Germany and the United Kingdom after the first shock. Again, these results fail to confirm the hypothesis of an important direct connection between energy prices and industry output. Thus, we turn to an assessment of the indirect substitution effects.

Table 3

Rank correlations between energy intensity and percentage changes in selected variables by industry and country (type 1 errors in parentheses).

Country	Industrial production[a]		Employment[b]		Real wages[c]		Capital formation[c]		Inventories[c]	
	1973–75	1978–80	1973–75	1978–80	1973–75	1978–80	1973–75	1978–80	1973–75	1978–80
Germany	−0.484	0.012	0.173	−0.268	−0.296	−0.321	−0.472	0.086	0.054	0.095
	(0.019)	(0.957)	(0.479)	(0.266)	(0.208)	(0.173)	(0.045)	(0.715)	(0.818)	(0.688)
Japan	−0.339	−0.077	0.129	−0.336	0.099	−0.073	0.323	−0.047	0.550	0.577
	(0.147)	(0.745)	(0.546)	(0.108)	(0.634)	(0.726)	(0.122)	(0.822)	(0.008)	(0.005)
United Kingdom	−0.479	−0.380	0.277	−0.320	−0.071	−0.334	−0.312	−0.565	0.037	−0.400
	(0.021)	(0.073)	(0.189)	(0.127)	(0.732)	(0.109)	(0.135)	(0.007)	(0.858)	(0.055)
United States	−0.110	−0.313	0.228	−0.126	−0.280	−0.164	0.678	−0.208	0.664	0.276
	(0.618)	(0.146)	(0.282)	(0.554)	(0.179)	(0.433)	(0.001)	(0.318)	(0.004)	(0.186)

[a]Using tables 1 and 2.
[b]Using tables 2 and 4.
[c]Using table 2 and data corresponding to the industries listed in table 4 (and drawn from the same source).

4. Wage rigidity and the price shocks

Wage inflexibility is often cited as the reason for the increase in unemployment experienced after each of the two oil price shocks, and differences in the degree of wage flexibility across countries are similarly regarded as the principal explanation for variations in economic performance among countries.[9] The energy connection in the argument, in brief, is that an increase in the price of energy will reduce the quantity of energy inputs and the productivity of labor, so that real wages must fall in order to maintain the level of employment.[10] If real wages are sticky, employment will fall and reduce the level of output. In effect, the second term on the right-hand side of eq. (3) is negative and exacerbates the direct effect of the rise in the price of energy on output.

Among the many attempts to measure wage flexibility, few measure the gap that may develop between actual real wages and the level necessary to maintain the level of employment; that is, a measure of the gap between labor supply and demand. Perhaps the most careful estimates of wage gaps are provided by Bruno and Sachs (1985), who seek to measure the difference between real wages and the marginal product of labor at a high level of employment.[11] Their empirical results are consistent with actual labor market performance in Europe and the United States, but they yield the anomaly that Japan's wage gap increased throughout the 1970s to the point of being the largest among all industrial countries by the time of the second energy price shock.[12] Yet, as observed in fig. 1, Japan was unique among industrial countries in avoiding a rise in unemployment after the 1979 oil shock.

Percentage changes in employment by industry and country are shown in table 4. Like the output figures in table 1, employment declined more pervasively across industries after the first shock than after the second shock, except in the United Kingdom. Still, the pattern of the decline in employment by industry differs within each country between the two shocks, and the differences do not always correspond to those noted earlier for output. Correlations (and Type 1 errors) of changes in industry employment in the

[9]See Mork (1981), Bruno and Sachs (1985), Grubb, Jackman and Layard (1983) and Adams, Fenton and Larson (1986).

[10]Energy substitution relationships with labor and capital may be such that a rise in energy prices will not reduce the demand for labor, as shown by Vinals (1984). The empirical literature does not clear up the issue, as demonstrated by comparing Berndt and Wood (1979), Griffin (1981) and Solow (1987).

[11]Since marginal productivity data are not available, a Cobb–Douglas production function is estimated to make use of the underlying assumption that the ratio of average to marginal product is constant.

[12]A subsequent refinement of the estimates by Bruno (1986) failed to remove the anomaly for Japan. Other variations of the model by Artus (1984) do not alter the basic results. See Helliwell (1988) for a review of the wage flexibility research.

Table 4

Percentage changes in employment by industry in four countries, 1973–75 and 1978–80.[a]

ISIC	Industry	Germany 1973–75	Germany 1978–80	Japan 1973–75	Japan 1978–80	United Kingdom 1973–75	United Kingdom 1978–80	United States 1973–75	United States 1978–80
311	Food	−4.12	−0.56	1.98	0.10	−0.25	−4.52	−1.17	−0.37
314	Tobacco	−7.14	2.27	0.00	−1.22	−2.50	−6.94	−1.47	−0.85
321	Textiles	−8.87	−2.11	−7.10	−2.69	−2.96	−10.60	−7.72	−3.58
322	Apparel	−10.00	−2.30	3.64	−1.37	−3.68	−9.71	−6.10	0.17
323	Leather	−7.61	−2.56	2.63	0.00	−2.44	−9.38	−2.38	−2.91
324	Footwear	−10.00	0.00	1.67	0.00	−4.27	−10.61	−7.02	−2.61
331	Wood	−0.58	0.17	−3.50	−2.25	−1.23	−5.24	−6.77	−2.50
332	Furniture	*	*	0.55	−0.57	−2.07	−7.20	−8.76	−0.68
341	Paper	−5.10	0.91	2.79	−1.23	−1.82	−9.05	−4.34	0.63
342	Printing	−5.48	2.27	−2.17	1.17	−1.64	−4.29	−0.65	5.15
351	Industrial chem.	−8.47	0.18	0.59	−2.05	−0.20	−10.00	0.11	0.00
352	Other chem.	*	*	−2.07	0.75	1.10	−4.35	−3.91	0.66
353	Petroleum ref.	*	*	5.56	0.00	−2.78	−5.88	1.53	0.49
355	Rubber	−7.72	0.49	−3.47	0.78	−1.67	−10.42	−6.45	−5.36
361	Pottery	−5.92	1.22	1.28	0.64	1.69	−12.73	−3.19	3.75
362	Glass	−5.85	−0.64	−5.84	−0.79	−0.78	−11.11	−4.95	−3.80
369	Other non-metals	−9.50	1.17	−2.44	−0.42	−1.58	−7.38	−4.10	−1.92
371	Steel	−2.74	−0.47	−2.00	−1.91	−2.14	−15.23	−4.48	−3.65
372	Non-ferrous metals	−4.10	1.87	−3.61	0.35	−1.33	−11.73	−6.67	0.69
381	Metal products	−6.44	−0.29	−3.31	0.39	0.17	−8.39	−4.55	0.57
382	Machinery	−2.48	1.03	−3.65	1.78	−0.74	−10.10	−0.91	3.56
383	Electrical mach.	−4.13	0.44	−6.82	4.38	−2.94	−8.20	−7.58	2.93
384	Transport equip.	−3.89	2.06	−2.10	0.52	−0.86	−9.13	−7.14	−3.23
385	Other equip.	−1.59	1.86	−3.94	4.13	−0.60	−5.50	1.55	1.94

[a]* = not available. Entries are for a two-year interval using end-of-year figures.

Sources: United Nations, *The Growth of World Industry* vol. 1 for the years 1973 through 1975, and *Industrial Statistics Yearbook* vol. 1 for the years 1978 through 1980.

two shock periods are 0.315 (0.188) for Germany, −0.220 (0.202) for Japan, 0.132 (0.538) for the United Kingdom, and 0.421 (0.041) for the United States. These figures indicate that the changes in industry employment and output after both shocks are somewhat similar only in the United States. The inference might be drawn that the private sector in the United States failed to learn from the first experience, though the United Kingdom suffered considerably more after the second shock than any of the other countries.[13]

If the rise in energy prices was responsible for creating a wage gap, one might expect the gaps to be widest in the industries where energy is most important (ignoring differences in labor supply conditions across industries). That is, we should expect to observe a systematic relationship between the importance of energy used in production and the decline in employment among different industries during the two shock periods. These rank correlations are given in the third and fourth columns of table 3. The correlations are positive after the first price shock and negative after the second price shock, but the level of significance is low in all cases. The absence of a relationship between energy intensity and employment suggests that changes in energy prices were not responsible for creating a wage gap. This conclusion is reinforced by the absence of significant correlations between energy intensity and changes in real wages in columns five and six of table 3.[14] The lack of significance could be interpreted as the result of rigid wages – that is, the downward pressure on real wages was not realized – except that the coefficients indicate no more flexibility in Japan than in the other countries, while the United Kingdom exhibits the most flexibility in 1978–80. Both observations are inconsistent with actual employment experience as seen in fig. 1.

5. Energy prices and capital obsolescence

The physical capital stock in place is relatively fixed over short periods of time, but the flow of services from the capital stock could decline abruptly as a result of a sharp increase in the price of energy. This would occur if the rise in energy prices renders a substantial part of the capital stock prematurely obsolete. For example, the least energy-efficient vintages of the capital stock may be used less frequently or retired faster in an effort to reduce production costs. Also, shifts in product demand away from energy

[13]Note further that the United Kingdom suffered the worst recession among the four countries after 1979 in spite of approaching energy self-sufficiency and the position of a net oil exporter. This observation, together with the fact that Japan avoided a recession despite complete dependence on imports, illustrates that the degree of oil import dependence is a poor proxy for energy insecurity.

[14]The real wage figures correspond to the employment figures in table 4 and are drawn from the same sources.

intensive commodities may unemploy capital that cannot be used for other purposes. The reduction in capital services means, in effect, that the first term on the right-hand side of eq. (3) is negative and would add to the direct effect of a rise in energy prices on output.

Unfortunately, there is no direct empirical evidence of the effect of energy price shocks on the flow of capital services. Baily (1981) and Berndt and Wood (1985) conclude from analyses of statistical measures of the capital stock that a decline in capital services could possibly explain the decline in factor productivity during the 1970s, but they provide no evidence that the decline is associated with the rise in energy prices. Baily (1982) finds a strong correlation between labor productivity and capital intensity by manufacturing industry in the United States, which he interprets as supporting the capital obsolescence hypothesis, but again he finds no evidence of a connection with rising energy prices.

Correlations between energy intensities and changes in capital formation by manufacturing industry, given in columns seven and eight in table 3, do not reflect any systematic patterns in industry investment after the two price shocks. Only three of the eight correlations differ from zero at the 0.05 level of significance, and these three do not have the same sign. Correlations obtained by using investment in plant and equipment instead of gross capital formation, or levels of capital spending in place of percentage changes, are no more enlightening.[15]

6. Shifts in the composition of demand

Not captured in eq. (3) is the possible effect of an energy-induced shift in the composition of aggregate demand. Such a shift in demand implies the need for a reallocation of resources from the production of one commodity to another. Two outcomes may occur. First, the transfer of resources may take place as required, but factor productivity may be lower in expanding sectors than in contracting sectors, causing indicators of aggregate economic performance (though not necessarily economic welfare) to deteriorate. Second, the transfer of resources may not take place because rigidities in relative commodity or factor prices prevent the appropriate signal from occurring, or because factors of production are not sufficiently mobile in the short run to respond to the price signals. In this case unemployment would rise and business inventories would be larger or smaller than desired in the periods immediately following the two energy price shocks.

[15]There is also no significant correlation between the pattern of investment by industry for the period between the two shocks and output and employment performance after the second oil shock. However, the absence of such a relationship bears little weight regarding the learning hypothesis noted earlier, since it is the kind of investment rather than the volume of investment that is pertinent to this issue.

Most of the empirical literature on this issue is concerned with the implications of actual transfers of resources on overall factor productivity. Although there is some confusion in the literature, it may be summarized as saying that shifts in output and input mixes do not account for the productivity slowdown in industrial countries during the 1970s.[16] The study by Baily (1982) is of special interest in this regard because he looks for and fails to find a connection between rising energy prices and the productivity slowdown.

The second possibility is that resources may temporarily fail to move from declining to expanding sectors of the economy following a shift in the composition of demand. Lilien (1982) finds that slow adjustments in labor transfers across individual sectors could be responsible for the cyclical swings in unemployment in the United States in 1975 and 1980. While employment in service sectors rose in both periods, the decline in durable manufacturing was large enough to pull down overall employment. After each cyclical recovery, employment in manufacturing failed to recover. Although Lilien does not test for an energy connection, we have seen in table 1 that there is no correlation between energy intensity and changes in employment in manufacturing industries in four countries.

Another possible result of a disequilibrium shift in the mix of aggregate demand is unintended changes in inventories. While no data are available on intended inventories to test this hypothesis, it is of interest to see if inventories vary systematically among industries according to their energy intensity. A decline in inventories would be procyclical and an increase in inventories would be countercyclical. The last two columns of table 3 provide correlations between energy intensity and percentage changes in inventories by manufacturing industry. The correlations are positive and significant in both shock periods for Japan and the United States, while negative and significant in the second shock period for the United Kingdom. Thus, for Japan and the United States, the apparent willingness of the high energy intensity industries to build inventories during the two recessions suggests that these industries were operating in a countercyclical fashion rather than leading the charge into a recession.

7. Conclusions

Doubts about the importance of energy price changes to overall economic performance are reinforced by the absence of any apparent connection between energy intensity and various activity variables from manufacturing

[16]See Denison (1979, 1984), Baily (1982) and Wolf (1985) for analyses of the United States productivity slowdown and Neff and Dean (1984) for France, Germany and the United Kingdom. One reason for the confusion among the results of different studies, as shown by Baumol and Wolff (1984), is that different measures of the shift effect are used.

industries in four industrial countries. The activity variables were chosen to reflect hypotheses regarding both direct and indirect price effects on the economy, and none of the relationships were supported by the data. It is, of course, possible that the energy connection is more complex than that which can be revealed in simple bivariate correlations. The value of these results is in questioning simple explanations of the role of energy in the economy and to encourage others to develop and test more subtle hypotheses. In view of the lack of evidence elsewhere in the literature in support of an energy connection, the task will not be an easy one.

There is an obvious alternative explanation of the recessions experienced in the four countries examined here which is consistent with observed experience. Monetary policy was tightened in all of the countries after each energy price shock, with one exception.[17] The exception was the expansionary position taken by Japan after the second energy price shock, and in this case Japan was alone among the four countries in avoiding another recession.

It may be said that the timing of the two oil price shocks was particularly unfortunate because they both occurred at times when most countries were already battling against inflation, deflationary policies were in place, and their economies were already moving toward the downward phase of the business cycle. The energy price shocks, by adding to fears about inflation, perhaps contributed more to the subsequent recessions by reinforcing the decisions of the monetary authorities than by their destabilizing effect on economy. One can only speculate how much different the economic record of the 1970s would have been if the energy price shocks had occurred in an otherwise more stable economic environment. While it would be wrong to conclude from the evidence presented here that energy prices played no part in the worldwide recessions during the 1970s, at least it can be said that the burden of proof required for a macroeconomic cost justification for energy security programs has not been met.

[17]A description of stabilization policy in each country during the 1970s is given in Bohi (1989). Bruno (1986) also concludes that wage gaps are less important in explaining cross-country differences in unemployment rates than monetary and fiscal policy differences.

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Physical and economic aspects of resource quality

The cost of oil supply in the lower 48 United States, 1936–1988*

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For the past half century, the average cost of finding new oil in the lower 48 U.S. has increased in a non-linear fashion. The average cost of producing oil decreased then increased over the same period, with costs rising since the mid-1960s. These results indicate that the cost increasing effects of resource depletion have outweighed the cost decreasing effects of technological improvements in the two primary stages of the oil supply process. Finding and production costs are also highly correlated with the rate of effort expended in each stage, and short-run changes in the rate of effort drive average costs above or below the long-run trend. Previous models which ignored the interplay between short- and long-run effects on cost produced misleading results concerning the scarcity of crude oil in the U.S. The drilling boom of the early 1980s arrested the rate of decline in new additions to reserves, but the average costs associated with those additions were the highest on record. Attempts to sustain production in the lower 48 U.S. through massive drilling programs targeting the large number of undiscovered small fields and infill drilling in existing fields are likely to drive average costs even higher.

1. Introduction

Analysis and debate of the link between quality of society's natural resource base and its economic well-being has a long and rich history. Of particular interest is the question of whether biophysical constraints, manifest by increasing costs of natural resources, will constrain economic growth, or whether human ingenuity, manifest by technical change, can overcome physical scarcity. The assessment of crude oil resources in the U.S. historically has been the most divisive issue in energy policy formulation. The oil

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TESTING FOR THE EFFECTS OF OIL-PRICE RISES USING VECTOR AUTOREGRESSIONS*

BY JOHN BURBIDGE AND ALAN HARRISON[1]

1. INTRODUCTION

The formation of the Organization of Petroleum Exporting Countries (OPEC) has been responsible for a considerable amount of research addressing the question of the impact on the domestic economy of exogenous changes in oil prices. Much of the research has been theoretical, and has generated a number of alternative models of an increase in the relative price of an imported intermediate good. (See, for example, Bruno [1982], Bruno and Sachs [1982], Harkness [1982], and references therein.) These models generally predict that oil-price shocks lead to increases in wages and prices and decreases in real output. Less work of an empirical nature has been undertaken to test these predictions, and much of what has been done tends to use simulation methods.[2,3] In this paper, we adopt the somewhat different approach of analyzing the effects of oil-price rises in unrestricted systems of equations estimated for five countries in the Organization for Economic Co-operation and Development (OECD). We consider the economies of the U.S., Japan, the Federal Republic of Germany (henceforth Germany), the United Kingdom, and Canada, using monthly data for the period January, 1961 to June, 1982, and estimate a seven-variable vector autoregression (VAR) for each. These VARs are then converted to their moving-average representations, and Sims's [1980a] innovation-accounting techniques are used to examine the impact of

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[1] We have benefited considerably from the help, advice and suggestions of David Backus, Stanley Fischer, James Hamilton, Jon Hamilton, John Kennan, Paul Krugman, Robert Litterman, Angelo Melino, Jeffrey Sachs, Christopher Sims, and two anonymous referees, and have also received useful comments on earlier drafts from participants in seminars at the Australian National University, Monash University, Queen's University, and the University of Adelaide. During part of the time the research was being undertaken, John Burbidge was on sabbatical leave at Massachusetts Institute of Technology, and Alan Harrison was on leave at the University of Adelaide, South Australia. We are grateful to these institutions for their hospitality, and John Burbidge also thanks the Social Science and Humanities Research Council of Canada for financial support.

[2] Mork and Hall [1980], Bruno and Sachs [1981], and Darby [1982] use simulation models to analyze the rise in the price of oil in the early 1970s. Mork and Hall are concerned with its effects on the U.S. economy, while Bruno and Sachs, and Darby, consider the impact on a number of OECD countries.

[3] In a recent empirical study that does *not* rely on simulation experiments, Hamilton [1983] employs a methodology related to that adopted here. The relationship between Hamilton's work and our own is discussed in Section 6.

oil-price changes. Impulse responses are computed, which show how the equation system of each country responds to a positive shock in the price of oil, followed by historical decompositions, to determine what part of the cyclical fluctuations in prices and real output after each of two oil-price shocks can be attributed to the shocks.

The paper is organized as follows. We begin by discussing the choice of variables for the VAR. Section 3 reports the VARs, and discusses the behavior of the variable central to our analysis, the real price of oil. In Sections 4 and 5 the moving average representations are used to generate the impulse responses and the historical decompositions. Section 6 describes various experiments designed to check the sensitivity of the evidence from our analyses to alternative specifications, and briefly compares this evidence with that of Hamilton [1983]. A summary of our main results concludes the paper.

Perhaps the main finding to emerge from our study is the significant difference between the effects of the 1973–1974 set of oil-price shocks and those of the 1979–1980 shocks. In the case of the latter, the impact of oil-price innovations on prices and output is minimal in all countries except Japan, whereas for the 1973–1974 shocks, the influence of the price of oil on these variables appears to have been quite strong. Notwithstanding this, our analysis also shows that downturns in industrial production in the mid-70s would probably have occurred in any event; the oil-price increase, therefore, served to deepen a recession that was already on the way.

2. CHOICE OF VARIABLES FOR THE VAR

To address the question of the impact of the price of oil on domestic economic variables, a complete model is probably most appropriate. Such a model can be extremely tightly structured, and simulation models are typically of this type. Alternatively, much less can be incorporated into the maintained hypothesis, particularly when, as Sims [1980a] notes, specifying a model often involves imposing many quite arbitrary restrictions. Such a warning seems especially apposite in the present context, when the channels of influence of the price of oil may be many and varied. We, therefore, feel that the innovation-accounting techniques pioneered by Sims, and further developed by Doan and Litterman [1981], are potentially more informative than standard macroeconomic modelling might be.

The first step in the use of these techniques is the choice of how many, and which, variables to include in the VAR. These decisions are inevitably somewhat arguable, reflecting practical considerations, such as degrees of freedom, as much as economic considerations. We elected for VARs containing seven variables. Here, we describe the variables only briefly, adding mnemonics for ease of later reference; full details of all series are provided in the Appendix.

The price of oil (*PF*) is a relative price: the ratio of the Saudi Arabian price, in U.S. dollars per barrel, to a weighted average of the consumer price indices in the five countries studied. We chose to work with a relative price since this is the variable whose effect is analyzed in theoretical models of oil-price shocks. In addition to *PF*, the six other data series in our VARs were: *IPROW*, a measure of total industrial production in OECD countries other than the country involved; *IP*, industrial production in the domestic economy; *R*, a measure of the short-term interest rate;[4] *M*, currency and demand deposits; *W*, average hourly earnings in manufacturing; and *CPI*, the consumer price index. The effects of *PF* on *CPI* and *IP* were, of course, our primary objects of interest; *IPROW* was added to capture demand influences that might operate through changes in domestic exports,[5] and the remaining variables, *R*, *M* and *W*, were included to permit oil-price shocks to operate indirectly on *CPI* and *IP* through the monetary sector and through wages.

3. THE VECTOR AUTOREGRESSIONS

Ignoring deterministic components for ease of exposition, a VAR system can be written as

$$A(B)y_t = \varepsilon_t, \tag{1}$$

where $A(B)$ is an $n \times n$ matrix of polynomials in the backward-shift operator, B, n is the number of endogeneous variables in the system, y_t is an $n \times 1$ vector of endogeneous variables, and ε_t is an $n \times 1$ vector of random variables, each of which is serially uncorrelated, with finite variance and zero mean. $A(B)$ is normalized so that the first entry of each polynomial on A's diagonal is unity.

To estimate $A(B)$, one must limit the length of lag in the polynomials. If m is the lag length, the number of coefficients to be estimated is $n(nm+d)$, where d is the number of deterministic components. With about 20 years of monthly data and n equal to seven, we felt able to experiment with m values up to six. We found that little was gained by allowing for longer than four lags,[6] so that the VARs were estimated with m equal to four, for the period May, 1962 to June, 1982.

Before estimation, which was by ordinary least squares,[7] all series except *R* were first logged; then seasonal frequencies were removed by twelfth-differencing

[4] For the U.S., the U.K., and Canada, R is the yield on 90-day treasury bills. For Japan and Germany, however, we used an average of call-money rates, because both countries fixed the treasury-bill rate for parts of our data period.

[5] *IPROW* may be misleading in the case of Japan, since over half of its exports go to non-OECD countries; see Japanese Statistics Bureau (1980), pp. 292–293.

[6] Four lags were tested in the U.S. VAR as a restriction on five and six lags, and a likelihood ratio test on the system of equations rejected the restriction each time, but in both cases the main results of our analysis were unaffected (see Section 6, below). Furthermore by testing the restriction one equation at a time, we established that for four variables (*IPROW*, *M*, *W*, *IP*) the restriction to four lags could not be rejected.

[7] All the empirical work reported in this paper was performed with the RATS package of Doan and Litterman [1981].

(again in all series except R), after use of the spectral analysis section in RATS established that there was little to choose between this technique and seasonal dummies. (It is twelfth-differencing, of course, that is responsible for the loss of the first year's data.) The only deterministic components in the VARs were a constant and a linear time trend.

Although the estimation of a VAR avoids the imposition of "restrictions based on supposed *a priori* knowledge" (Sims [1980a, p. 15]), it is still subject to restrictions of a different type, as Sims readily acknowledges. In the context of our study, these give rise to particular concern regarding the variable PF (Hamilton [1983, pp. 232–233]), since it is not all clear that the assumptions implicit in the VAR, linearity for example, hold in this case. The price of oil has periodically exhibited large increases, and it is precisely on these increases that much of Section 5 of the paper concentrates. It therefore seemed instructive to plot the innovations from the PF equation in one of the VARs, and those for the U.S. VAR are displayed in Figure 1. The figure includes lines either side of zero at plus and minus two standard deviations of the innovations, from which it is clear that the oil-price shocks of 1973–1974 and 1979–1980 generate uncharacteristically large residuals. Eight lie outside the two-standard-deviations band, and in Section 6, below, we consider the importance of these to the results of our analysis.

One way of summarizing the results of VAR estimation is to calculate the critical levels[8] of F-tests of the hypothesis that all lags of a particular variable in each equation are zero. These critical levels are presented in Table 1. The PF equations suggest a struggle over the relative price of oil, whereby increases in the Saudi Arabian price are subsequently eroded by inflation in non-OPEC countries.[9] For the U.S., Japan and Germany, CPI affects PF, while PF drives CPI in all countries, except (possibly) Canada. PF also influences W in all countries except Germany.[10] In addition, PF affects $IPROW$, and, through $IPROW$, IP in two of the more "open" economies: Germany and the U.K., although an interpretation of unidirectional causality may be ruled out since there is a suggestion of feedback between PF and $IPROW$.

If we are to carry out a very precise examination of the influence on each country of the price of oil, however, it is not clear that Table 1 is the best vehicle for the exercise. As Sims has noted, estimated VARs "are difficult to describe succinctly" [1980a, p. 20]; he goes on to argue that the moving-average representation offers a far more comprehensible picture, and it is to this that we turn in the following section.

[8] The critical level is the significance level at which the null hypothesis is just rejected (Lehmann, [1959, p. 62]). A figure less than 0.05, for example, therefore implies rejection of the null hypothesis at the 5 per cent level.

[9] See Sachs [1981] for some evidence of how balance of payments data are changed by inflation, which reduces the real value of OPEC assets in the U.S. and other countries.

[10] In Germany, W may be relatively fixed because of the elastic supply of foreign labor.

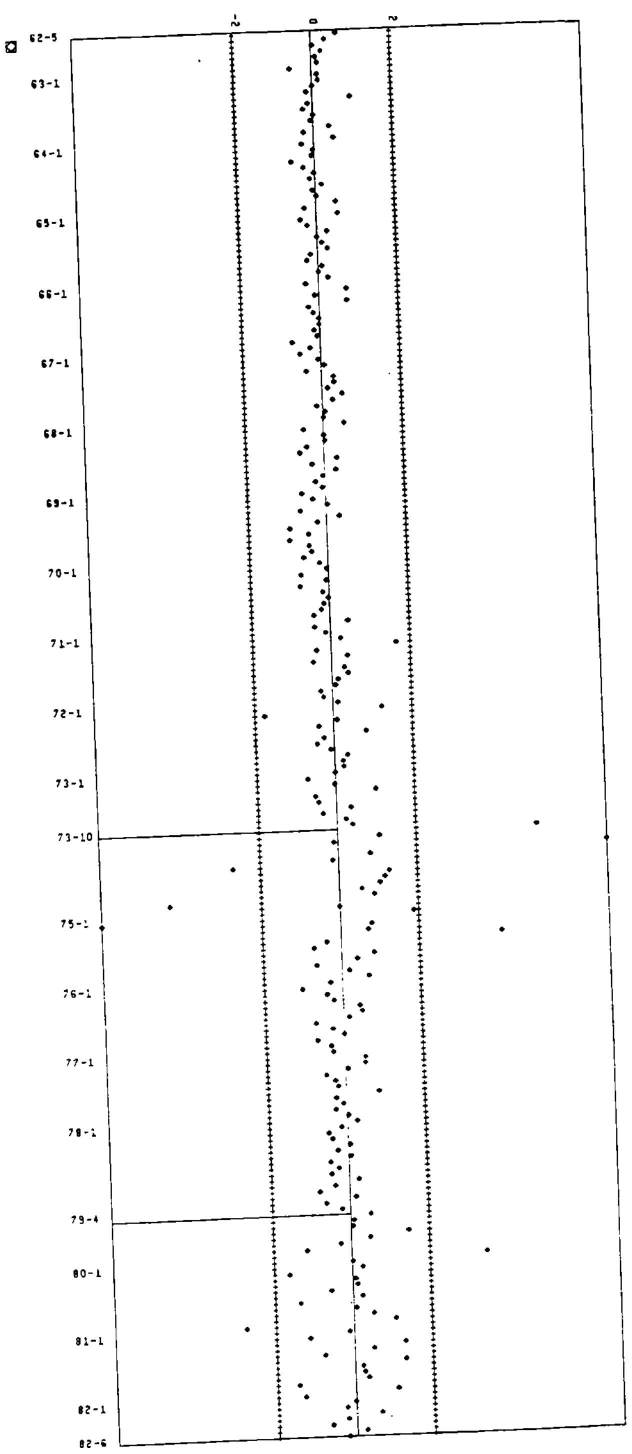


FIGURE 1
INNOVATIONS IN PF FROM THE U.S. VAR, 1962 (5) TO 1982 (6).

TABLE 1

CRITICAL LEVELS OF F-TESTS OF HYPOTHESES THAT ALL LAGS OF INDICATED RIGHT-HAND-SIDE VARIABLES ARE ZERO

Equation with Dependent Variable	Country	*PF*	*IPROW*	*R*	*M*	*W*	*CPI*	*IP*
PF	US	*	0.42	0.75	0.16	0.38	0.06	0.11
	Japan	*	0.16	0.04	0.15	0.02	*	0.73
	Germany	*	0.54	*	*	0.14	0.01	0.08
	UK	*	0.07	0.65	0.96	0.25	0.79	0.57
	Canada	*	0.13	0.07	0.48	0.11	0.34	0.66
IPROW	US	0.09	*	0.70	*	*	0.86	*
	Japan	0.18	*	0.08	0.30	0.28	0.69	0.40
	Germany	*	*	0.40	0.35	0.40	0.05	0.05
	UK	*	*	0.73	0.58	0.39	0.75	*
	Canada	0.02	*	0.89	0.03	0.13	0.75	0.13
R	US	0.42	0.94	*	*	0.31	*	0.44
	Japan	0.19	0.62	*	0.58	0.64	0.21	0.03
	Germany	0.03	0.38	*	0.24	0.66	0.04	0.21
	UK	0.87	0.05	*	0.11	0.15	0.21	0.67
	Canada	0.33	0.37	*	0.11	0.10	*	0.09
M	US	0.14	0.25	*	*	0.12	0.21	0.12
	Japan	0.24	0.14	0.35	*	*	0.28	0.02
	Germany	0.03	*	*	*	*	0.09	0.76
	UK	0.28	*	*	*	0.75	0.78	0.72
	Canada	0.39	0.10	*	*	0.76	0.10	0.18
W	US	*	0.02	0.06	0.41	*	0.45	*
	Japan	*	0.31	0.51	0.10	*	*	*
	Germany	0.16	0.35	*	0.02	*	0.04	0.04
	UK	*	0.20	0.50	0.17	*	0.03	0.35
	Canada	*	0.01	0.26	0.69	*	0.04	0.33
CPI	US	0.02	*	0.22	0.02	0.45	*	0.33
	Japan	*	*	0.05	0.40	*	*	0.49
	Germany	0.04	0.04	0.02	0.12	0.37	*	0.08
	UK	*	*	0.11	0.92	*	*	*
	Canada	0.09	0.45	0.24	0.76	0.96	*	0.61
IP	US	0.20	0.22	*	*	*	0.21	*
	Japan	0.20	0.17	0.34	0.05	0.06	0.34	*
	Germany	0.48	*	0.72	0.94	0.23	0.37	*
	UK	*	*	0.76	*	0.06	0.20	*
	Canada	0.39	0.26	0.70	0.15	*	0.58	*

* Indicates number of less than 0.01

4. THE EFFECTS OF AN OIL-PRICE SHOCK

In this section, we examine the responses of each equation system to a shock in *PF*. The conversion of the autoregressive representation in equation (1) to the moving-average representation, which this requires, can be done provided that the roots of the polynomial given by the determinant of A lie outside the unit circle. Thus

$$y_t = (A(B))^{-1}\varepsilon_t = C(B)\varepsilon_t = \sum_{i=0}^{\infty} C_i\varepsilon_{t-i}, \tag{2}$$

and, given the normalization of A, C_0 is the identity matrix.

Consider a temporary shock to the k^{th} component of ε_t such that ε_t^k equals unity. Then the response of y_t^k equals unity, and the response of $y_{t+j}=C_j\varepsilon_t^k$, for $j=1, 2, 3,\ldots$, which is just the k^{th} column of C_j. Thus, the columns of C_j give us the impulse responses of each endogenous variable, at time $t+j$, to shocks administered at time t.

Figures 2 to 8 show the responses, over 72 months, to a shock in *PF* equal to the standard deviation of its innovations; each variable's response is scaled by the standard deviation of the variable's innovations. Before computing the responses on which these graphs are based, we first orthogonalized the innovations. To do this, it was necessary to choose an ordering for the variables in the system, since the method of orthogonalization involves the assignment of contemporaneous correlation to particular series. To the first series in the chosen ordering is attributed contemporaneous correlation between it and all other series

FIGURES 2 through 8 are responses to a one-standard-deviation shock in PF.

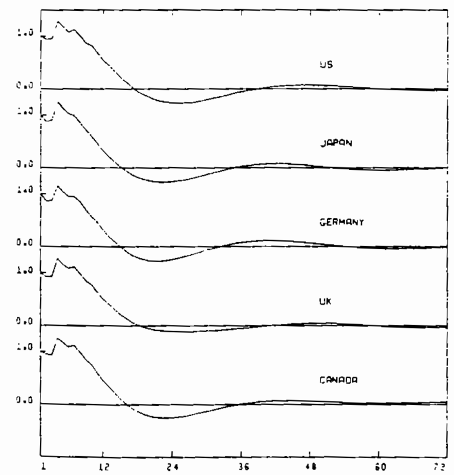


FIGURE 2 PF

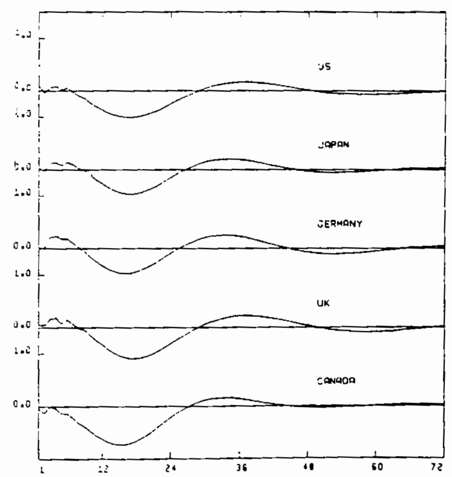


FIGURE 3 IPROW

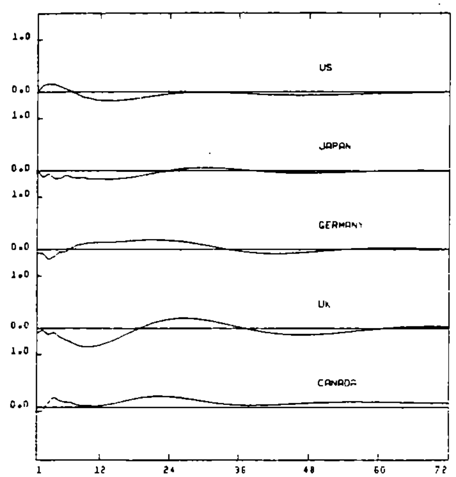


FIGURE 4 R

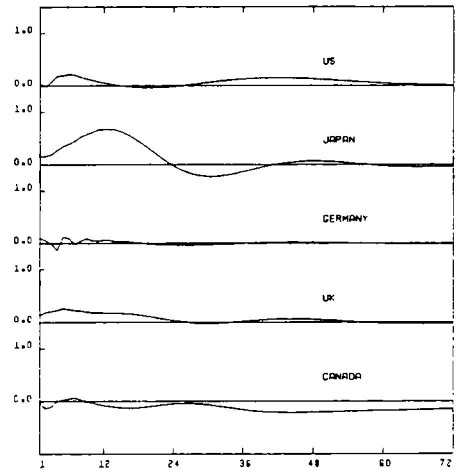


FIGURE 5 M

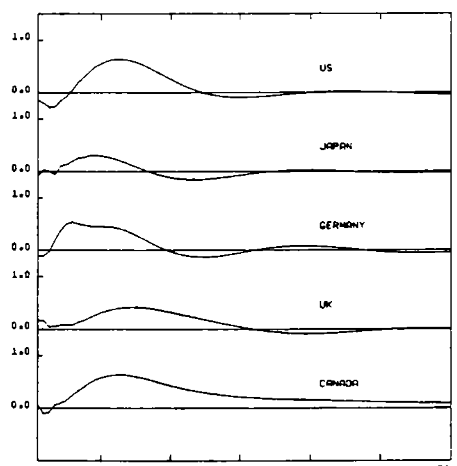


FIGURE 6 W

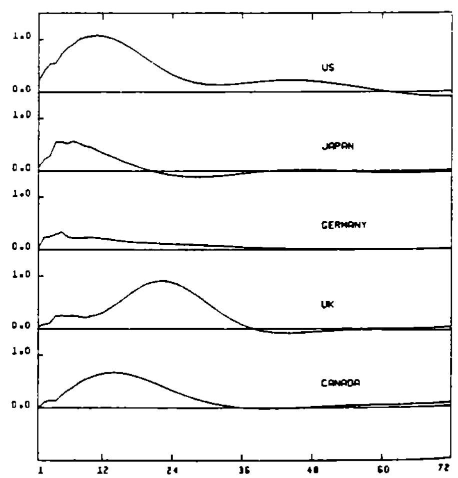


FIGURE 7 CPI

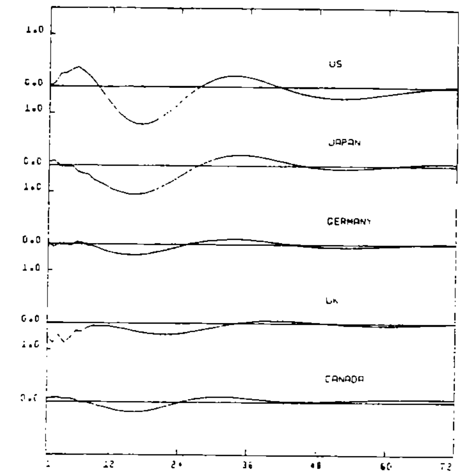


FIGURE 8 IP

2 to n; to series 2, the contemporaneous correlation between it and series 3 to n; and so on.[11] Thus, at one end of the ordering an innovation in series 1 is allowed to influence all variables contemporaneously; at the other extreme, an innovation in series n influences only itself contemporaneously. Since our interest is in discovering the effects of changes in *PF*, it seemed appropriate to place it at the top of the ordering; the desire to allow *PF* maximum opportunity to influence *CPI* and *IP* suggested that the remaining variables should be ordered as *IPROW*, *R*, *M*, *W*, *CPI*, *IP*.[12]

In the light of the differences across countries in the *F* tests (Table 1), we should probably not be surprised at the variation across countries in Figures 2 to 8. Some systematic patterns are apparent, however. For *PF* and *IPROW*, the effect of the shock dies out almost completely in all countries after three years, in the latter case having depressed the variable for about two years. Effects on *R* and *M*, as fractions of one standard deviation, are mostly much smaller in magnitude, and the pattern of response varies appreciably across countries. There is some suggestion of a negative correlation between *R* and *M* in some countries (notably the U.K.) over the first two years, although the U.S. results provide a contrary impression, and the evidence generally is weak.

[11] This describes the class of Choleski factorizations of the variance-covariance matrix of the innovations, Ω, that is, we create orthogonal innovations, v_t, such that $\varepsilon_t = Sv_t$, where S is a lower triangular nxn matrix, $SS' = \Omega$, and S is chosen so that the variance-covariance matrix of the v's is an n^{th} order identity matrix.

[12] Impulse responses are sometimes influenced by the ordering of variables. As one might expect, however, the degree to which this occurs is governed, at least in part, by the extent of contemporaneous correlation. In the case of our data, contemporaneous correlation is relatively small, so that the arbitrariness that our particular ordering introduces into the results is probably not serious, but in Section 6 we consider this issue more systematically by repeating our analysis with *PF* placed last.

The results further indicate that oil-price shocks increase wages and prices in all countries, albeit with appreciable variation in the size of the effect. In the case of W, the U.S. and Canadian responses are largest, and that of Japan the smallest. For CPI, the U.S. and the U.K. exhibit the most sizeable reactions to the oil-price shock, and only one country, Germany, reveals a weak effect. The responses of IP are quite small for all but two countries; the exceptions are the U.S., where a small positive response is followed by a large negative one, and Japan.

The initial positive response in U.S. is inconsistent with the predictions of most

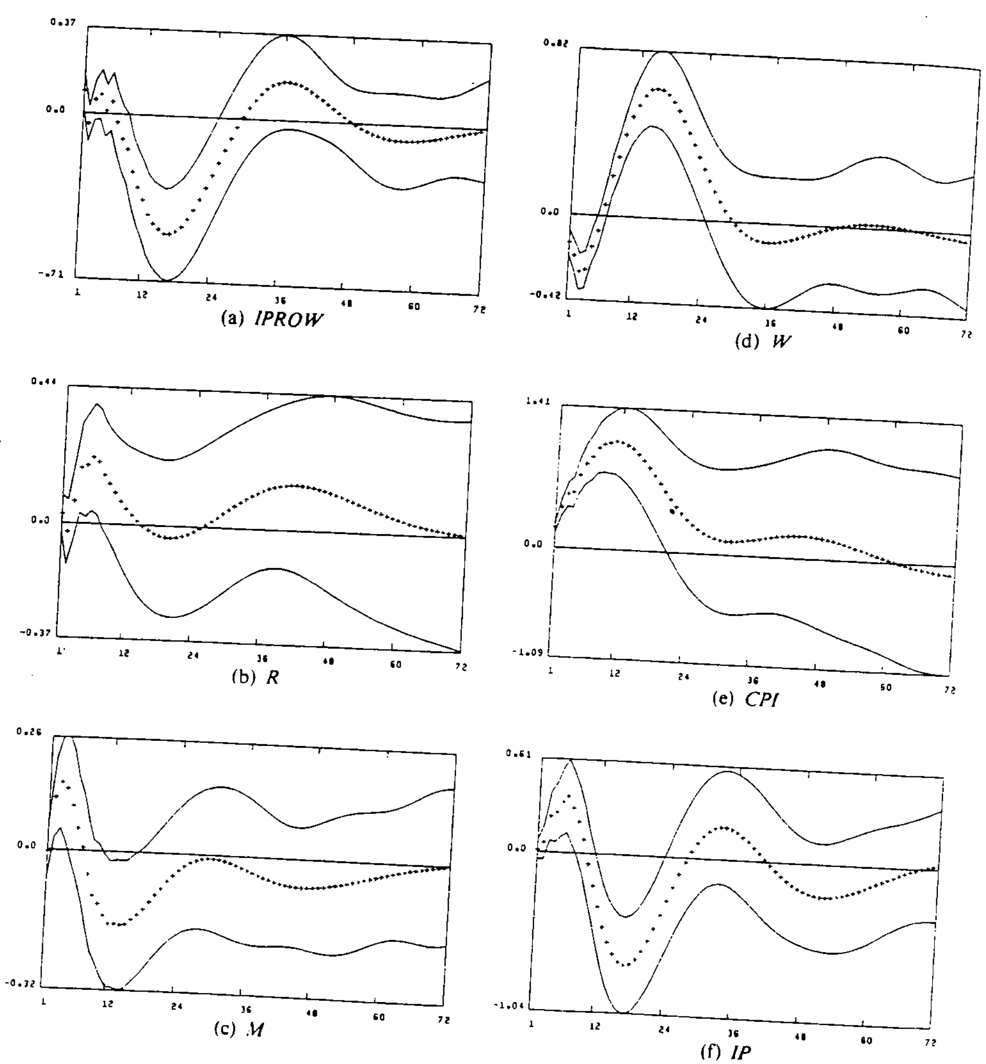


FIGURE 9
RESPONSES, AND RESPONSES PLUS AND MINUS ONE STANDARD DEVIATION, FOR THE U.S.

short-run models of oil-price shocks, but we have yet to consider whether this response, or indeed any of the responses, is statistically significant, an issue we now address.

RATS, the estimation package, provides a method of establishing the significance of impulse responses, based on the posterior distribution of the orthogonalized responses (Doan and Litterman [1981, ch. 12]). One simply computes the standard error of the posterior distribution; addition of the standard error to, and subtraction of it from, the impulse response provides a one-standard-error band from which one can assess statistical significance. We performed this exercise, making 100 draws from the posterior distribution. The results across the five countries were broadly similar, and accordingly, we present in Figure 9 only those for the U.S. These confirm the positive response of W and CPI, and the negative reaction of IP, to the shock in PF, but suggest that the responses of M and R are not statistically important.

The combined evidence of Figures 2 to 8 and Figure 9 seem to suggest therefore that increases in the price of oil exert both the inflationary, and, to a lesser extent, the recessionary, pressures so frequently predicted by models of oil-price shocks. In the next section we examine whether these pressures can be identified in historical decompositions of the actual behavior of prices and output after the shocks of 1973–1974 and 1979–1980.

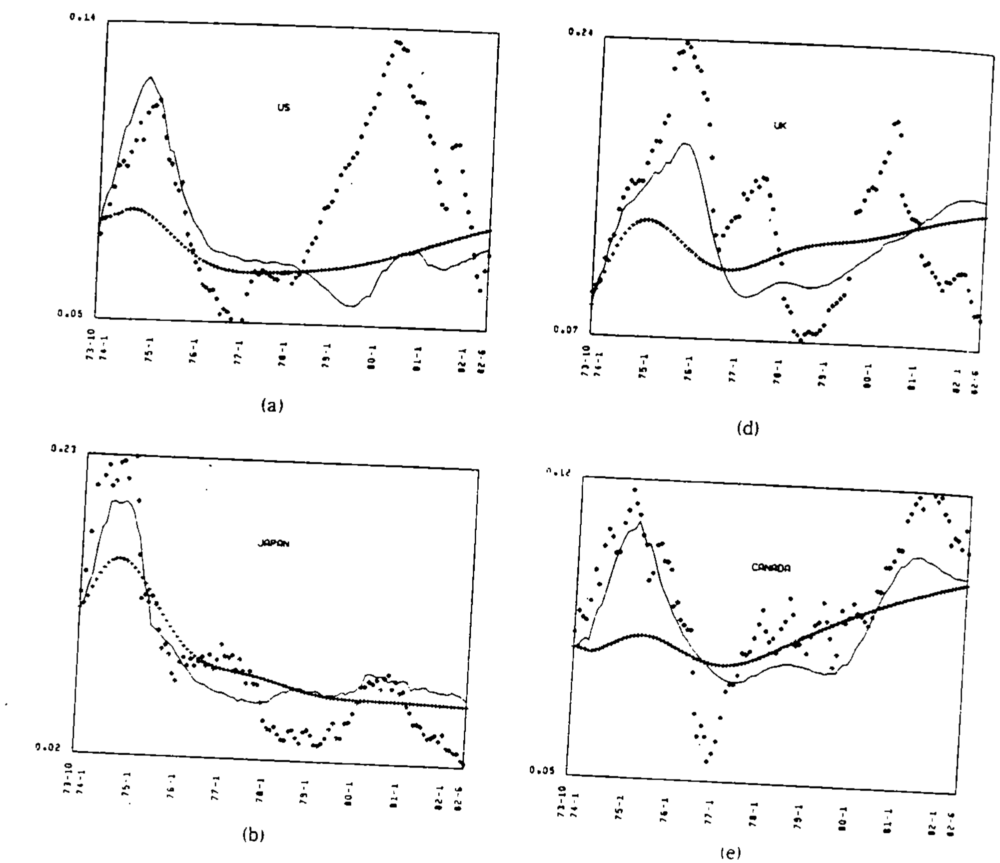
5. HISTORICAL DECOMPOSITIONS

The moving average representation with orthogonal innovations can be written as

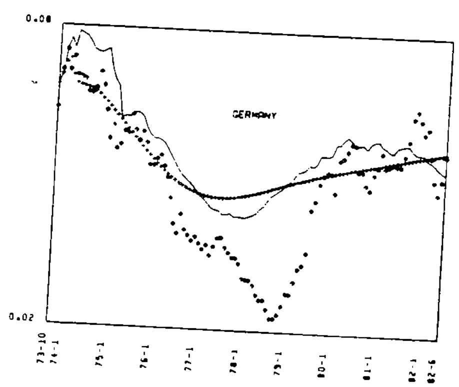
$$(3) \qquad y_{T+j} = \sum_{i=0}^{\infty} C_i S v_{T+j-i}$$
$$= \sum_{i=0}^{j-1} C_i S v_{T+j-i} + \sum_{i=j}^{\infty} C_i S v_{T+j-i},$$

where T is some base period in the sample, and $T+j$ is less than or equal to the last period of the sample. The first term represents that part of the historical time series, y_{T+j}, that is due to innovations since period, T; the second term is a base projection of y_{T+j}, based on information available at time, T.

In Figures 10 and 11 we focus on the base projection (plus signs), the base projection plus the cumulative impact of the PF innovations (solid line), which we refer to as the base-plus-oil projection, and the actual historical time series (scatter of points), all for CPI and IP. T is chosen to be September, 1973, the month before the first major oil-price shock, so that the gap between the base projection and the actual series is entirely attributable to innovations since that month; the contribution of innovations in the price of oil, therefore, is reflected in the extent to



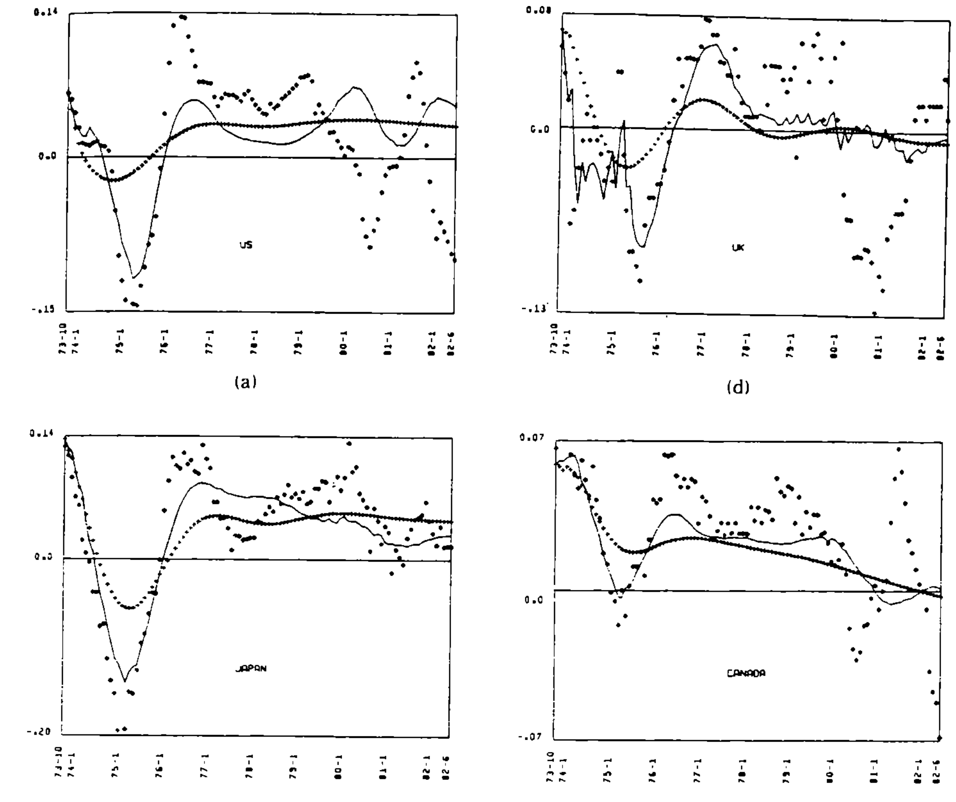
(a) (d) (b) (e)



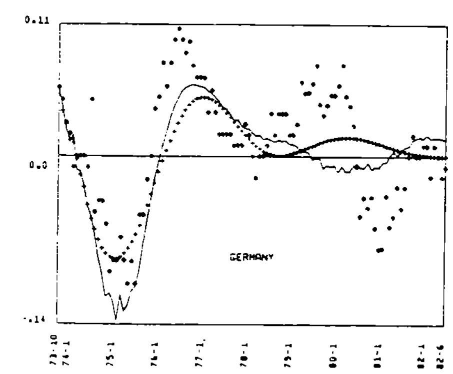
(c)

FIGURE 10

HISTORICAL DECOMPOSITIONS OF CPI INTO A BASE (SEPTEMBER, 1973) PROJECTION (PLUS SIGNS), BASE-PLUS-OIL PROJECTION (SOLID LINE), AND ACTUAL SERIES (SCATTER OF POINTS), OCTOBER, 1973 TO JUNE, 1982.



(a) (d) (b) (e)



(c)

FIGURE 11

HISTORICAL DECOMPOSITIONS OF IP INTO A BASE (SEPTEMBER, 1973) PROJECTION (PLUS SIGNS), BASE-PLUS-OIL PROJECTION (SOLID LINE), AND ACTUAL SERIES (SCATTER OF POINTS), OCTOBER, 1973 TO JUNE, 1982.

which the base-plus-oil projection closes this gap.[13,14]

Neither Figure 10, nor Figure 11, allows one to interpret the contribution of innovations in *PF* to the behavior of *CPI* and *IP* as being even broadly similar across countries. Indeed, there is no reason why they should allow such an interpretation, given the differences among the countries in monetary policy, domestic pricing policy for oil, and suchlike. Some similarities between certain countries do nevertheless exist. For example, in Figure 10, for the *CPI*, the oil-price innovations since September 1973 in the U.S. and Canada largely account for the extra inflation, up to late 1975 or early 1976, beyond that already underway and captured, therefore, in the base projection. In the U.K., by contrast, the absolute impact of the oil-price innovations in the first three years is greater, but *PF* still explains only about one-half of the difference between the peak inflation level of 24% (August, 1975) and the base projection. Japan is different again; peak inflation rivals that for the U.K. but much of this is in the base projection, so that although perhaps one-half of the extra inflation can also be attributed to oil-price innovations in this case, the absolute size of the effect of *PF* is small. In Germany, the effect of the innovations in *PF* is to generate a projection in excess of actual inflation; the maximum inflation rate is anyway much lower, only 8%, and must of this is in the base projection.

Beyond the first two to three years after September, 1973, *PF*'s influence on *CPI* wanes in all five countries, sizeable deviations of the actual series from the base projection often remaining entirely unexplained when the oil-price innovations are added. The innovations do not become entirely irrelevant in Canada, however: beginning in 1980, inflation begins to rise again, reaching a maximum in July, 1981, and over this period the extra information contained in the oil-price innovations improves upon the base projection quite noticeably.

Turning next to the results for *IP*, shown in Figure 11, we find more which seems common to all countries. Most strikingly, perhaps, the base projections all suggest significant reductions in the rate of growth of output after September, 1973; indeed for a period of a year or more the projected rates of growth are negative in all countries except Canada. This suggests that the mid-70s recession, so evident in the movements of the actual *IP* series, was on the way even before the large oil-price rises in late 1973.[15]

[13] Historical decompositions partition the difference between the actual series and the base projection among the variables in the VARs. Hence, the base projection augmented by the innovations in all seven variables yields the actual series.

[14] The figures on the vertical axes of the graphs give the values of the series at the upper and lower boundaries. It is worth bearing in mind that, since our data are logarithms of twelfth-differences, the series can be read as approximate annual rates of growth.

[15] A statement similar to this one appeared in an earlier draft of the paper, and was greeted with some skepticism by certain readers. It was argued that few observers in 1973 were predicting a recession for 1974 and 1975, and perhaps our use of data up to 1981 to estimate the VARs was responsible for this result. We therefore re-estimated the VARs for the sub-period up to

(*Continued on next page*)

What role did *PF* play in the recession? For all countries except Germany, innovations in *PF* go a long way to closing the gap between the base projection and the actual series over the period up to late 1975 or early 1976. Thereafter, the impact of innovations in *PF* differs somewhat across countries. In the U.K. there is evidence of a strong continuing influence of *PF* on *IP*, but for the U.S., Japan, and (arguably) Canada, the graphs suggest only a limited role for *PF*. Its innovations help to explain the recovery from recession beginning in late 1975; by the end of 1976, this influence wanes, however.

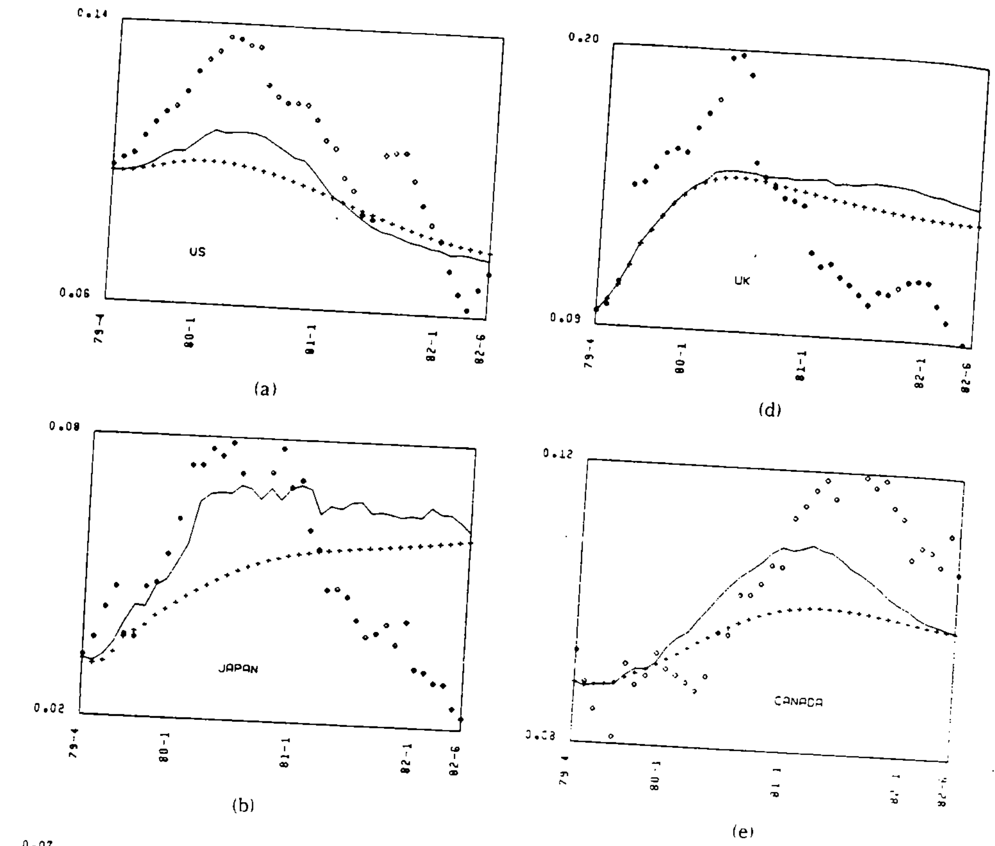
As is evident from Figures 10 and 11, late 1979 and early 1980 was a period when the pattern of rising rates of price inflation and falling rates of growth of real output were repeated. These trends are sometimes attributed to the second major series of oil-price rises, namely those beginning in April, 1979, but as the preceding paragraphs have made clear, Canada apart, there is little in the figures to substantiate this. This does not constitute a systematic investigation of the effects of the 1979–1980 oil-price shocks, however. What is required is a re-estimation of the historical decompositions with T set to be March, 1979, and the results of such an analysis, for *CPI* and *IP* once again, are displayed in Figures 12 and 13.

The contrasts between these graphs and Figures 10 and 11 are quite striking. Innovations in *PF* account for none of the deviation of the U.K.'s *CPI* from its base projection, and in the U.S., Germany and Canada, too, the contribution of *PF* to *CPI* is relatively small. *PF* contributes appreciably to higher Japanese inflation in 1979 and early 1980, however, although even in this case the base-plus-oil projection goes awry once inflation turns down from its peak in late 1980. For *IP*, Japan stands in still sharper contradistinction to the other countries: except in Japan, the base-plus-oil projection typically deviates only slightly from the base projection, and the complete decompositions (not shown) suggest that the behavior of each series is best explained by its own innovations. In short, the price of oil does not appear to have been a major factor in causing the declining rates of output growth or the increasing rates of price inflation in the U.S., Germany, the U.K., or Canada.

Overall then, it seems that four of the five OECD countries we have considered responded very differently to the two sets of oil-price shocks, with only Japan manifesting any appreciable impact of *PF* on *CPI* and *IP* after the 1979–1980 increases. Furthermore, it must be remembered, when considering the importance of the 1973–1974 shock, that in a number of respects the analysis is biased in favor of finding such a result: for instance, *PF* was placed first in the ordering for the

(*Continued*)

September, 1973, and then generated forecasts of the path of *IP* subsequent to that month. In common with the base projections, these suggest falls in the rate of growth of output for all countries until late 1974, or early 1975, and recovery thereafter; furthermore, for three of the five, the U.S., Japan and Germany, the forecast minimum rate of growth over this mid-70s period is actually lower than the minimum value from the base projection.



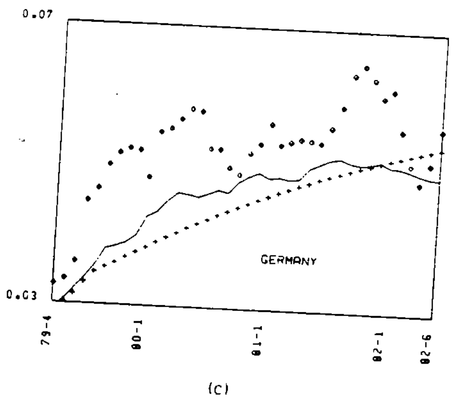
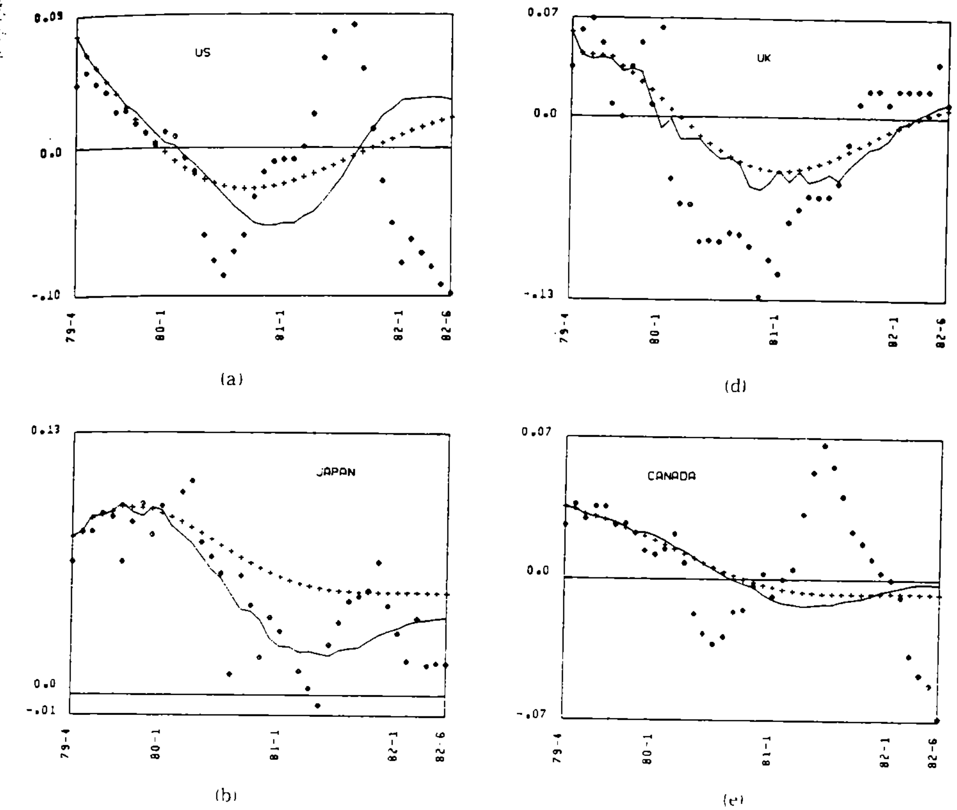


FIGURE 12
HISTORICAL DECOMPOSITIONS OF CPI INTO A BASE (MARCH, 1979) PROJECTION (PLUS SIGNS), BASE-PLUS-OIL PROJECTION (SOLID LINE), AND ACTUAL SERIES (SCATTER OF POINTS), APRIL, 1979 TO JUNE, 1982.

orthogonalization, thereby attributing contemporaneous correlation between PF and all other variables in the VAR to PF. Additionally, at various points in the paper we have raised other issues regarding the particular specification chosen that might cause us to qualify conclusions drawn from the analysis of Sections 4



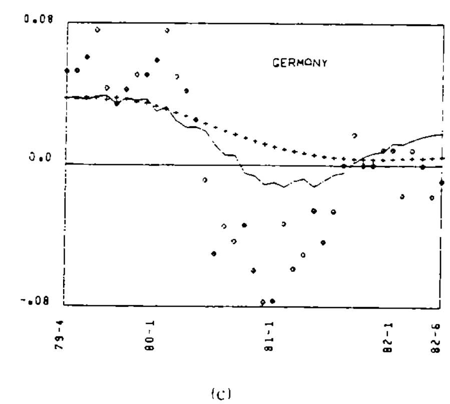


FIGURE 13
HISTORICAL DECOMPOSITIONS OF IP INTO A BASE (MARCH, 1979) PROJECTION (PLUS SIGNS), BASE-PLUS-OIL PROJECTION (SOLID LINE), AND ACTUAL SERIES (SCATTER OF POINTS), APRIL, 1979 TO JUNE, 1982.

and 5. We therefore conducted a number of experiments designed to check the robustness of our results, and these are reported in the following section, together with a brief comparison of these results with those of Hamilton [1983].

6. SPECIFICATION

In the first part of this section we address three issues of specification. All have been alluded to earlier. First, we investigate whether the nature of the variable *PF* causes problems for our analysis. Next, we examine the importance of the ordering of the variables in the VAR. Finally, we consider the effect of increasing the number of lags included in the estimation of the VARs. In all cases, our experiments were carried out only on the U.S. system of equations, for the sake of brevity.

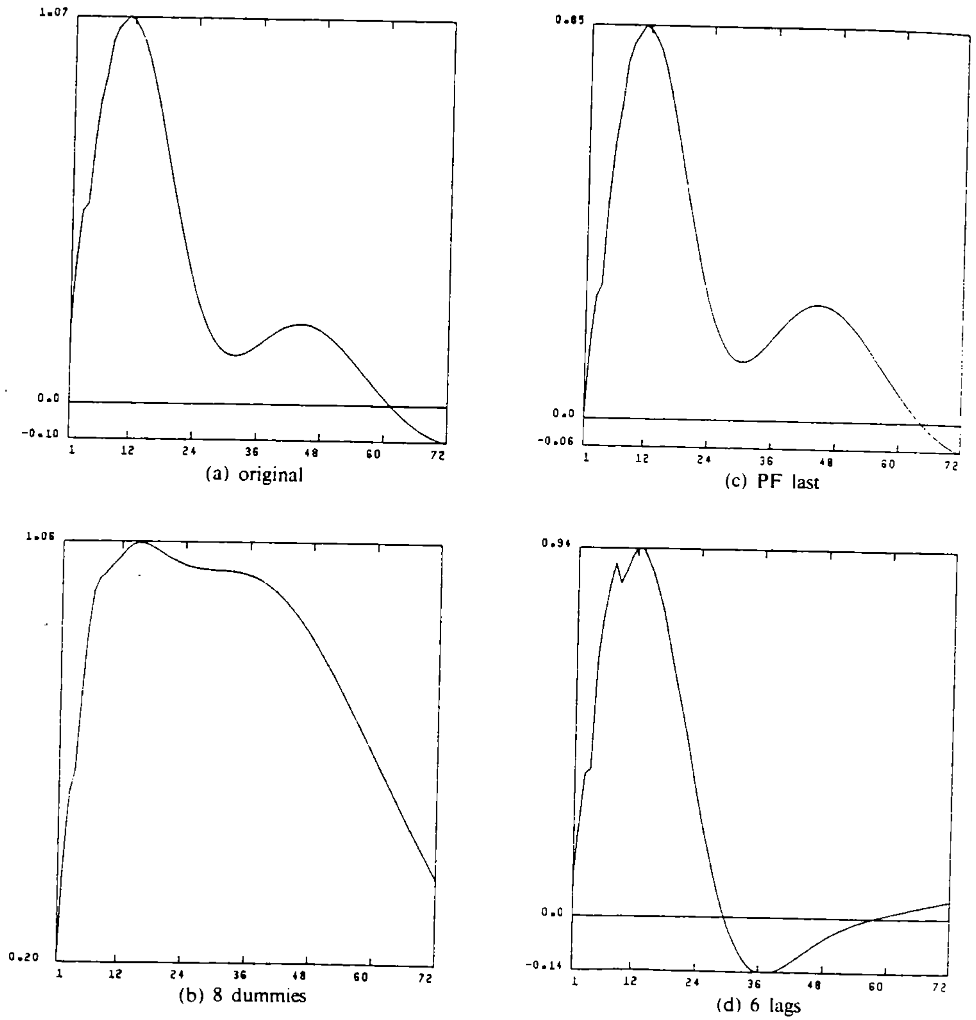


FIGURE 14
RESPONSES OF U.S. CPI TO A ONE-STANDARD-DEVIATION SHOCK IN PF.

As Figure 1 illustrates, eight innovations in the *PF* equation for the U. S. lie outside the two-standard-deviations band, and it is quite possible that the results that suggest a strong impact on *CPI* and *IP* rest heavily on these few outliers. Accordingly, eight dummies were constructed, each set to unity for one of the eight large innovations and zero otherwise, and these were added to the U.S. VAR. The impulse responses associated with this altered system were then computed. CPI's response is shown in panel (b) of Figure 14, and *IP*'s is in the equivalent panel of Figure 15; the graphs in panel (a) of each figure reproduce the original responses (from Figures 7 and 8), which are included for purposes of comparison. The strong inflationary pressure, evident in panel (a) of Figure 14, persists in panel (b); similarly the recessionary impact seen in panel (a) of Figure 15 is maintained in panel (b), and in both cases the graphs suggest that inclusion of the dummies causes the effects of the shock to die away less quickly.

We have earlier suggested (footnote 12) that our results are probably not sensitive to the ordering chosen for the orthogonalization. To examine this question more closely, we computed the impulse responses, and the historical decompositions[16] of the period from October 1973, based on an ordering with *PF* last instead of first, and with the other variables unchanged. The response of *CPI* to a shock in *PF* is in panel (c) of Figure 14, that of *IP* is in panel (c) of Figure 15, the historical decomposition of *CPI* is in panel (b) of Figure 16, and that of *IP* is in panel (b) of Figure 17. (The graphs in the first panel of each of Figures 16 and 17 reproduce the original decompositions from Figures 10 and 11.)

Considering first the impulse responses, we find that in this case both the direction and the general pattern of the responses are unchanged when *PF* is placed last in the ordering, although there is a slight weakening in the size of the effect on *CPI* and *IP*. The historical decompositions also suggest that the position of *PF* in the ordering is not critical. For the *CPI*, the base-plus-oil projection actually tracks the actual inflation of 1974 and 1975 more closely, and for *IP* there is only a slight reduction in the proportion of the difference between the actual series and the base projection explained by *PF*.

The third experiment involved the inclusion of extra lags in the VAR, prompted by the finding that four lags was rejected as a restriction of systems with five or six lags. We have earlier argued (footnote 6) that extending the VAR to six lags leaves our results largely unchanged, and this can be seen from the impulse responses based on this system (panel (d) of Figure 14 and panel (d) of Figure 15), and from the historical decompositions (panel (c) of Figure 16 and panel (c) of Figure 17). This is not to say that nothing changes, however. In Figure 16, the historical decomposition of the behavior of CPI, a comparison of panels (a) and (c) reveals an improvement in the base projection: more of the increased

[16] The reader may at this point ask why we did not generate the historical decomposition for the previous experiment. The answer is that the dummies are added as deterministic components to the VAR, that is, to all seven equations, and thereby enhance the base projection to such an extent that there is little left to explain.

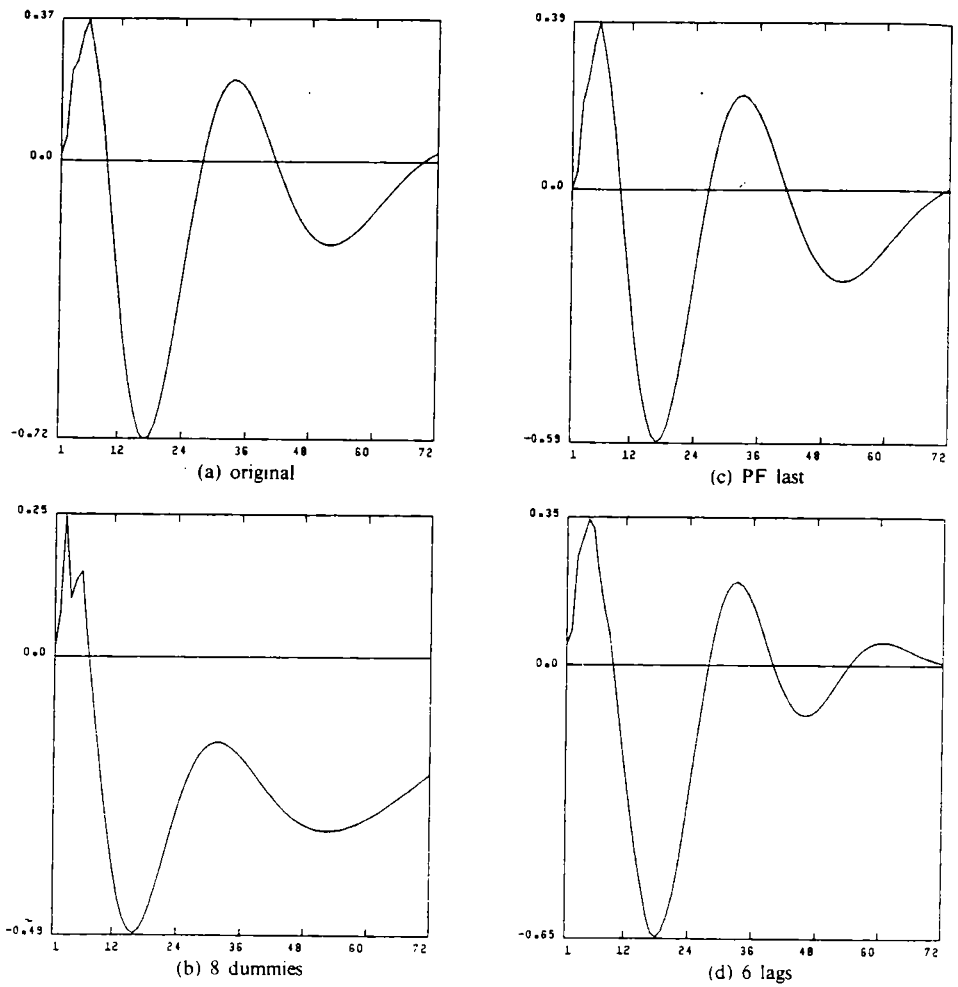


FIGURE 15
RESPONSES OF U.S. IP TO A ONE-STANDARD-DEVIATION SHOCK IN PF.

inflation of late 1974 and early 1975 is captured, as is the relatively low inflation of late 1976 and early 1977. These observations notwithstanding, the deviation in the former case of the actual series from the base projection is still sizeable, and the base-plus-oil projection largely closes this gap.

None of our three experiments seems able, therefore, to alter our conclusion that a large part of the higher inflation and lower rates of real growth in 1974 and 1975 can be attributed to oil-price shocks.[17] We now compare this conclusion

[17] Strictly speaking, of course, this role for the price of oil has only been substantiated for the U.S., whose equation system was the one on which the experiments were performed.

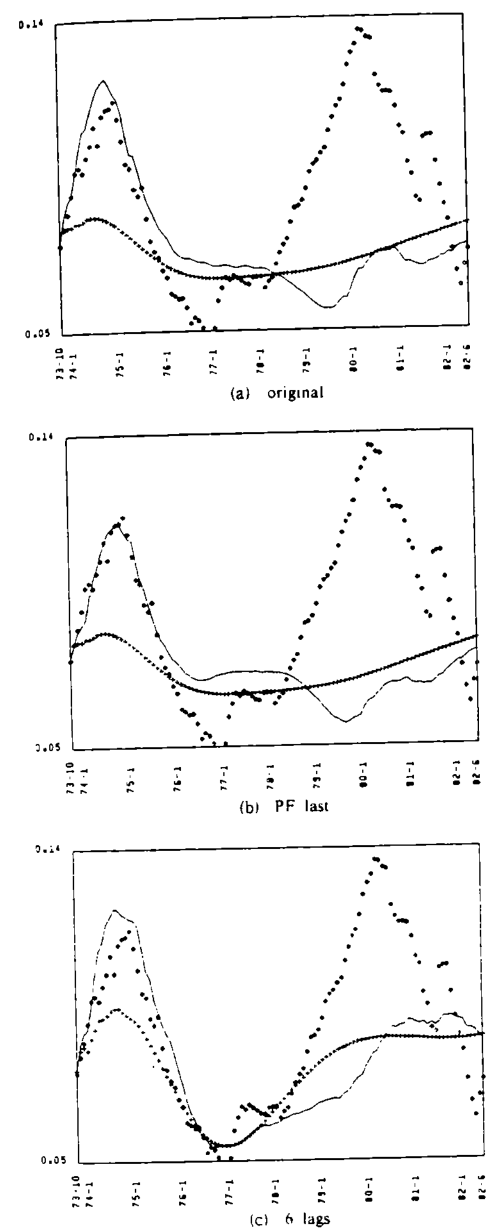


FIGURE 16
HISTORICAL DECOMPOSITION OF U.S. CPI INTO A BASE (SEPTEMBER, 1973) PROJECTION (PLUS SIGNS), BASE-PLUS-OIL PROJECTION (SOLID LINE), AND ACTUAL SERIES (SCATTER OF POINTS), OCTOBER, 1973 TO JUNE, 1982.

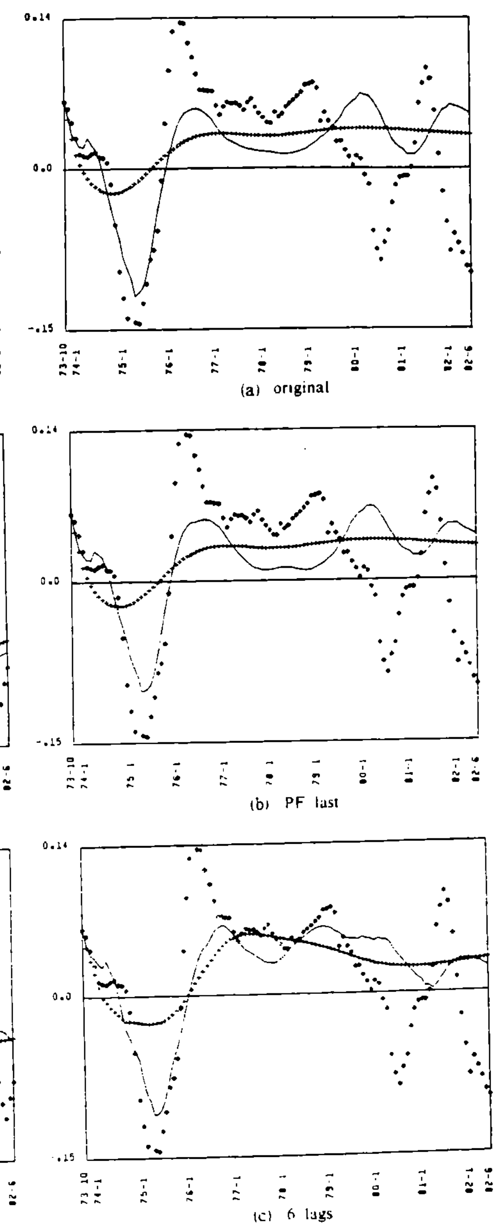


FIGURE 17
HISTORICAL DECOMPOSITION OF U.S. IP INTO A BASE (SEPTEMBER, 1973) PROJECTION (PLUS SIGNS), BASE-PLUS-OIL PROJECTION (SOLID LINE), AND ACTUAL SERIES (SCATTER OF POINTS), OCTOBER, 1973 TO JUNE, 1982.

and the different picture that emerged from our analysis of the 1979–1980 oil-price shocks, with the findings from the study by Hamilton [1983].

Hamilton's approach is similar to ours in a number of respects, notably the use of a VAR model. He adopts the six-variable system of Sims [1980a], and conducts various bivariate and multivariate causality tests. He investigates the tendency for postwar recessions in the U.S. economy to follow rises in the nominal price of oil [1983, Fig. 1, p. 229], and attempts to establish whether oil can be assigned a causal role, or whether, instead, both events can be traced to the influence of a third force. Using data covering the period 1948 to 1972, he argues that, through elimination of alternative possibilities, "the case is strengthened for the ... interpretation ... [that] at least some of the recessions prior to 1973 would have been different had the oil price increase ... not occurred" [1983, p. 247]. This, in turn, leads him to suggest that the recessions since 1972 can be likewise explained, although for the most part he does not use data covering these recessions, suggesting that, by so doing, he is avoiding a possible source of nonstationarity, and also separating "the data that suggested the hypothesis (i.e., post-OPEC experience) from those on which it is to be tested" [1983, p. 233].

It should be clear, then, that this paper and Hamilton's are complementary: by somewhat differing means, both come to the same conclusion regarding the impact on U. S. real output of the 1973–1974 oil-price shock. In addition, we examine the effect on prices, we look directly at the "post-OPEC experience" instead of making inferences from estimation based only on pre-OPEC data, and, as a result, find significant differences between the influence of the 1973–1974 and the 1979–1980 oil-price shocks. Finally, and most obviously, we do not confine our attention to the U.S., looking also at Canada, Germany, Japan and the U.K.

7. SUMMARY

In this paper, the innovation-accounting techniques pioneered by Sims [1980a], and used by him to study, *inter alia*, the role of money in macroeconomic fluctuations [1980b], have been applied to the question of determining the influence on five OECD economies of the large oil-price rises in the 1970s. As Lucas [1980, pp. 705–706] argues, attributing virtually everything to supply shocks "does not seem to be worth taking seriously," but the deluge of theoretical papers over the past few years dealing with the impact of supply shocks demonstrates that the economics profession believes the effect of the oil-price rises to have been important. Yet, apart from the simulation studies cited earlier, systematic empirical work addressed to the question of just how important has, by contrast, been sparse.

The seven-variable VARs estimated and discussed in Section 3 provide descriptive statistical models whose moving-average representations are used in two ways in Sections 4 and 5 to study the various effects of oil-price changes. First, the impulse responses to an oil-price shock are computed. These describe the responses of each country's system of equations to the shock; they reveal effects of the shock on both the price level and industrial output, the two variables on which we concentrate attention in our discussion of the results. In the case of the price level, the impact on the U.S. and Canadian economies is substantial, with smaller (but still significant) effects in Japan, Germany, and the U.K. For industrial production, we find that the price of oil exerts a sizeable influence in the U.S. and the U.K., but the responses in other countries are, by comparison, quite small.

Our second method of investigation involves decomposition of the behavior of prices and output into a base projection, movement attributable to innovations before an oil-price shock, and a base-plus-oil projection, which augments the base projection by taking account of innovations in the price of oil since the shock. The gap between the base projection and the actual series is, therefore, entirely a consequence of innovations in all variables since the shock, and the importance of the oil price can be gauged by the extent to which the base-plus-oil projection closes this gap. Two shocks are analyzed: the series of oil-price rises after September, 1973, and the more recent set of increases which began in April, 1979. For the first shock, we find a substantial impact of oil-price innovations on both prices and output in the months following the shock, a result that Section 6 suggests is quite robust to alternative specifications. In the case of the second shock, however, the influence of the oil price is quite minimal, except in Japan.

The base projections of the historical decompositions additionally provide us with evidence on what was in store had the oil-price rises of late 1973 and early 1974 not occurred. They suggest that the mid-70s recession was already on its way before the large oil-price rises in late 1973; the shock just made matters worse. Similarly, the base projections associated with our investigation of the more recent oil-price shock are quite successful in keeping track of the behavior of prices and output after the shock. All in all it is less easy than some might think, it seems, to lay all the blame on external influences, namely OPEC, for the poor economic performance of much of the non-OPEC world over the past 10 years.

McMaster University, Canada.

APPENDIX

DATA SOURCES

In this appendix we give a brief description of each of the data series used, together with its source. All series are monthly. We cover the *PF* and *IP* series first and then turn to the other series, by country.

PF: Ratio of *PFIFS* to a weighted average of the *CPI*s for the United States, Japan, Germany, the United Kingdom, and Canada, where the weights are based on 1970 gross domestic products, measured in U.S. dollars; source: *The National Accounts of OECD Countries* 1950–1974, Vol. 1, p. 114. *PFIFS* is the price of petroleum (in U.S. dollars per barrel) in Ras Tanura, Saudi Arabia; source: *International Financial Statistics*, various issues.

IP, *IPROW*: The OECD publishes seasonally adjusted indices of industrial production for each OECD country and for the OECD as a whole. Given the weights for each country, one can then construct *IPROW* appropriate to that country; sources: OECD, *Main Economic Indicators*: *Historical Statistics* 1960–1979, and Supplement No. 1 (September 1980); OECD, *Main Economic Indicators*, various issues; OECD, *Indicators of Industrial Activity*, various issues.

(a) *United States*

R: Yield on 90-day treasury bills, not seasonally adjusted; source: Citibank data tape, and *Survey of Current Business*, various issues.

M: Currency and demand deposits, not seasonally adjusted; source: Table A13 of the *Federal Reserve Bulletin*.

W: Average hourly earnings, excluding overtime, of production workers in manufacturing (dollars per man hour), not seasonally adjusted; sources: *Employment and Earnings, U.S.*, 1909–1978, U.S. Department of Labor, BLS, 1979, Bulletin 1312-11 and *Employment and Earnings*, various issues.

CPI: All-items index of consumer prices, urban consumers, not seasonally adjusted; source: CANSIM data base, B53204.

(b) *Japan*

R: Call money rate; average (mode before May, 1972) of daily interest rates in Tokyo, not seasonally adjusted; sources: OECD, *Main Economic Indicators*: *Historical Statistics* 1960–1975, and *Main Economic Indicators*, various issues.

M: Currency and demand deposits, seasonally adjusted; sources: OECD, *Main Economic Indicators*: *Historical Statistics* 1960–1975, and *Main Economic Indicators*, various issues.

W: Ratio of monthly earnings of regular workers in manufacturing to monthly hours worked by regular workers, both seasonally adjusted; sources: OECD, *Main Economic Indicators*: *Historical Statistics* 1960–1975, and *Main Economic Indicators*, various issues.

CPI: All-items index of consumer prices, seasonally adjusted; sources: OECD, *Main Economic Indicators*: *Historical Statistics* 1960–1975, and *Main Economic Indicators*, various issues.

(c) *Germany*

R: Call money rate in Frankfurt, average of extreme daily interest rates quoted between the 23rd of the month and the end of the month; sources: OECD, *Main Economic Indicators*: *Historical Statistics* 1960–1975, and *Main Economic Indicators*, various issues.

M: Currency and demand deposits, seasonally adjusted; sources: OECD, *Main Economic Indicators*: *Historical Statistics* 1960–1975, and *Main Economic Indicators*, various issues.

W: OECD does not publish a monthly series. We therefore interpolated the quarterly series of average hourly wage rates in manufacturing to obtain a monthly series; sources: OECD, *Main Economic Indicators*: *Historical Statistics* 1960–1975, and *Main Economic Indicators*, various issues.

CPI: All-items consumer price index, seasonally adjusted; sources; OECD, *Main Economic Indicators*: *Historical Statistics* 1960–1975, and *Main Economic Indicators*, various issues.

(d) *United Kingdom* (all data not seasonally adjusted)

R: Average rate of discount on 91-day treasury bills; source: CSO, *Financial Statistics*, various issues.

M: Currency and demand deposits; sources: OECD, *Main Economic Indicators*: *Historical Statistics* 1960–1975, and *Main Economic Indicators*, various issues. Prior to October 1971, monthly data are not available. We therefore constructed the observations in the following way. For the period March, 1963 to September, 1971, we collected the quarterly figures for *M*1 (currency plus current accounts; source: CSO, *Financial Statistics*, various issues). It has been suggested, however, that these estimates "may have been too low, perhaps by 200–250 million at the end of September 1971", (Bank of England, *Bank of England Quarterly Bulletin*, Vol. 12, No. 1, March 1972, p. 77), and we therefore made an appropriate adjustment, multiplying the figures by 1.024, the correction implied by the upper limit of this possible understatement. Next, we made this revised quarterly series consistent with the monthly series. To do this, we computed the mean differentials between the two series for March, June, September and December from the available observations on both series for 1972 to 1978, and applied these to the appropriate earlier quarterly observations. Finally, we interpolated the values of the missing observations using information on two related monthly series, current account deposits at the London Clearing Banks, and currency in circulation with the public (source: CSO, *Monthly Digest of Statistics*, various issues). The interpolation procedure we adopted was one proposed by Friedman and Schwartz in their excellent discussion of the subject [1970, pp. 321–328], and involved estimating the linear trend values for missing observations for *M*1, and then adjusting these in line with the deviations from trend of the sum of current account deposits and currency in circulation. This still left us without observations for January, 1961 to February, 1963. Again, monthly data on current account deposits plus currency are available and we therefore used these figures, adjusting them by the corresponding month's differential between current account deposits plus currency and our constructed $M1$ series in the period March, 1963 to February, 1964.

W: Index of basic hourly wage rates of manual workers in manufacturing industries; source: CSO, *Monthly Digest of Statistics*, various issues.

CPI: All-items index of retail prices; source: CSO, *Monthly Digest of* Statistics, various issues.

(e) *Canada* (all data not seasonally adjusted)

R: Yield on 90-day treasury bill; source: CANSIM data base, B14007.

M: Currency and demand deposits; source: CANSIM data base, B2013.

W: Average hourly earnings of hourly-rated workers in all manufacturing industries, based on the 1960 SIC, source: CANSIM data base, D1518.

CPI: All-items consumer price index; source: CANSIM data base, D616101.

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MODEL SPECIFICATION TESTS BASED ON ARTIFICIAL LINEAR REGRESSIONS*

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1. INTRODUCTION

In this paper, we develop a simple computational procedure for performing a wide variety of model specification tests. These tests are either explicit Lagrange Multiplier tests or asymptotically equivalent variants, and thus require estimates under the null hypothesis only. They may be used to test for many types of misspecification in the context of rather general nonlinear models. Our procedure is based on an artificial linear regression, so that the test statistics can easily be calculated using any regression package. This artificial regression can also be used to compute covariance matrix estimates or as part of a nonlinear maximization algorithm.

The results of the paper can best be understood as extensions of relatively familiar results for nonlinear regression models. Consider the model

$$y = z(\beta) + u, \quad u \sim N(O, \sigma^2 I), \tag{1}$$

where y is an n-vector of observations on a dependent variable, β is a vactor of parameters to be estimated, and $z(\beta)$ is a vector-valued function whose t-th component $z_t(\beta)$ may depend on exogenous variables and on lagged values of the dependent variable. Following Durbin [1970], we may linearize (1) around any particular value β^* to obtain the artificial linear regression

$$y - z^* = Z^* b + \text{residuals} \tag{2}$$

where z^* denotes $z(\beta^*)$ and Z^* denotes the matrix whose ti-th element is the derivative of $z_t(\beta)$ with respect to β_i, evaluated at β^*. If β^* is chosen to be the vector of unrestricted maximum likelihood estimates $\hat{\beta}$, then the least squares coefficient estimates $\hat{b}$ from (2) must be identically zero, as a consequence of the first-order conditions for $\hat{\beta}$. Moreover, the OLS variance-covariance matrix calculated for $\hat{b}$, $\hat{\sigma}^2(\hat{Z}^{\mathrm{T}}\hat{Z})^{-1}$, provides a consistent estimate of the variance-covariance matrix of $\hat{\beta}$.

Alternatively, β^* may be chosen to be $\tilde{\beta}$, a vector of maximum likelihood

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The First Oil Shock — 20 Years Later

Two decades ago, the world was in the midst of an oil price shock. Within a period of a few months, world oil prices quadrupled and a sales embargo deprived the United States (and a few other countries) of access to some of their main traditional sources of imported oil. This concrete manifestation of the significance of oil as a political weapon marked the coming of age of OPEC and led most oil-importing countries to adopt wide-ranging measures aimed at reducing their dependence on foreign sources of oil.

Much has happened in the intervening 20 years. *Energy Studies Review* is pleased to bring to you this collection of six papers which offers both a retrospective view of these developments and an examination of their longer-term consequences. This is the fourth *ESR* co-edition prepared in collaboration with the Institut d'Économie et de Politique de l'Énergie (IEPE) operated by the Centre National de la Recherche Scientifique (CNRS) at the university centre in Grenoble (France). Energy analysts at IEPE have provided four of the papers, while the remaining two have been authored by researchers at Canadian universities. We are pleased with the success of this international collaboration and wish to thank our colleagues at IEPE for their excellent cooperation.

The first two articles, by *Dominique Finon* and *William Anderson* respectively, take off from the same starting point. They both observe that, in the aftermath of the first world oil-price shock, most oil-importing countries introduced numerous policy measures aimed at reducing energy consumption. In these countries, this objective remained at the top of the energy policy agenda for most of the decade after the measures were introduced. As oil prices fell during the early 1980s, energy efficiency and conservation began to assume less importance at the policy level, a process which was greatly accelerated by the price collapse of 1986.

Finon examines major policy developments in the industrialized world during this period. He notes that in the early 1970s the main justification for policy intervention advanced by the governments of oil-importing countries centred on concerns for energy security. As the years passed and the perception of a greater abundance of oil progressively became the dominant view, concerns over energy security were eroded, and the main reason proffered for intervention disappeared. Increased reliance on market forces became the operative thrust of energy policy in the late 1980s.

The environmental consequences of energy use have sparked a revival of interest in a more interventionist policy stance. Finon notes, however, that reliance on market forces to solve the main problems of resource allocation in the energy sector continues, while government intervention tends increasingly to focus on dealing with the environmental costs of fuel use.

This notion — that the focus of government intervention in the energy sector has shifted to the environmental dimension — is the starting point

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for Anderson's paper. He believes that environmental policy and energy policy need to be closely intertwined: energy policy should be more environmentally-oriented than is currently the case. Considering the four major categories of response to environmental damage — abatement, structural change, substitution and conservation — he argues that a prudent strategy will stress conservation. In his search for efficient approaches to policy, Anderson surveys the advantages and limitations of standards and market-based instruments. The development of efficient strategies requires both international cooperation to solve trans-boundary environmental problems and cooperation across scientific and policy disciplines to provide a better understanding of the nature of the problem and the outlines of possible solutions.

The next three papers deal with the operation of the world oil market, its evolution over the last 20 years, and future prospects. *Patrick Criqui* sets the world oil market within the global economic system and argues that oil-market developments were closely linked to events occurring on the broader canvas of the world economy. He briefly surveys the results of standard macroeconomic analyses of the major economic difficulties we have faced in the past two decades and then enlarges the perspective by considering long-term economic history and analyses of economic fluctuations. Drawing on the work of Schumpeter and others, he argues that long cycles have characterized the evolution of the world economy and that these cycles have strongly influenced developments on the oil market.

In this framework, Criqui is able to formulate an explanatory scheme of the way the world economy evolves which takes account of what has happened in the energy sector since the 1973 oil shock. This in turn allows him to speculate on conditions that could possibly generate a new oil shock over the next decade.

Antoine Ayoub, a long-time observer of world oil market developments, focuses on the interaction between economic and political factors in determining crude oil prices and other oil-market developments, and on the problems involved in integrating this interaction into an economic analysis of oil markets. He sees the abolition of the concession system and the nationalization of oil companies in the OPEC countries as the key turning point in the evolution of the overall economic structure of the oil sector. They provide a clear illustration of how institutional change can induce a whole set of economic phenomena, either directly or indirectly. For example, the nationalizations led to the break-up of the system of vertical integration, the emergence of free oil markets, and more recently to a trend towards reintegration in a different form. On pricing, Ayoub discusses how economic factors have interacted with OPEC policy to cause oil prices to fluctuate between roughly-defined floor and ceiling prices.

Sadek Boussena focuses his discussion of oil markets since the 1973 shock on the actions of the Organization of Oil Exporting Countries. From his vantage point as a close observer (now an academic researcher, he was President of OPEC in 1990-91), Boussena tries to understand the Organization's current behaviour by analyzing what it has learned from the last 20 years of being a key player in world oil markets. He traces changes in OPEC's policy stance through three phases of oil-price trends, discussing how that stance was affected by the need to deal with its internal balance of power and by changes in the international context in which it operates. Boussena concludes by formulating two broadly-defined strategic paths that OPEC could follow — one characterized by an attempt to create a more predictable world oil market through OPEC's taking the lead in stabilization efforts, the other involving near-abandonment of its formerly declared role of market regulator. He argues that its current stance suggests it will follow the latter path.

Finally, in a survey of changes in the energy sector over the last two decades, it is appropriate to include an examination of the rocky road travelled by nuclear power and its prospects for the future. *Michel Damian* provides such an examination within a framework that focuses on the nature of nuclear technology in an industrial context. He argues that the problems of the nuclear industry can be understood in terms of the tensions involved in trying to use a technology that requires the management of highly complex and public risk within a system of economic organization and decision making that was not designed for that purpose.

In considering how the movement in support of sustainable development may provide new support for nuclear energy, Damian makes that link appear more complex and rich than conventionally understood. In the long term, making other energy industries conform to the requirements of sustainable development may be a prerequisite for the further development of the nuclear industry. Furthermore, there is something to learn from the fact that nuclear power can be represented as the first instance in which those responsible for an industry have had to face, at least to a certain extent, the implications of sustainability.

The Editors

A Detailed Comparison of Average Energy Prices Increases
A $100/ton Carbon Price Increase Vs. OPEC Price Shocks of the 1970's

Government statistics on increases in inflation-adjusted primary fuel prices during the 1970s OPEC price shocks tell two different stories. The Bureau of Labor Statistics (BLS) suggests increases of about a factor of two and a half, while Energy Information Agency (EIA) data suggest price increases of roughly three and a half, depending on the choice of deflator. This memo addresses these discrepancies and also assesses the equivalence of the 1970's oil shocks to the fuel price increases from a $100/ton price of carbon. It concludes that the implications for primary fuel prices of a $100/ton carbon price are likely to be at least half of the average fuel price increases observed between 1972 and 1982, although the exact comparison is sensitive to the weighting method and the choice of weights.

Federal Statistics on the Magnitude of the Oil Price Shocks

BLS data indicate that nominal producer prices for a fossil fuel composite rose from 16.8 in 1972 to 100 in 1982, a multiple of about 6. (Although real energy prices in 1981 were about 6 percent higher than in 1982, 1982 is taken as a comparison year.) Prices for finished producer goods rose by a factor of 2.4 over this interval, while the consumer price index rose by a multiple of 2.3. Thus the price of primary fuel rose by a factor of 2.5=6/2.4 relative to finished producer goods and 2.6=6/2.3 relative to consumer prices. If compared with the increase in the GDP implicit price deflator, an even broader measure of prices, then the relative price change is 2.8 fold.

The Energy Information Agency uses a different approach to calculate average energy prices; this different approach leads to different conclusions. Unlike the BLS, which calculates average energy price increases by weighting price increases for homogeneous fuels by their share of value, the EIA calculates average energy price increases by weighting the price increases by their share of total energy use measured in British thermal units. The fossil fuel nominal price index rose by a factor of 7.89 during this period, from .35 to 2.76. Deflating by the GDP implicit price deflator (that the EIA prefers) yields a real price change of 3.8 fold. (Using instead the CPI to improve comparability with the BLS statistics gives a real price change of 3.4 fold.)

Thus, relative to consumer prices, the BLS approach implies that energy prices from 1972 to 1982 rose by 160 percent, while the EIA approach implies an increase of 240 percent. Relative to the GDP deflator, the BLS approach implies an increase of 180 percent, and the EIA approach implies an increase of 280 percent. Thus the difference between the two methods is between 80 and 100 percentage points.

Average Fuel Price Increases from Carbon Price Increases

To develop estimates of the average fuel price increases from a positive carbon price we rely here on two sources of information about effects of a $100/ton carbon price. The ACCF book "An Economic Perspective on Climate Change Policies"contains a chapter by Lawrence Horwitz that states that $100/ton implies tax rates of $1.66/mcf for natural gas, $11.42/barrel for crude oil, and $56.4/short ton for coal (p.126). In addition, the IAT May 30 draft report states that "a permit price of $100/ton is the equivalent of a price increase of 26 cents per gallon of refined petroleum product, $1.49 per thousand cubic feet of natural gas, and $52.52 per ton of coal. Note that although the price increases of the refined petroleum product is not strictly comparable to the price increase of crude oil, given 42 gallons per barrel, the ACCF estimate is equivalent to 27 cents per gallon. Thus these estimates are fairly close given the imprecision of model forecasts. We will use the IAT forecasts, which are summarized below.

Fuels	Current Prices	Baseline Prices (2010) Range of 4 models	Price Increase With $100/ton Carbon Price	Percentage Increase Over Baseline
Coal ($/ton)	$27	$13.80 to $16.90	$52	333 %
Oil ($/barrel)	$17	$20.41 to $21.24	$10.9	53 %
Natural Gas ($/1000cf)	$ 2.04	$ 2.01 to $2.46	$ 1.49	66%

There are a variety of methods to average these fuel price increases. However, valid comparisons between an increase in carbon prices and the oil price shocks of the 1970s should rely on energy prices increases that are averaged using the same methods. Therefore we limit the analysis to methods adopted by BLS and EIA and described above.

To implement the EIA method, we weight the above percentage price increases by each fuels share of Btus. Using the shares of aggregate consumption figures provided by EIA for its reference case forecast for 2010 (22.68, 42.24, and 28.77 quads respectively for coal, natural gas and petroleum) to weight the price increases, the average energy price increase from a $100/ton carbon price is estimated as 165 percent.[1] This is approximately half the comparable Btu-weighted average energy price increase observed from 1972 to 1982. Of course the mix of fuels has changed; using the average of the weights implied by the 1972 mix and the 1982 mix would imply an increase of only 123 percent. (These weights were .23, .34 and .43 respectively for coal, natural gas and petroleum). Thus using the Btu weighted approach preferred by EIA, the average primary fuel price increase from a $100/ton carbon price is between 33 and 49 percent of the average fuel price increases observed from 1972 to 1982 depending on the choice of weights and the index used to deflate the 1970 fuel price increases.

To implement the BLS method we use the value weights used by BLS in its producer price index of fuel prices. Using the 1982 value weights (.14, .37 and .50 respectively) the

[1]Note that this approach, like EIA's approach to the oil price shocks of the 70's, averages only fossil fuels. Average increases of all primary fuel prices including renewables would be smaller.

average energy price increase from a $100/ton carbon price is 97 percent. Using the 1972 value weights, the average energy price increase from a $100/ton carbon price is 167 percent. Recall that the increase BLS calculated for the period 1972 to 1982 was 160 percent relative to consumer prices (measured by the CPI) and 180 percent relative to the GDP deflator. Thus on a value-weighted basis the magnitude of the average fuel price increases associated with a $100/ton carbon price is the same as either half of the 1972 to 1982 oil price increases, or the totality of these price increases, depending on the choice of weights.

Would Stabilizing U.S. Carbon Emissions Feel Like Another 1970's Oil Shock?

Both the '73 and '79 energy price shocks were similar in magnitude to what is projected to result from a policy to stabilize carbon dioxide emissions at 1990 levels by 2010 without trading or joint implementation.

Price Effects of Stabilizing Carbon Emissions

- Government agencies have estimated the implicit price of carbon in fossil fuels that would be implied by a policy to stabilize carbon dioxide emissions at 1990 levels by the year 2010. These estimates presume no trading of emissions reductions among countries and no joint implementation. They are uncertain, and may be too optimistic due to a rosy view of ongoing technological progress. They suggest that the implicit price of a ton of carbon would be about $100 by 2010 and that fuel prices would rise as summarized below:

Fuels	Current Prices	Baseline Prices (2010)	Prices With $100/ton Carbon Price	Increase Over Baseline
Gasoline ($/gallon)	$ 1.14	$ 1.22 to$1.40	$ 1.58	21 %
Coal ($/ton)	$27	$13.80 to $16.90	$79	400 %
Oil ($/barrel)	$17	$20.41 to $21.24	$33	58 %
Natural Gas ($/1000cf)	$ 2.04	$ 2.01 to $2.46	$ 3.7	64%

- The price hike would be about 88 % for primary fuels (coal, oil and natural gas).

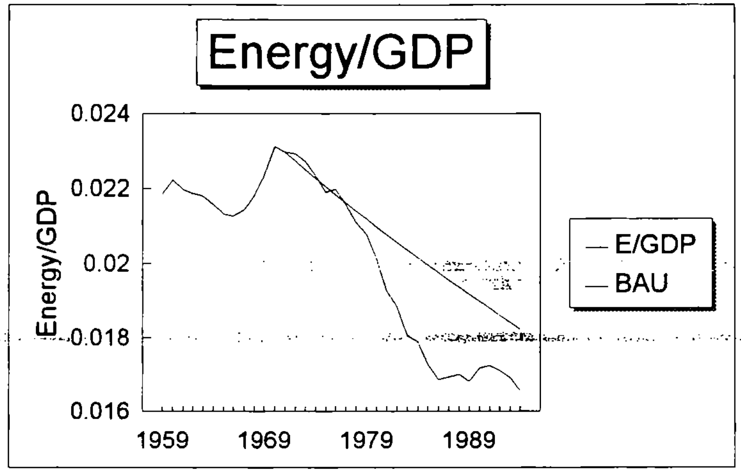
Price Hikes During the Oil Shocks.

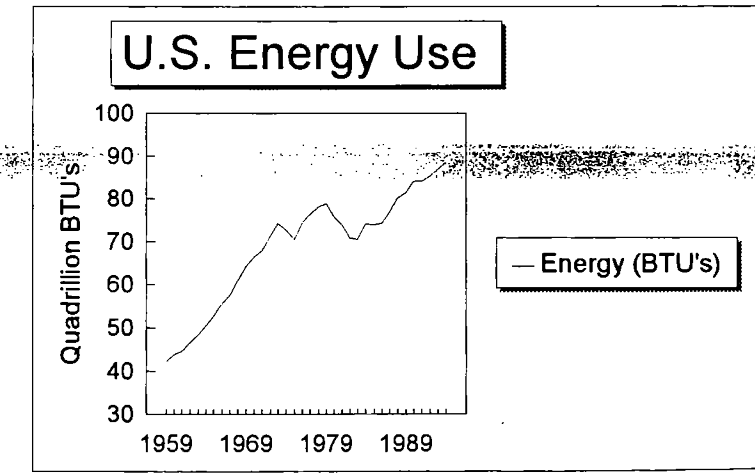
- The oil price shocks of the '70s led to a doubling of fossil fuel prices net of inflation between 1972 and 1975 and another doubling by 1981. See Figure.
- Gasoline prices rose by 30 percent between 1972 and 1974 and by nearly another 50 percent from 1974 to 1981.
- These increases are similar in magnitude to the price increases projected for 2010.

Comparability of These Projections with the 1970s Price Shocks Is Limited

- The shocks were surprises, but a carbon tax would be anticipated.
- The oil shocks affected oil prices directly and other fossil fuels only as substitutes. However, a carbon tax would affect all fuels in proportion to carbon content.

year	Energy (BTU's)	GDP (1987 dollars)	E/GDP	BAU	How much lower E/GDP was than BAU
1959	42.14	1928.8	0.02185	0.0218	0.00%
1960	43.8	1970.8	0.02222	0.0222	0.00%
1961	44.46	2023.8	0.02197	0.022	0.00%
1962	46.53	2128.1	0.02186	0.0219	0.00%
1963	48.32	2215.6	0.02181	0.0218	0.00%
1964	50.5	2340.6	0.02158	0.0216	0.00%
1965	52.68	2470.5	0.02132	0.0213	0.00%
1966	55.66	2616.2	0.02128	0.0213	0.00%
1967	57.57	2685.2	0.02144	0.0214	0.00%
1968	61	2796.9	0.02181	0.0218	0.00%
1969	64.19	2873	0.02234	0.0223	0.00%
1970	66.43	2873.9	0.02311	0.0231	0.00%
1971	67.89	2955.9	0.02297	0.023	0.00%
1972	71.26	3107.1	0.02293	0.0227	-0.86%
1973	74.28	3268.6	0.02273	0.0225	-0.95%
1974	72.58	3248.1	0.02235	0.0223	-0.27%
1975	70.55	3221.7	0.0219	0.0221	0.75%
1976	74.36	3380.8	0.02199	0.0218	-0.69%
1977	76.29	3533.3	0.02159	0.0216	0.15%
1978	78.09	3703.5	0.02109	0.0214	1.53%
1979	78.9	3796.8	0.02078	0.0212	1.99%
1980	75.96	3776.3	0.02011	0.021	4.31%
1981	73.99	3843.1	0.01925	0.0208	7.89%
1982	70.85	3760.3	0.01884	0.0206	9.14%
1983	70.52	3906.6	0.01805	0.0204	12.78%
1984	74.14	4148.5	0.01787	0.0202	12.77%
1985	73.98	4279.8	0.01729	0.02	15.43%
1986	74.3	4404.5	0.01687	0.0198	17.10%
1987	76.89	4539.9	0.01694	0.0196	15.47%
1988	80.22	4718.6	0.017	0.0194	13.88%
1989	81.33	4838	0.01681	0.0192	14.02%
1990	84.09	4897.3	0.01717	0.019	10.51%
1991	83.96	4867.6	0.01725	0.0188	8.91%
1992	85.16	4979.3	0.0171	0.0186	8.74%
1993	86.88	5134.5	0.01692	0.0184	8.81%
1994	88.45	5342.4	0.01656	0.0182	10.09%





Question:

What can the energy price increases during the 1970's oil shock tell us about what would happen to energy prices in the future from a $110/ton carbon tax?

What happened to energy prices in the 1970's?

For comparison to a carbon tax shock, we look primarily to the large jump in energy prices from 1972 to 1982, when real energy prices went from historical norms to an all time high. Because nominal prices increase along with energy prices, the most useful statistic to compare across time is a measure of relative prices: the price of energy relative to the price of other goods. There are several ways to compute the relative price of energy, and they all involve indices of prices, both for various sources of energy and for other goods.

Examples of energy price indices

Price Index	Variable Name for Index	Data Source
Producer Price Index (PPI) for fuels (crude materials for further processing)	F	1996 Economic Report of the President (ERP) p. 350
PPI for fuels and related products and power (industrial commodities)	R	1996 Economic Report of the President (ERP) p. 352

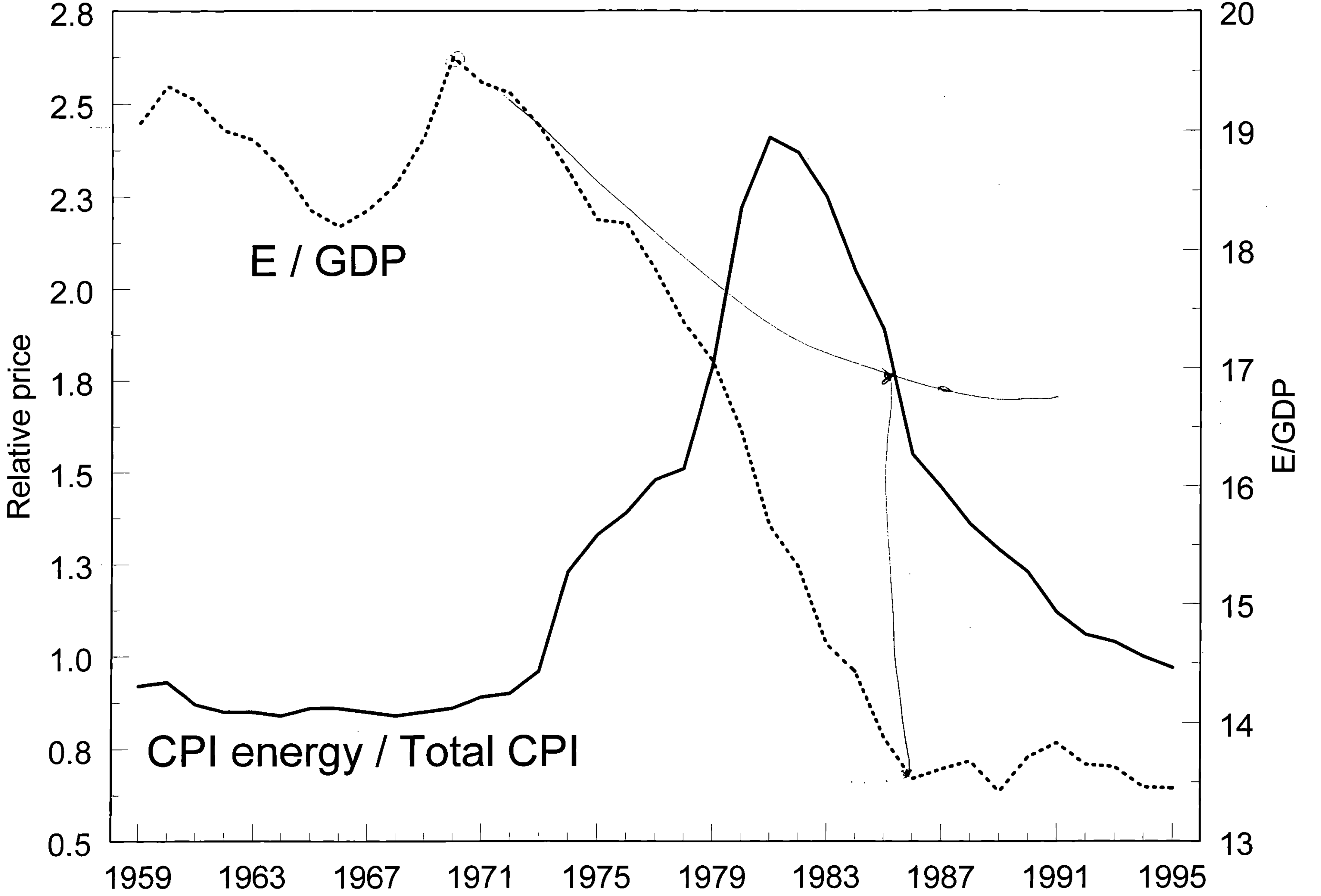
Examples of general price indices

Price Index	Variable Name for Index	Data Source
PPI for total industrial commodities	I	1996 ERP p. 352
PPI for all crude materials for further processing	C	1996 ERP p. 351
Consumer price index for all items	P	1996 ERP p. 343

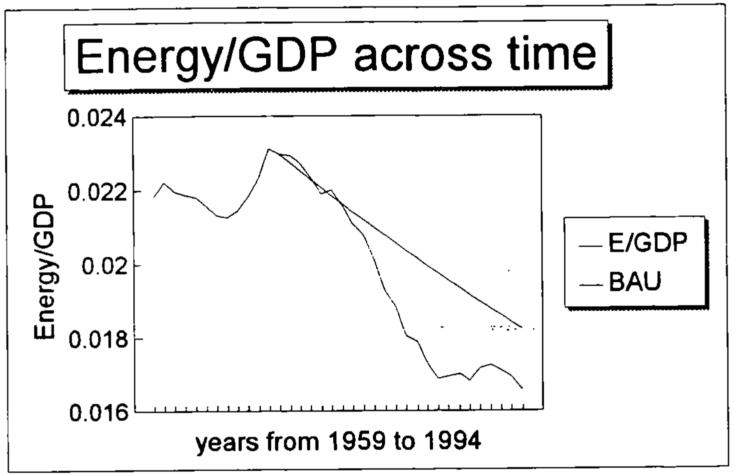
Relative Prices in 1972 and 1981, and the percent change

Price Index	1972 F	1972 R	1982 F	1982 R	% change in relative price from 1972 to 1982	
I	F/I = .444	R/I = .452	F/I = 1	R/I = 1	F/I 125%	R/I 121.05%
C	F/C = .421	R/C = .429	F/C = 1	R/C = 1	F/C 137.5%	R/C 133.33%
P	F/P = .402	R/P = .409	F/P = 1.036	R/P = 1.036	F/P 157.83%	R/P 153.31%

E/GDP & Relative Energy Price



year	E/GDP	BAU	How much lower E/GDP was than BAU
1959	0.021848	0.021848	0.00%
1960	0.022224	0.022224	0.00%
1961	0.021969	0.021969	0.00%
1962	0.021865	0.021865	0.00%
1963	0.021809	0.021809	0.00%
1964	0.021576	0.021576	0.00%
1965	0.021324	0.021324	0.00%
1966	0.021275	0.021275	0.00%
1967	0.02144	0.02144	0.00%
1968	0.02181	0.02181	0.00%
1969	0.022342	0.022342	0.00%
1970	0.023115	0.023115	0.00%
1971	0.022968	0.022968	0.00%
1972	0.022935	0.022738	-0.86%
1973	0.022725	0.022511	-0.95%
1974	0.022345	0.022285	-0.27%
1975	0.021898	0.022063	0.75%
1976	0.021995	0.021842	-0.69%
1977	0.021592	0.021624	0.15%
1978	0.021085	0.021407	1.53%
1979	0.020781	0.021193	1.99%
1980	0.020115	0.020981	4.31%
1981	0.019253	0.020772	7.89%
1982	0.018842	0.020564	9.14%
1983	0.018052	0.020358	12.78%
1984	0.017872	0.020155	12.77%
1985	0.017286	0.019953	15.43%
1986	0.016869	0.019753	17.10%
1987	0.016936	0.019556	15.47%
1988	0.017001	0.01936	13.88%
1989	0.016811	0.019167	14.02%
1990	0.017171	0.018975	10.51%
1991	0.017249	0.018785	8.91%
1992	0.017103	0.018598	8.74%
1993	0.016921	0.018412	8.81%
1994	0.016556	0.018227	10.09%



E/GDP & Relative Energy Price (Levels)

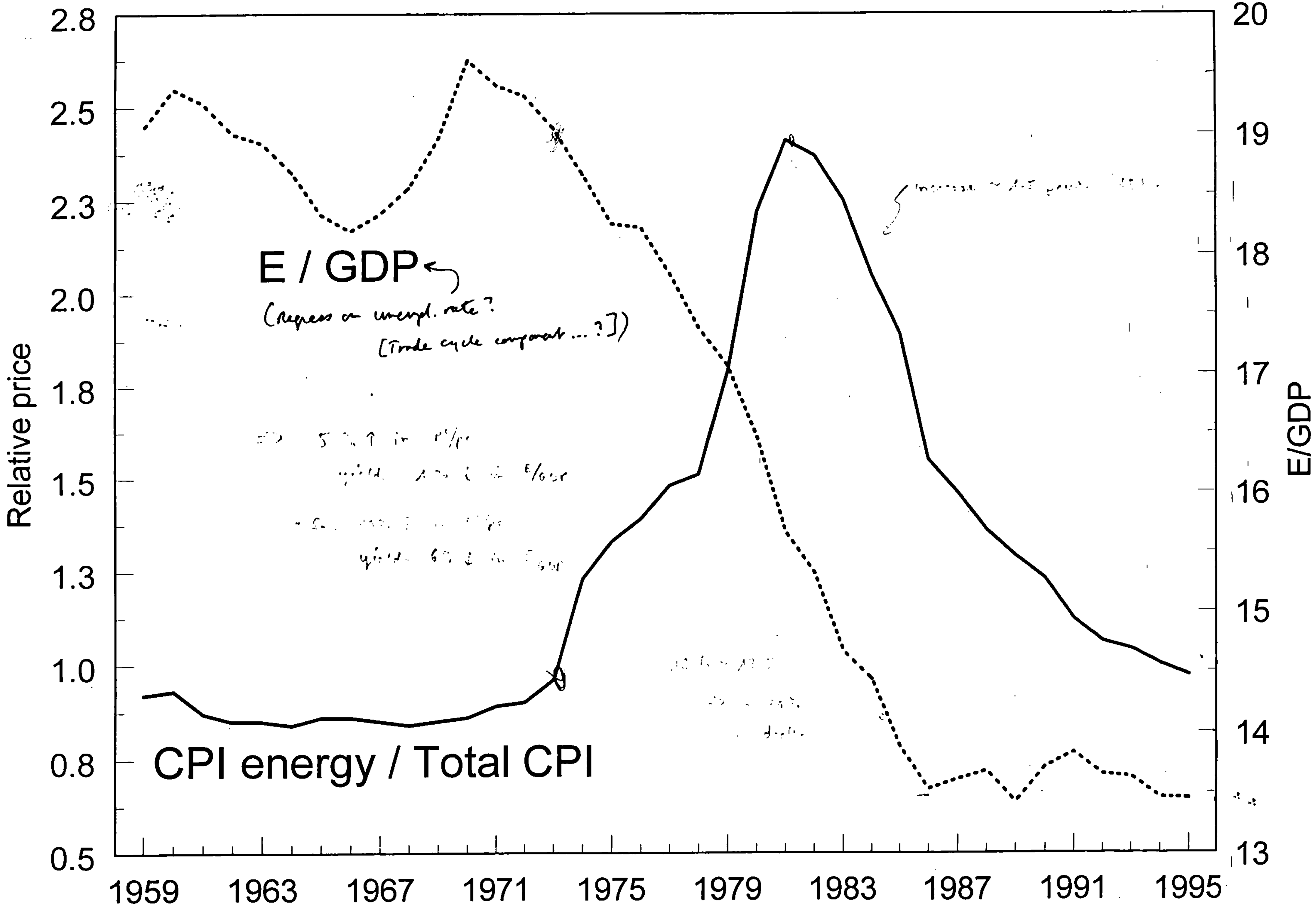


TABLE B-55.—*Manufacturers' new and unfilled orders, 1954–95*

[Amounts in millions of dollars; monthly data seasonally adjusted]

New orders[1]: Total	New orders: Durable goods industries: Total	New orders: Durable goods industries: Capital goods industries, nondefense	New orders: Nondurable goods industries	Unfilled orders[2]: Total	Unfilled orders: Durable goods industries	Unfilled orders: Nondurable goods industries	Unfilled orders—shipments ratio[3]: Total	Ratio: Durable goods industries	Ratio: Nondurable goods industries
22,335	10,768	...	11,566	48,266	45,250	3,016	3.42	4.12	0.96
27,465	14,996	...	12,469	60,004	56,241	3,763	3.63	4.27	1.12
28,368	15,365	...	13,003	67,375	63,880	3,495	3.87	4.55	1.04
27,559	14,111	...	13,448	53,183	50,352	2,831	3.35	4.00	.85
27,193	13,387	...	13,805	46,609	43,807	2,802	3.02	3.62	.85
30,711	15,979	...	14,732	51,717	48,369	3,348	2.94	3.47	.92
30,232	15,288	...	14,944	44,213	41,650	2,563	2.71	3.29	.71
31,112	15,753	...	15,359	46,624	43,582	3,042	2.58	3.08	.78
33,440	17,363	...	16,078	47,798	45,170	2,628	2.64	3.18	.68
35,511	18,671	...	16,840	53,417	50,346	3,071	2.74	3.31	.72
38,240	20,507	...	17,732	64,518	61,315	3,203	2.99	3.59	.71
42,137	23,286	...	18,851	78,249	74,459	3,790	3.25	3.86	.79
46,420	26,163	...	20,258	96,846	93,002	3,844	3.74	4.48	.75
47,067	25,803	...	21,265	103,711	99,735	3,976	3.66	4.37	.73
50,657	28,051	6,314	22,606	108,377	104,393	3,984	3.79	4.58	.69
53,990	29,876	7,046	24,114	114,341	110,161	4,180	3.71	4.45	.69
52,022	27,340	6,072	24,682	105,008	100,412	4,596	3.61	4.36	.76
55,921	29,905	6,682	26,016	105,247	100,225	5,022	3.32	4.00	.76
64,182	35,038	7,745	29,144	119,349	113,034	6,315	3.26	3.85	.86
76,003	42,627	9,926	33,376	156,561	149,204	7,357	3.80	4.51	.91
87,327	46,862	11,594	40,465	187,043	181,519	5,524	4.09	4.93	.62
85,139	41,957	9,886	43,181	169,546	161,664	7,882	3.69	4.45	.82
99,513	51,307	11,490	48,206	178,128	169,857	8,271	3.24	3.88	.74
115,109	61,035	13,681	54,073	202,024	193,323	8,701	3.24	3.85	.71
131,629	72,278	17,588	59,351	259,169	248,281	10,888	3.57	4.20	.81
147,604	79,483	21,154	68,121	303,593	291,321	12,272	3.89	4.62	.82
156,359	79,392	21,135	76,967	327,416	315,202	12,214	3.85	4.58	.75
168,025	83,654	21,806	84,371	326,547	314,707	11,840	3.87	4.68	.69
162,140	78,064	19,213	84,077	311,887	300,798	11,089	3.84	4.74	62
175,451	88,140	19,624	87,311	347,273	333,114	14,159	3.53	4.29	.69
192,879	100,164	23,669	92,715	373,529	359,651	13,878	3.60	4.37	.64
195,706	102,356	24,545	93,351	387,095	372,027	15,068	3.67	4.46	.68
195,204	103,647	23,983	91,557	393,412	376,622	16,790	3.59	4.40	70
209,389	110,809	26,095	98,579	430,288	408,602	21,686	3.63	4.42	83
227,026	121,445	30,729	105,581	471,951	450,002	21,949	3.64	4.45	76
235,932	124,933	32,725	110,999	510,459	488,780	21,679	4.00	4.91	.78
240,646	123,556	32,254	117,090	524,846	502,914	21,932	4.14	5.13	.76
234,354	117,878	29,468	116,476	511,122	487,892	23,230	4.08	5.06	.81
241,545	122,614	29,653	118,932	475,304	452,383	22,921	3.46	4.21	.77
255,701	133,273	31,889	122,428	441,947	420,288	21,659	3.04	3.65	.72
281,953	151,878	37,530	130,074	456,838	431,305	25,533	2.87	3.43	76
272,616	148,549	36,630	124,067	446,233	424,128	22,105	3.11	3.73	.74
271,786	145,882	36,382	125,904	446,204	423,750	22,454	3.07	3.69	.74
274,691	146,906	36,127	127,785	446,398	423,268	23,130	3.03	3.63	.76
275,182	147,345	35,815	127,837	447,337	423,681	23,656	3.04	3.64	.77
277,441	149,412	35,498	128,029	448,546	424,583	23,963	3.01	3.60	.76
279,788	151,212	38,055	128,576	449,767	425,784	23,983	2.98	3.58	.76
274,305	145,251	36,310	129,054	448,587	424,563	24,024	2.99	3.60	.75
287,222	154,675	37,595	132,547	447,729	423,619	24,110	2.89	3.47	.73
287,248	155,433	39,056	131,815	448,843	424,702	24,141	2.90	3.48	.74
285,985	154,150	38,276	131,835	450,853	426,266	24,587	2.94	3.52	.76
293,716	159,321	40,781	134,395	453,378	428,295	25,083	2.88	3.45	.76
299,514	162,310	37,759	137,204	456,838	431,305	25,533	2.87	3.43	.76
301,724	164,507	41,785	137,217	460,772	434,733	26,039	2.85	3.41	.76
300,804	163,338	42,055	137,466	463,020	436,865	26,155	2.86	3.42	.76
299,625	163,042	42,628	136,583	464,208	438,336	25,872	2.85	3.41	.75
293,069	155,553	40,072	137,516	461,984	435,919	26,065	2.86	3.44	.75
297,046	159,502	43,115	137,544	461,937	435,809	26,128	2.82	3.38	.75
296,754	159,031	42,964	137,723	459,979	434,012	25,967	2.78	3.34	.72
293,863	156,130	40,233	137,733	460,368	434,223	26,145	2.84	3.42	.74
301,903	164,082	41,676	137,821	459,250	434,109	25,141	2.74	3.30	.70
306,123	168,951	46,941	137,172	461,093	437,121	23,972	2.74	3.30	.67
305,143	167,068	43,488	138,075	463,081	439,560	23,521	2.77	3.34	.66

averages of monthly not seasonally adjusted figures.
sted, end of period.
orders at end of period to shipments for period; excludes industries with no unfilled orders. Annual figures relate to sea-
ta for December.

nning 1958 are not strictly comparable with earlier data.

nt of Commerce, Bureau of the Census.

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TABLE B-56.—*Consumer price indexes for major expenditure classes, 1950–95*

[For all urban consumers; 1982–84=100]

Year or month	All items (CPI-U)	Food and beverages: Total[1]	Food and beverages: Food	Housing: Total	Housing: Shelter	Housing: Fuel and other utilities	Housing: Household furnishings and operation	Apparel and upkeep	Transportation	Medical care	Entertainment	Other goods and services	Energy[2]
1950	24.1	...	25.4	...	...	...	...	40.3	22.7	15.1	...	...	...
1951	26.0	...	28.2	...	...	...	...	43.9	24.1	15.9	...	...	...
1952	26.5	...	28.7	...	...	...	...	43.5	25.7	16.7	...	...	...
1953	26.7	...	28.3	...	22.0	22.5	...	43.1	26.5	17.3	...	...	...
1954	26.9	...	28.2	...	22.5	22.6	...	43.1	26.1	17.8	...	...	...
1955	26.8	...	27.8	...	22.7	23.0	...	42.9	25.8	18.2	...	...	...
1956	27.2	...	28.0	...	23.1	23.6	...	43.7	26.2	18.9	...	...	...
1957	28.1	...	28.9	...	24.0	24.3	...	44.5	27.7	19.7	...	...	21.5
1958	28.9	...	30.2	...	24.5	24.8	...	44.6	28.6	20.6	...	...	21.5
1959	29.1	...	29.7	...	24.7	25.4	...	45.0	29.8	21.5	...	...	21.9
1960	29.6	...	30.0	...	25.2	26.0	...	45.7	29.8	22.3	...	...	22.4
1961	29.9	...	30.4	...	25.4	26.3	...	46.1	30.1	22.9	...	...	22.5
1962	30.2	...	30.6	...	25.8	26.3	...	46.3	30.8	23.5	...	...	22.6
1963	30.6	...	31.1	...	26.1	26.6	...	46.9	30.9	24.1	...	...	22.6
1964	31.0	...	31.5	...	26.5	26.6	...	47.3	31.4	24.6	...	...	22.5
1965	31.5	...	32.2	...	27.0	26.6	...	47.8	31.9	25.2	...	...	22.9
1966	32.4	...	33.8	...	27.8	26.7	...	49.0	32.3	26.3	...	...	23.3
1967	33.4	35.0	34.1	30.8	28.8	27.1	42.0	51.0	33.3	28.2	40.7	35.1	23.8
1968	34.8	36.2	35.3	32.0	30.1	27.4	43.6	53.7	34.3	29.9	43.0	36.9	24.2
1969	36.7	38.1	37.1	34.0	32.6	28.0	45.2	56.8	35.7	31.9	45.2	38.7	24.8
1970	38.8	40.1	39.2	36.4	35.5	29.1	46.8	59.2	37.5	34.0	47.5	40.9	25.5
1971	40.5	41.4	40.4	38.0	37.0	31.1	48.6	61.1	39.5	36.1	50.0	42.9	26.5
1972	41.8	43.1	42.1	39.4	38.7	32.5	49.7	62.3	39.9	37.3	51.5	44.7	27.2
1973	44.4	48.8	48.2	41.2	40.5	34.3	51.1	64.6	41.2	38.8	52.9	46.4	29.4
1974	49.3	55.5	55.1	45.8	44.4	40.7	56.8	69.4	45.8	42.4	56.9	49.8	38.1
1975	53.8	60.2	59.8	50.7	48.8	45.4	63.4	72.5	50.1	47.5	62.0	53.9	42.1
1976	56.9	62.1	61.6	53.8	51.5	49.4	67.3	75.2	55.1	52.0	65.1	57.0	45.1
1977	60.6	65.8	65.5	57.4	54.9	54.7	70.4	78.6	59.0	57.0	68.3	60.4	49.4
1978	65.2	72.2	72.0	62.4	60.5	58.5	74.7	81.4	61.7	61.8	71.9	64.3	52.5
1979	72.6	79.9	79.9	70.1	68.9	64.8	79.9	84.9	70.5	67.5	76.7	68.9	65.7
1980	82.4	86.7	86.8	81.1	81.0	75.4	86.3	90.9	83.1	74.9	83.6	75.2	86.0
1981	90.9	93.5	93.6	90.4	90.5	86.4	93.0	95.3	93.2	82.9	90.1	82.6	97.7
1982	96.5	97.3	97.4	96.9	96.9	94.9	98.0	97.8	97.0	92.5	96.0	91.1	99.2
1983	99.6	99.5	99.4	99.5	99.1	100.2	100.2	100.2	99.3	100.6	100.1	101.1	99.9
1984	103.9	103.2	103.2	103.6	104.0	104.8	101.9	102.1	103.7	106.8	103.8	107.9	100.9
1985	107.6	105.6	105.6	107.7	109.8	106.5	103.8	105.0	106.4	113.5	107.9	114.5	101.6
1986	109.6	109.1	109.0	110.9	115.8	104.1	105.2	105.9	102.3	122.0	111.6	121.4	88.2
1987	113.6	113.5	113.5	114.2	121.3	103.0	107.1	110.6	105.4	130.1	115.3	128.5	88.6
1988	118.3	118.2	118.2	118.5	127.1	104.4	109.4	115.4	108.7	138.6	120.3	137.0	89.3
1989	124.0	124.9	125.1	123.0	132.8	107.8	111.2	118.6	114.1	149.3	126.5	147.7	94.3
1990	130.7	132.1	132.4	128.5	140.0	111.6	113.3	124.1	120.5	162.8	132.4	159.0	102.1
1991	136.2	136.8	136.3	133.6	146.3	115.3	116.0	128.7	123.8	177.0	138.4	171.6	102.5
1992	140.3	138.7	137.9	137.5	151.2	117.8	118.0	131.9	126.5	190.1	142.3	183.3	103.0
1993	144.5	141.6	140.9	141.2	155.7	121.3	119.3	133.7	130.4	201.4	145.8	192.9	104.2
1994	148.2	144.9	144.3	144.8	160.5	122.8	121.0	133.4	134.3	211.0	150.1	198.5	104.6
1995	152.4	148.9	148.4	148.5	165.7	123.7	123.0	132.0	139.1	220.5	153.9	206.9	105.2
1994: Jan	146.2	144.3	143.7	142.9	158.1	121.6	120.5	130.4	131.6	206.4	148.5	195.1	101.3
Feb	146.7	143.6	142.9	143.7	159.1	122.4	120.4	132.4	131.9	207.7	149.1	195.2	102.0
Mar	147.2	143.9	143.2	144.1	159.8	122.4	120.6	136.1	132.2	208.3	149.6	195.5	101.9
Apr	147.4	144.0	143.4	143.9	159.6	121.6	120.6	136.4	132.6	209.2	149.7	196.4	102.0
May	147.5	144.1	143.5	144.1	159.6	122.2	121.1	135.6	132.8	209.7	149.9	197.1	102.9
June	148.0	144.2	143.5	144.9	160.1	124.2	121.4	133.8	133.8	210.4	149.8	197.6	105.7
July	148.4	144.8	144.2	145.4	160.8	124.3	121.5	130.9	134.6	211.5	150.2	198.0	106.8
Aug	149.0	145.3	144.8	145.9	161.7	124.3	121.4	131.1	135.9	212.2	150.2	199.4	108.5
Sept	149.4	145.6	145.0	145.8	161.6	124.2	121.4	134.2	135.9	212.8	150.7	201.4	108.2
Oct	149.5	145.6	145.0	145.7	162.0	122.4	121.4	135.2	136.1	214.0	151.0	201.9	105.8
Nov	149.7	145.9	145.3	145.5	162.1	121.8	121.1	134.2	137.1	214.7	151.6	202.3	105.7
Dec	149.7	147.2	146.8	145.4	161.8	122.0	120.8	130.5	137.1	215.3	151.2	202.4	104.7
1995: Jan	150.3	147.9	147.5	146.4	162.9	122.9	121.8	129.4	137.3	216.6	152.1	203.0	104.2
Feb	150.9	147.8	147.4	147.0	163.8	122.6	122.4	131.1	137.5	217.9	152.5	204.1	103.7
Mar	151.4	147.9	147.4	147.4	164.5	122.3	122.6	134.4	138.0	218.4	152.6	204.0	103.2
Apr	151.9	148.9	148.4	147.4	164.7	122.1	122.6	134.8	139.1	218.9	153.3	204.3	103.9
May	152.2	148.7	148.3	147.6	164.8	122.5	122.7	133.4	140.3	219.3	153.6	204.9	106.3
June	152.5	148.4	147.9	148.5	165.5	125.0	122.5	130.5	141.1	219.8	153.2	205.3	109.3
July	152.5	148.6	148.1	149.2	166.4	125.1	123.0	128.3	140.1	220.8	153.6	205.7	108.1
Aug	152.9	148.9	148.4	149.6	166.8	125.7	123.4	130.1	139.2	221.6	154.1	207.7	107.4
Sept	153.2	149.4	148.9	149.5	166.8	124.9	123.8	132.7	138.8	222.1	154.9	210.2	106.2
Oct	153.7	149.8	149.4	149.7	167.3	123.9	123.9	134.5	139.4	222.9	155.2	210.7	104.5
Nov	153.6	149.8	149.4	149.4	167.3	123.1	123.6	133.7	139.4	223.5	156.0	211.2	102.8
Dec	153.5	150.3	149.9	149.7	167.4	123.7	123.8	130.6	139.1	223.8	156.2	211.1	103.3

[1] Includes alcoholic beverages, not shown separately.
[2] Household fuels—gas (piped), electricity, fuel oil, etc.—and motor fuel. Motor oil, coolant, etc. also included through 1982

Note.—Data beginning 1983 incorporate a rental equivalence measure for homeowners' costs.

Source: Department of Labor, Bureau of Labor Statistics.

TABLE B-57.—Consumer price indexes for selected expenditure classes, 1950–95

[For all urban consumers; 1982–84=100, except as noted]

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Year or month	Food and beverages: Total[1]	Food: Total	Food: At home	Food: Away from home	Shelter: Total	Shelter: Renters' costs: Total[2]	Shelter: Renters' costs: Rent, residential	Shelter: Homeowners' costs[2]	Shelter: Maintenance and repairs	Fuel and other utilities: Total	Fuels: Total	Fuels: Fuel oil and other household fuel commodities	Fuels: Gas (piped) and electricity (energy services)	Other utilities and public services
1950	...	25.4	27.3	...	...	...	29.7	...	...	...	...	11.3	19.2	...
1951	...	28.2	30.3	...	...	...	30.9	...	...	...	...	11.8	19.3	...
1952	...	28.7	30.8	...	...	...	32.2	...	...	...	...	12.1	19.5	...
1953	...	28.3	30.3	21.5	22.0	...	33.9	...	20.5	22.5	...	12.6	19.9	...
1954	...	28.2	30.1	21.9	22.5	...	35.1	...	20.9	22.6	...	12.6	20.2	...
1955	...	27.8	29.5	22.1	22.7	...	35.6	...	21.4	23.0	...	12.7	20.7	...
1956	...	28.0	29.6	22.6	23.1	...	36.3	...	22.3	23.6	...	13.3	20.9	...
1957	...	28.9	30.6	23.4	24.0	...	37.0	...	23.2	24.3	...	14.0	21.1	...
1958	...	30.2	32.0	24.1	24.5	...	37.6	...	23.6	24.8	...	13.7	21.9	...
1959	...	29.7	31.2	24.8	24.7	...	38.2	...	24.0	25.4	...	13.9	22.4	...
1960	...	30.0	31.5	25.4	25.2	...	38.7	...	24.4	26.0	...	13.8	23.3	...
1961	...	30.4	31.8	26.0	25.4	...	39.2	...	24.8	26.3	...	14.1	23.5	...
1962	...	30.6	32.0	26.7	25.8	...	39.7	...	25.0	26.3	...	14.2	23.5	...
1963	...	31.1	32.4	27.3	26.1	...	40.1	...	25.3	26.6	...	14.4	23.5	...
1964	...	31.5	32.7	27.8	26.5	...	40.5	...	25.8	26.6	...	14.4	23.5	...
1965	...	32.2	33.5	28.4	27.0	...	40.9	...	26.3	26.6	...	14.6	23.5	...
1966	...	33.8	35.2	29.7	27.8	...	41.5	...	27.5	26.7	...	15.0	23.6	...
1967	35.0	34.1	35.1	31.3	28.8	...	42.2	...	28.9	27.1	21.4	15.5	23.7	46.6
1968	36.2	35.3	36.3	32.9	30.1	...	43.3	...	30.6	27.4	21.7	16.0	23.9	47.1
1969	38.1	37.1	38.0	34.9	32.6	...	44.7	...	33.2	28.0	22.1	16.3	24.3	48.4
1970	40.1	39.2	39.9	37.5	35.5	...	46.5	...	35.8	29.1	23.1	17.0	25.4	50.0
1971	41.4	40.4	40.9	39.4	37.0	...	48.7	...	38.6	31.1	24.7	18.2	27.1	53.4
1972	43.1	42.1	42.7	41.0	38.7	...	50.4	...	40.6	32.5	25.7	18.3	28.5	56.2
1973	48.8	48.2	49.7	44.2	40.5	...	52.5	...	43.6	34.3	27.5	21.1	29.9	57.8
1974	55.5	55.1	57.1	49.8	44.4	...	55.2	...	49.5	40.7	34.4	33.2	34.5	60.7
1975	60.2	59.8	61.8	54.5	48.8	...	58.0	...	54.1	45.4	39.4	36.4	40.1	63.9
1976	62.1	61.6	63.1	58.2	51.5	...	61.1	...	57.6	49.4	43.3	38.8	44.7	67.7
1977	65.8	65.5	66.8	62.6	54.9	...	64.8	...	62.0	54.7	49.0	43.9	50.5	70.8
1978	72.2	72.0	73.8	68.3	60.5	...	69.3	...	67.2	58.5	53.0	46.2	55.0	73.7
1979	79.9	79.9	81.8	75.9	68.9	...	74.3	...	74.0	64.8	61.3	62.4	61.0	74.3
1980	86.7	86.8	88.4	83.4	81.0	...	80.9	...	82.4	75.4	74.8	86.1	71.4	77.0
1981	93.5	93.6	94.8	90.9	90.5	...	87.9	...	90.7	86.4	87.2	104.6	81.9	84.3
1982	97.3	97.4	98.1	95.8	96.9	...	94.6	...	96.4	94.9	95.6	103.4	93.2	93.3
1983	99.5	99.4	99.1	100.0	99.1	103.0	100.1	102.5	99.9	100.2	100.5	97.2	101.5	99.5
1984	103.2	103.2	102.8	104.2	104.0	108.6	105.3	107.3	103.7	104.8	104.0	99.4	105.4	107.2
1985	105.6	105.6	104.3	108.3	109.8	115.4	111.8	113.1	106.5	106.5	104.5	95.9	107.1	112.1
1986	109.1	109.0	107.3	112.5	115.8	121.9	118.3	119.4	107.9	104.1	99.2	77.6	105.7	117.9
1987	113.5	113.5	111.9	117.0	121.3	128.1	123.1	124.8	111.8	103.0	97.3	77.9	103.8	120.1
1988	118.2	118.2	116.6	121.8	127.1	133.6	127.8	131.1	114.7	104.4	98.0	78.1	104.6	122.9
1989	124.9	125.1	124.2	127.4	132.8	138.9	132.8	137.3	118.0	107.8	100.9	81.7	107.5	127.1
1990	132.1	132.4	132.3	133.4	140.0	146.7	138.4	144.6	122.2	111.6	104.5	99.3	109.3	131.7
1991	136.8	136.3	135.8	137.9	146.3	155.6	143.3	150.2	126.3	115.3	106.7	94.6	112.6	137.9
1992	138.7	137.9	136.8	140.7	151.2	160.9	146.9	155.3	128.6	117.8	108.1	90.7	114.8	142.5
1993	141.6	140.9	140.1	143.2	155.7	165.0	150.3	160.2	130.6	121.3	111.2	90.3	118.5	147.0
1994	144.9	144.3	144.1	145.7	160.5	169.4	154.0	165.5	130.8	122.8	111.7	88.8	119.2	150.2
1995	148.9	148.4	148.8	149.0	165.7	174.3	157.8	171.0	135.0	123.7	111.5	88.1	119.2	152.8
1994: Jan	144.3	143.7	143.8	144.5	158.1	166.8	152.2	162.9	128.9	121.6	110.6	88.9	118.0	148.9
Feb	143.6	142.9	142.6	144.6	159.1	168.9	152.8	163.7	129.4	122.4	111.1	93.6	117.9	150.0
Mar	143.9	143.2	142.8	144.8	159.8	170.1	153.2	164.1	129.3	122.4	111.1	92.5	118.1	150.1
Apr	144.0	143.4	143.0	145.1	159.6	169.1	153.3	164.2	130.2	121.6	109.8	90.2	116.9	150.0
May	144.1	143.5	143.0	145.3	159.6	168.5	153.3	164.5	131.0	122.2	110.6	88.7	118.0	150.4
June	144.2	143.5	142.9	145.5	160.1	169.6	153.4	164.8	131.5	124.2	113.9	87.7	122.1	150.4
July	144.8	144.2	144.0	145.6	160.8	171.0	153.9	165.3	131.3	124.3	114.1	87.1	122.3	150.4
Aug	145.3	144.8	144.7	145.9	161.7	172.1	154.5	166.1	131.2	124.3	114.0	86.8	122.2	150.6
Sept	145.6	145.0	145.0	146.2	161.6	169.4	155.0	167.1	131.6	124.2	113.8	86.8	122.1	150.3
Oct	145.6	145.0	144.8	146.4	162.0	169.8	155.2	167.5	130.8	122.4	110.8	87.0	118.5	150.4
Nov	145.9	145.3	145.1	146.8	162.1	168.9	155.6	167.9	131.2	121.8	109.9	87.7	117.3	150.5
Dec	147.2	146.8	147.3	147.1	161.8	168.2	155.7	167.8	132.7	122.0	110.1	88.4	117.4	150.6
1995: Jan	147.9	147.5	148.2	147.4	162.9	170.7	156.1	168.4	133.1	122.9	110.7	89.4	118.0	152.1
Feb	147.8	147.4	147.9	147.6	163.8	172.9	156.4	168.9	133.8	122.6	110.4	89.6	117.6	151.8
Mar	147.9	147.4	147.6	148.1	164.5	174.6	156.7	169.2	134.2	122.3	109.8	89.0	117.1	151.9
Apr	148.9	148.4	149.2	148.3	164.7	174.1	157.0	169.6	134.2	122.1	109.3	88.4	116.6	152.2
May	148.7	148.3	148.7	148.6	164.8	173.7	157.2	170.0	134.6	122.5	109.8	88.3	117.2	152.3
June	148.4	147.9	148.1	148.8	165.5	174.7	157.5	170.6	135.0	125.0	113.8	87.9	121.9	152.7
July	148.6	148.1	148.2	149.1	166.4	176.7	157.9	171.2	135.1	125.1	113.7	87.1	121.9	153.0
Aug	148.9	148.4	148.4	149.4	166.8	176.9	158.2	171.6	135.4	125.7	114.6	86.6	123.0	153.1
Sept	149.4	148.9	149.2	149.6	166.8	175.1	158.5	172.4	135.4	124.9	113.4	86.6	121.6	153.2
Oct	149.8	149.4	149.7	150.0	167.3	175.3	158.9	173.0	136.3	123.9	111.5	86.9	119.3	153.5
Nov	149.8	149.4	149.5	150.2	167.3	173.8	159.3	173.5	136.2	123.1	110.1	87.7	117.6	153.6
Dec	150.3	149.9	150.3	150.4	167.4	173.2	159.6	174.0	136.6	123.7	110.9	89.6	118.3	153.9

[1] Includes alcoholic beverages, not shown separately.
[2] December 1982=100.

See next page for continuation of table.

[For all urban consumers; 1982–84=100, except as noted]

Year or month	Transportation: Total	Private transportation: Total[3]	Private transportation: New cars	Private transportation: Used cars	Private transportation: Motor fuel[4]	Private transportation: Automobile maintenance and repair	Private transportation: Other	Public transportation	Medical care: Total	Medical care commodities	Medic care servic
1950	22.7	24.5	41.1	...	19.0	18.9	...	13.4	15.1	39.7	[illegible]
1951	24.1	25.6	43.1	...	19.5	20.4	...	14.8	15.9	40.8	[illegible]
1952	25.7	27.3	46.8	...	20.0	20.8	...	15.8	16.7	41.2	[illegible]
1953	26.5	27.8	47.2	26.7	21.2	22.0	...	16.8	17.3	41.5	[illegible]
1954	26.1	27.1	46.5	22.7	21.8	22.7	...	18.0	17.8	42.0	[illegible]
1955	25.8	26.7	44.8	21.5	22.1	23.2	...	18.5	18.2	42.5	[illegible]
1956	26.2	27.1	46.1	20.7	22.8	24.2	...	19.2	18.9	43.4	[illegible]
1957	27.7	28.6	48.5	23.2	23.8	25.0	...	19.9	19.7	44.6	[illegible]
1958	28.6	29.5	50.0	24.0	23.4	25.4	...	20.9	20.6	46.1	[illegible]
1959	29.8	30.8	52.2	26.8	23.7	26.0	...	21.5	21.5	46.8	[illegible]
1960	29.8	30.6	51.5	25.0	24.4	26.5	...	22.2	22.3	46.9	19
1961	30.1	30.8	51.5	26.0	24.1	27.1	...	23.2	22.9	46.3	20
1962	30.8	31.4	51.3	28.4	24.3	27.5	...	24.0	23.5	45.6	20
1963	30.9	31.6	51.0	28.7	24.2	27.8	...	24.3	24.1	45.2	21
1964	31.4	32.0	50.9	30.0	24.1	28.2	...	24.7	24.6	45.1	22
1965	31.9	32.5	49.7	29.8	25.1	28.7	...	25.2	25.2	45.0	22
1966	32.3	32.9	48.8	29.0	25.6	29.2	...	26.1	26.3	45.1	23
1967	33.3	33.8	49.3	29.9	26.4	30.4	37.9	27.4	28.2	44.9	26
1968	34.3	34.8	50.7	...	26.8	32.1	39.2	28.7	29.9	45.0	27
1969	35.7	36.0	51.5	30.9	27.6	34.1	41.6	30.9	31.9	45.4	30
1970	37.5	37.5	53.0	31.2	27.9	36.6	45.2	35.2	34.0	46.5	32
1971	39.5	39.4	55.2	33.0	28.1	39.3	48.6	37.8	36.1	47.3	34
1972	39.9	39.7	54.7	33.1	28.4	41.1	48.9	39.3	37.3	47.4	35
1973	41.2	41.0	54.8	35.2	31.2	43.2	48.4	39.7	38.8	47.5	37
1974	45.8	46.2	57.9	36.7	42.2	47.6	50.2	40.6	47.4	49.2	41
1975	50.1	50.6	62.9	43.8	45.1	53.7	53.5	43.5	47.5	53.3	45
1976	55.1	55.6	66.9	50.3	47.0	57.6	61.8	47.8	52.0	56.5	51
1977	59.0	59.7	70.4	54.7	49.7	61.9	67.2	50.0	57.0	60.2	56
1978	61.7	62.5	75.8	55.8	51.8	67.0	69.9	51.5	61.8	64.4	61
1979	70.5	71.7	81.8	60.2	70.1	73.7	75.2	54.9	67.5	69.0	67
1980	83.1	84.2	88.4	62.3	97.4	81.5	84.3	69.0	74.9	75.4	74
1981	93.2	93.8	93.7	76.9	108.5	89.2	91.4	85.6	82.9	83.7	82
1982	97.0	97.1	97.4	88.8	102.8	96.0	97.7	94.9	92.5	92.3	92
1983	99.3	99.3	99.9	98.7	99.4	100.3	98.8	99.5	100.6	100.2	100
1984	103.7	103.6	102.8	112.5	97.9	103.8	103.5	105.7	106.8	107.5	106
1985	106.4	106.2	106.1	113.7	98.7	106.8	109.0	110.5	113.5	115.2	113
1986	102.3	101.2	110.6	108.8	77.1	110.3	115.1	117.0	122.0	122.8	121
1987	105.4	104.2	114.6	113.1	80.2	114.8	120.8	121.1	130.1	131.0	130
1988	108.7	107.6	116.9	118.0	80.9	119.7	127.9	123.3	138.6	139.9	138
1989	114.1	112.9	119.2	120.4	88.5	124.9	135.8	129.5	149.3	150.8	148
1990	120.5	118.8	121.0	117.6	101.2	130.1	142.5	142.6	162.8	163.4	162
1991	123.8	121.9	125.3	118.1	99.4	136.0	149.1	148.9	177.0	176.8	177
1992	126.5	124.6	128.4	123.2	99.0	141.3	153.2	151.4	190.1	188.1	190
1993	130.4	127.5	131.5	133.9	98.0	145.9	156.8	167.0	201.4	195.0	202
1994	134.3	131.4	136.0	141.7	98.5	150.2	162.1	172.0	211.0	200.7	213
1995	139.1	136.3	139.0	156.5	100.0	154.0	170.6	175.9	220.5	204.5	224
1994: Jan	131.6	128.2	134.7	136.8	92.6	148.1	159.5	175.3	206.4	197.8	208
Feb	131.9	128.5	135.0	134.1	93.6	148.6	159.7	175.9	207.7	198.7	209
Mar	132.2	128.6	135.3	133.6	93.3	149.0	160.2	178.5	208.3	199.1	210
Apr	132.6	129.2	135.4	135.3	94.8	149.4	160.4	176.5	209.2	199.7	211
May	132.8	130.0	135.7	137.9	96.0	149.7	160.8	169.9	209.7	200.1	212
June	133.8	131.0	135.8	140.9	98.2	149.8	161.3	169.9	210.4	200.5	212
July	134.6	131.8	135.8	142.6	100.5	150.0	161.5	171.4	211.5	201.3	213
Aug	135.9	133.0	135.6	144.0	104.1	150.7	162.0	173.2	212.2	201.7	214
Sept	135.9	133.1	135.7	145.4	103.7	151.2	162.1	171.7	212.8	201.7	215
Oct	136.1	133.6	136.6	147.7	101.8	151.7	164.1	168.4	214.0	202.2	216.
Nov	137.1	134.8	137.7	150.1	102.7	151.8	166.2	167.2	214.7	202.7	217.
Dec	137.1	134.9	138.5	151.5	100.4	151.9	167.6	165.6	215.3	202.9	218.
1995: Jan	137.3	134.9	139.0	152.4	98.7	152.0	168.8	168.4	216.6	203.1	219
Feb	137.5	135.0	139.1	153.3	98.0	152.5	169.4	169.9	217.9	203.5	221.
Mar	138.0	135.2	139.0	154.8	97.5	152.7	170.2	174.5	218.4	203.7	221.
Apr	139.1	136.2	139.3	156.7	99.5	153.2	170.9	176.7	218.9	203.6	222.
May	140.3	137.5	139.3	157.7	104.2	153.8	170.5	176.7	219.3	203.4	223
June	141.1	137.9	139.1	158.3	106.1	153.6	169.9	182.5	219.8	203.8	223.
July	140.1	136.9	138.3	157.5	103.6	154.0	169.6	181.8	220.8	204.4	224.
Aug	139.2	136.3	137.9	157.0	101.1	154.5	170.3	177.1	221.6	204.7	225.
Sept	138.8	135.9	137.8	156.5	99.8	155.1	170.1	176.1	222.1	204.8	226.
Oct	139.4	136.3	138.6	157.2	98.3	155.4	172.0	178.7	222.9	205.7	226.
Nov	139.4	136.5	140.1	157.8	96.4	155.7	172.7	177.5	223.5	206.3	227.
Dec	139.1	136.6	140.7	158.2	96.4	155.7	172.4	170.7	223.8	206.6	227

[3] Includes other new vehicles, not shown separately. Includes direct pricing of new trucks and motorcycles beginning 1982.
[4] Includes direct pricing of diesel fuel and gasohol beginning 1981.

Note.—See Note, Table B-56.

Source: Department of Labor, Bureau of Labor Statistics.

TABLE B–57.—*Consumer price indexes for selected expenditure classes, 1950–95*

[For all urban consumers; 1982–84=100, except as noted]

Year or month	Food and beverages: Total[1]	Food: Total	Food: At home	Food: Away from home	Shelter: Total	Renters' costs: Total[2]	Renters' costs: Rent, residential	Homeowners' costs[2]	Maintenance and repairs	Fuel and other utilities: Total	Fuels: Total	Fuel oil and other household fuel commodities	Gas (piped) and electricity (energy services)	Other utilities and public services
1950	....	25.4	27.3	....	....	....	29.7	....	....	....	....	11.3	19.2	....
1951	....	28.2	30.3	....	....	....	30.9	....	....	....	....	11.8	19.3	....
1952	....	28.7	30.8	....	....	....	32.2	....	....	....	....	12.1	19.5	....
1953	....	28.3	30.3	21.5	22.0	....	33.9	....	20.5	22.5	....	12.6	19.9	....
1954	....	28.2	30.1	21.9	22.5	....	35.1	....	20.9	22.6	....	12.6	20.2	....
1955	....	27.8	29.5	22.1	22.7	....	35.6	....	21.4	23.0	....	12.7	20.7	....
1956	....	28.0	29.6	22.6	23.1	....	36.3	....	22.3	23.6	....	13.3	20.9	....
1957	....	28.9	30.6	23.4	24.0	....	37.0	....	23.2	24.3	....	14.0	21.1	....
1958	....	30.2	32.0	24.1	24.5	....	37.6	....	23.6	24.8	....	13.7	21.9	....
1959	....	29.7	31.2	24.8	24.7	....	38.2	....	24.0	25.4	....	13.9	22.4	....
1960	....	30.0	31.5	25.4	25.2	....	38.7	....	24.4	26.0	....	13.8	23.3	....
1961	....	30.4	31.8	26.0	25.4	....	39.2	....	24.8	26.3	....	14.1	23.5	....
1962	....	30.6	32.0	26.7	25.8	....	39.7	....	25.0	26.3	....	14.2	23.5	....
1963	....	31.1	32.4	27.3	26.1	....	40.1	....	25.3	26.6	....	14.4	23.5	....
1964	....	31.5	32.7	27.8	26.5	....	40.5	....	25.8	26.6	....	14.4	23.5	....
1965	....	32.2	33.5	28.4	27.0	....	40.9	....	26.3	26.6	....	14.6	23.5	....
1966	....	33.8	35.2	29.7	27.8	....	41.5	....	27.5	26.7	....	15.0	23.6	....
1967	35.0	34.1	35.1	31.3	28.8	....	42.2	....	28.9	27.1	21.4	15.5	23.7	46.6
1968	36.2	35.3	36.3	32.9	30.1	....	43.3	....	30.6	27.4	21.7	16.0	23.9	47.1
1969	38.1	37.1	38.0	34.9	32.6	....	44.7	....	33.2	28.0	22.1	16.3	24.3	48.4
1970	40.1	39.2	39.9	37.5	35.5	....	46.5	....	35.8	29.1	23.1	17.0	25.4	50.0
1971	41.4	40.4	40.9	39.4	37.0	....	48.7	....	38.6	31.1	24.7	18.2	27.1	53.4
1972	43.1	42.1	42.7	41.0	38.7	....	50.4	....	40.6	32.5	25.7	18.3	28.5	56.2
1973	48.8	48.2	49.7	44.2	40.5	....	52.5	....	43.6	34.3	27.5	21.1	29.9	57.8
1974	55.5	55.1	57.1	49.8	44.4	....	55.2	....	49.5	40.7	34.4	33.2	34.5	60.7
1975	60.2	59.8	61.8	54.5	48.8	....	58.0	....	54.1	45.4	39.4	36.4	40.1	63.9
1976	62.1	61.6	63.1	58.2	51.5	....	61.1	....	57.6	49.4	43.3	38.8	44.7	67.7
1977	65.8	65.5	66.8	62.6	54.9	....	64.8	....	62.0	54.7	49.0	43.9	50.5	70.8
1978	72.2	72.0	73.8	68.3	60.5	....	69.3	....	67.2	58.5	53.0	46.2	55.0	73.7
1979	79.9	79.9	81.8	75.9	68.9	....	74.3	....	74.0	64.8	61.3	62.4	61.0	74.3
1980	86.7	86.8	88.4	83.4	81.0	....	80.9	....	82.4	75.4	74.8	86.1	71.4	77.0
1981	93.5	93.6	94.8	90.9	90.5	....	87.9	....	90.7	86.4	87.2	104.6	81.9	84.3
1982	97.3	97.4	98.1	95.8	96.9	....	94.6	....	96.4	94.9	95.6	103.4	93.2	93.3
1983	99.5	99.4	99.1	100.0	99.1	103.0	100.1	102.5	99.9	100.2	100.5	97.2	101.5	99.5
1984	103.2	103.2	102.8	104.2	104.0	108.6	105.3	107.3	103.7	104.8	104.0	99.4	105.4	107.2
1985	105.6	105.6	104.3	108.3	109.8	115.4	111.8	113.1	106.5	106.5	104.5	95.9	107.1	112.1
1986	109.1	109.0	107.3	112.5	115.8	121.9	118.3	119.4	107.9	104.1	99.2	77.6	105.7	117.9
1987	113.5	113.5	111.9	117.0	121.3	128.1	123.1	124.8	111.8	103.0	97.3	77.9	103.8	120.1
1988	118.2	118.2	116.6	121.8	127.1	133.6	127.8	131.1	114.7	104.4	98.0	78.1	104.6	122.9
1989	124.9	125.1	124.2	127.4	132.8	138.9	132.8	137.3	118.0	107.8	100.9	81.7	107.5	127.1
1990	132.1	132.4	132.3	133.4	140.0	146.7	138.4	144.6	122.2	111.6	104.5	99.3	109.3	131.7
1991	136.8	136.3	135.8	137.9	146.3	155.6	143.3	150.2	126.3	115.3	106.7	94.6	112.6	137.9
1992	138.7	137.9	136.8	140.7	151.2	160.9	146.9	155.3	128.6	117.8	108.1	90.7	114.8	142.5
1993	141.6	140.9	140.1	143.2	155.7	165.0	150.3	160.2	130.6	121.3	111.2	90.3	118.5	147.0
1994	144.9	144.3	144.1	145.7	160.5	169.4	154.0	165.5	130.8	122.8	111.7	88.8	119.2	150.2
1995	148.9	148.4	148.8	149.0	165.7	174.3	157.8	171.0	135.0	123.7	111.5	88.1	119.2	152.8
1994: Jan	144.3	143.7	143.8	144.5	158.1	166.8	152.2	162.9	128.9	121.6	110.6	88.9	118.0	148.9
Feb	143.6	142.9	142.6	144.6	159.1	168.9	152.8	163.7	129.4	122.4	111.1	93.6	117.9	150.0
Mar	143.9	143.2	142.8	144.8	159.8	170.1	153.2	164.1	129.3	122.4	111.1	92.5	118.1	150.1
Apr	144.0	143.4	143.0	145.1	159.6	169.1	153.3	164.2	130.2	121.6	109.8	90.2	116.9	150.0
May	144.1	143.5	143.0	145.3	159.6	168.5	153.3	164.5	131.0	122.2	110.6	88.7	118.0	150.4
June	144.2	143.5	142.9	145.5	160.1	169.6	153.4	164.8	131.5	124.2	113.9	87.7	122.1	150.4
July	144.8	144.2	144.0	145.6	160.8	171.0	153.9	165.3	131.3	124.3	114.1	87.1	122.3	150.4
Aug	145.3	144.8	144.7	145.9	161.7	172.1	154.5	166.1	131.2	124.3	114.0	86.8	122.2	150.6
Sept	145.6	145.0	145.0	146.2	161.6	169.4	155.0	167.1	131.6	124.2	113.8	86.8	122.1	150.3
Oct	145.6	145.0	144.8	146.4	162.0	169.8	155.2	167.5	130.8	122.4	110.8	87.0	118.5	150.4
Nov	145.9	145.3	145.1	146.8	162.1	168.9	155.6	167.9	131.2	121.8	109.9	87.7	117.3	150.5
Dec	147.2	146.8	147.3	147.1	161.8	168.2	155.7	167.8	132.7	122.0	110.1	88.4	117.4	150.6
1995: Jan	147.9	147.5	148.2	147.4	162.9	170.7	156.1	168.4	133.1	122.9	110.7	89.4	118.0	152.1
Feb	147.8	147.4	147.9	147.6	163.8	172.9	156.4	168.9	133.8	122.6	110.4	89.6	117.6	151.8
Mar	147.9	147.4	147.6	148.1	164.5	174.6	156.7	169.2	134.2	122.3	109.8	89.0	117.1	151.9
Apr	148.9	148.3	149.2	148.3	164.7	174.1	157.0	169.6	134.2	122.1	109.3	88.4	116.6	152.2
May	148.7	148.3	148.7	148.6	164.8	173.7	157.2	170.0	134.6	122.5	109.8	88.3	117.2	152.3
June	148.4	147.9	148.1	148.8	165.5	174.7	157.5	170.6	135.0	125.0	113.8	87.9	121.9	152.7
July	148.6	148.1	148.2	149.1	166.4	176.7	157.9	171.2	135.1	125.1	113.7	87.1	121.9	153.0
Aug	148.9	148.4	148.4	149.4	166.8	176.9	158.2	171.6	135.4	125.7	114.6	86.6	123.0	153.1
Sept	149.4	148.9	149.2	149.6	166.8	175.1	158.5	172.4	135.4	124.9	113.4	86.6	121.6	153.2
Oct	149.8	149.4	149.7	150.0	167.3	175.3	158.9	173.0	136.3	123.9	111.5	86.9	119.3	153.5
Nov	149.8	149.4	149.5	150.2	167.3	173.8	159.3	173.5	136.2	123.1	110.1	87.7	117.6	153.6
Dec	150.3	149.9	150.3	150.4	167.4	173.2	159.6	174.0	136.6	123.7	110.9	89.6	118.3	153.9

[1] Includes alcoholic beverages, not shown separately.
[2] December 1982=100.

See next page for continuation of table.

[For all urban consumers; 1982–84=100, except as noted]

Year or month	Transportation: Total	Private transportation: Total[3]	New cars	Used cars	Motor fuel[4]	Automobile maintenance and repair	Other	Public transportation	Medical care: Total	Medical care commodities	Medic care servic
1950	22.7	24.5	41.1	....	19.0	18.9	....	13.4	15.1	39.7	12
1951	24.1	25.6	43.1	....	19.5	20.4	....	14.8	15.9	40.8	13
1952	25.7	27.3	46.8	....	20.0	20.8	....	15.8	16.7	41.2	14
1953	26.5	27.8	47.2	26.7	21.2	22.0	....	16.8	17.3	41.5	14
1954	26.1	27.1	46.5	22.7	21.8	22.7	....	18.0	17.8	42.0	15
1955	25.8	26.7	44.8	21.5	22.1	23.2	....	18.5	18.2	42.5	15
1956	26.2	27.1	46.1	20.7	22.8	24.2	....	19.2	18.9	43.4	16
1957	27.7	28.6	48.5	23.2	23.8	25.0	....	19.9	19.7	44.6	17
1958	28.6	29.5	50.0	24.0	23.4	25.4		20.9	20.6	45.1	1
1959	29.8	30.8	52.2	26.8	23.7	26.0	....	21.5	21.5	46.8	1
1960	29.8	30.6	51.5	25.0	24.4	26.5	....	22.2	22.3	46.9	1
1961	30.1	30.8	51.5	26.0	24.1	27.1	....	23.2	22.9	46.3	2
1962	30.8	31.4	51.3	28.4	24.3	27.5	....	24.0	23.5	45.6	2
1963	30.9	31.6	51.0	28.7	24.2	27.8	....	24.3	24.1	45.2	21
1964	31.4	32.0	50.9	30.0	24.1	28.2	....	24.7	24.6	45.1	2
1965	31.9	32.5	49.7	29.8	25.1	28.7	....	25.2	25.2	45.0	2
1966	32.3	32.9	48.8	29.0	25.6	29.2	....	26.1	26.3	45.1	2
1967	33.3	33.8	49.3	29.9	26.4	30.4	37.9	27.4	28.2	44.9	2
1968	34.3	34.8	50.7	....	26.8	32.1	39.2	28.7	29.9	45.0	2
1969	35.7	36.0	51.5	30.9	27.6	34.1	41.6	30.9	31.9	45.4	3
1970	37.5	37.5	53.0	31.2	27.9	36.6	45.2	35.2	34.0	46.5	3
1971	39.5	39.4	55.2	33.0	28.1	39.3	48.6	37.8	36.1	47.3	3
1972	39.9	39.7	54.7	33.1	28.4	41.1	48.9	39.3	37.3	47.4	3
1973	41.2	41.0	54.8	35.2	31.2	43.2	48.4	39.7	38.8	47.5	3
1974	45.8	46.2	57.9	36.7	42.2	47.6	50.2	40.6	42.4	49.2	4
1975	50.1	50.6	62.9	43.8	45.1	53.7	53.5	43.5	47.5	53.3	4
1976	55.1	55.6	66.9	50.3	47.0	57.6	61.8	47.8	52.0	56.5	5
1977	59.0	59.7	70.4	54.7	49.7	61.9	67.2	50.0	57.0	60.2	5
1978	61.7	62.5	75.8	55.8	51.8	67.0	69.9	51.5	61.8	64.4	6
1979	70.5	71.7	81.8	60.2	70.1	73.7	75.2	54.9	67.5	69.0	6
1980	83.1	84.2	88.4	62.3	97.4	81.5	84.3	69.0	74.9	75.4	7
1981	93.2	93.8	93.7	76.9	108.5	89.2	91.4	85.6	82.9	83.7	8
1982	97.0	97.1	97.4	88.8	102.8	96.0	97.7	94.9	92.5	92.3	9
1983	99.3	99.3	99.9	98.7	99.4	100.3	98.8	99.5	100.6	100.2	10
1984	103.7	103.6	102.8	112.5	97.9	103.8	103.5	105.7	106.8	107.5	10
1985	106.4	106.2	106.1	113.7	98.7	106.8	109.0	110.5	113.5	115.2	11
1986	102.3	101.2	110.6	108.8	77.1	110.3	115.1	117.0	122.0	122.8	12
1987	105.4	104.2	114.6	113.1	80.2	114.8	120.8	121.1	130.1	131.0	13
1988	108.7	107.6	116.9	118.0	80.9	119.7	127.9	123.3	138.6	139.9	13
1989	114.1	112.9	119.2	120.4	88.5	124.9	135.8	129.5	149.3	150.8	14
1990	120.5	118.8	121.0	117.6	101.2	130.1	142.5	142.6	162.8	163.4	16
1991	123.8	121.9	125.3	118.1	99.4	136.0	149.1	148.9	177.0	176.8	17
1992	126.5	124.6	128.4	123.2	99.0	141.3	153.2	151.4	190.1	188.1	19
1993	130.4	127.5	131.5	133.9	98.0	145.9	156.8	167.0	201.4	195.0	20
1994	134.3	131.4	136.0	141.7	98.5	150.2	162.1	172.0	211.0	200.7	21
1995	139.1	136.3	139.0	156.5	100.0	154.0	170.6	175.9	220.5	204.5	22
1994: Jan	131.6	128.2	134.7	136.8	92.6	148.1	159.5	175.3	206.4	197.8	20
Feb	131.9	128.5	135.0	134.1	93.6	148.6	159.7	175.9	207.7	198.7	20
Mar	132.2	128.6	135.3	133.6	93.3	149.0	160.2	178.5	208.3	199.1	21
Apr	132.6	129.2	135.4	135.3	94.8	149.4	160.4	176.5	209.2	199.7	21
May	132.8	130.0	135.7	137.9	96.0	149.7	160.8	169.9	209.7	200.1	21
June	133.8	131.0	135.8	140.9	98.2	149.8	161.3	169.9	210.4	200.5	21
July	134.6	131.8	135.8	142.6	100.5	150.0	161.5	171.4	211.5	201.3	21
Aug	135.9	133.0	135.6	144.0	104.1	150.7	162.0	173.2	212.2	201.7	21
Sept	135.9	133.1	135.7	145.4	103.7	151.2	162.1	171.7	212.8	201.7	21
Oct	136.1	133.6	136.6	147.7	101.8	151.7	164.1	168.4	214.0	202.2	21
Nov	137.1	134.8	137.7	150.1	102.7	151.8	166.2	167.2	214.7	202.7	21
Dec	137.1	134.9	138.5	151.5	100.4	151.9	167.6	165.6	215.3	202.9	21
1995: Jan	137.3	134.9	139.0	152.4	98.7	152.0	168.8	168.4	216.6	203.1	21
Feb	137.5	135.0	139.1	153.3	98.0	152.5	169.4	169.9	217.9	203.5	22
Mar	138.0	135.2	139.0	154.8	97.5	152.7	170.2	174.5	218.4	203.7	22
Apr	139.1	136.2	139.3	156.7	99.5	153.2	170.9	176.7	218.9	203.6	22
May	140.3	137.5	139.3	157.7	104.2	153.8	170.5	176.7	219.3	203.4	22
June	141.1	137.9	139.1	158.3	106.1	153.6	169.9	182.5	219.8	203.8	22
July	140.1	136.9	138.3	157.5	103.6	154.0	169.6	181.8	220.8	204.4	22
Aug	139.2	136.3	137.9	157.0	101.1	154.5	170.3	177.1	221.6	204.7	22
Sept	138.8	135.9	137.8	156.5	99.8	155.1	170.1	176.1	222.1	204.8	22
Oct	139.4	136.3	138.6	157.2	98.3	155.4	172.0	178.7	222.9	205.7	22
Nov	139.4	136.5	140.1	157.8	96.4	155.7	172.7	177.5	223.5	206.3	22
Dec	139.1	136.6	140.7	158.2	96.4	155.7	172.4	170.7	223.8	206.6	22

[3] Includes other new vehicles, not shown separately. Includes direct pricing of new trucks and motorcycles beginning 1982.
[4] Includes direct pricing of diesel fuel and gasohol beginning 1981.

Note.—See Note, Table B-56.

Source: Department of Labor, Bureau of Labor Statistics.

TABLE B–55.—*Manufacturers' new and unfilled orders, 1954–95*

[Amounts in millions of dollars; monthly data seasonally adjusted]

nth	New orders[1]				Unfilled orders[2]			Unfilled orders—shipments ratio[3]		
	Total	Durable goods industries		Nondurable goods industries	Total	Durable goods industries	Nondurable goods industries	Total	Durable goods industries	Nondurable goods industries
		Total	Capital goods industries, nondefense							
	22,335	10,768	...	11,566	48,266	45,250	3,016	3.42	4.12	0.96
	27,465	14,996	...	12,469	60,004	56,241	3,763	3.63	4.27	1.12
	28,368	15,365	...	13,003	67,375	63,880	3,495	3.87	4.55	1.04
	27,559	14,111	...	13,448	53,183	50,352	2,831	3.35	4.00	.85
	27,193	13,387	...	13,805	46,609	43,807	2,802	3.02	3.62	.85
	30,711	15,979	...	14,732	51,717	48,369	3,348	2.94	3.47	.92
	30,232	15,288	...	14,944	44,213	41,650	2,563	2.71	3.29	.71
	31,112	15,753	...	15,359	46,624	43,582	3,042	2.58	3.08	.78
	33,440	17,363	...	16,078	47,798	45,170	2,628	2.64	3.18	.68
	35,511	18,671	...	16,840	53,417	50,346	3,071	2.74	3.31	.72
	38,240	20,507	...	17,732	64,518	61,315	3,203	2.99	3.59	.71
	42,137	23,286	...	18,851	78,249	74,459	3,790	3.25	3.86	.79
	46,420	26,163	...	20,258	96,846	93,002	3,844	3.74	4.48	.75
	47,067	25,803	...	21,265	103,711	99,735	3,976	3.66	4.37	.73
	50,657	28,051	6,314	22,606	108,377	104,393	3,984	3.79	4.58	.69
	53,990	29,876	7,046	24,114	114,341	110,161	4,180	3.71	4.45	.69
	52,022	27,340	6,072	24,682	105,008	100,412	4,596	3.61	4.36	.76
	55,921	29,905	6,682	26,016	105,247	100,225	5,022	3.32	4.00	.76
	64,182	35,038	7,745	29,144	119,349	113,034	6,315	3.26	3.85	.86
	76,003	42,627	9,926	33,376	156,561	149,204	7,357	3.80	4.51	.91
	87,327	46,862	11,594	40,465	187,043	181,519	5,524	4.09	4.93	.62
	85,139	41,957	9,886	43,181	169,546	161,664	7,882	3.69	4.45	.82
	99,513	51,307	11,490	48,206	178,128	169,857	8,271	3.24	3.88	.74
	115,109	61,035	13,681	54,073	202,024	193,323	8,701	3.24	3.85	.71
	131,629	72,278	17,588	59,351	259,169	248,281	10,888	3.57	4.20	.81
	147,604	79,483	21,154	68,121	303,593	291,321	12,272	3.89	4.62	82
	156,359	79,392	21,135	76,967	327,416	315,202	12,214	3.85	4.58	.75
	168,025	83,654	21,806	84,371	326,547	314,707	11,840	3.87	4.68	.69
	162,140	78,064	19,213	84,077	311,887	300,798	11,089	3.84	4.74	.62
	175,451	88,140	19,624	87,311	347,273	333,114	14,159	3.53	4.29	.69
	192,879	100,164	23,669	92,715	373,529	359,651	13,878	3.60	4.37	.64
	195,706	102,356	24,545	93,351	387,095	372,027	15,068	3.67	4.46	.68
	195,204	103,647	23,983	91,557	393,412	376,622	16,790	3.59	4.40	.70
	209,389	110,809	26,095	98,579	430,288	408,602	21,686	3.63	4.42	.83
	227,026	121,445	30,729	105,581	471,951	450,002	21,949	3.64	4.45	.76
	235,932	124,933	32,725	110,999	510,459	488,780	21,679	4.00	4.91	78
	240,646	123,556	32,254	117,090	524,846	502,914	21,932	4.14	5.13	.76
	234,354	117,878	29,468	116,476	511,122	487,892	23,230	4.08	5.06	.81
	241,545	122,614	29,653	118,932	475,304	452,383	22,921	3.46	4.21	.77
	255,701	133,273	31,889	122,428	441,947	420,288	21,659	3.04	3.65	.72
	281,953	151,878	37,530	130,074	456,838	431,305	25,533	2.87	3.43	.76
	272,616	148,549	36,630	124,067	446,233	424,128	22,105	3.11	3.73	.74
	271,786	145,882	36,382	125,904	446,204	423,750	22,454	3.07	3.69	.74
	274,691	146,906	36,127	127,785	446,398	423,268	23,130	3.03	3.63	.76
	275,182	147,345	35,815	127,837	447,337	423,681	23,656	3.04	3.64	.77
	277,441	149,412	35,498	128,029	448,546	424,583	23,963	3.01	3.60	.76
	279,788	151,212	38,055	128,576	449,767	425,784	23,983	2.98	3.58	.76
	274,305	145,251	36,310	129,054	448,587	424,563	24,024	2.99	3.60	.75
	287,222	154,675	37,595	132,547	447,729	423,619	24,110	2.89	3.47	.73
	287,248	155,433	39,056	131,815	448,843	424,702	24,141	2.90	3.48	.74
	285,985	154,150	38,276	131,835	450,853	426,266	24,587	2.94	3.52	.76
	293,716	159,321	40,781	134,395	453,378	428,295	25,083	2.88	3.45	.76
	299,514	162,310	37,759	137,204	456,838	431,305	25,533	2.87	3.43	.76
	301,724	164,507	41,785	137,217	460,772	434,733	26,039	2.85	3.41	.76
	300,804	163,338	42,055	137,466	463,020	436,865	26,155	2.86	3.42	.76
	299,625	163,042	42,628	136,583	464,208	438,336	25,872	2.85	3.41	.75
	293,069	155,553	40,072	137,516	461,984	435,919	26,065	2.86	3.44	.75
	297,046	159,502	43,115	137,544	461,937	435,809	26,128	2.82	3.38	.75
	296,754	159,031	42,964	137,723	459,979	434,012	25,967	2.78	3.34	.72
	293,863	156,130	40,233	137,733	460,368	434,223	26,145	2.84	3.42	.74
	301,903	164,082	41,676	137,821	459,250	434,109	25,141	2.74	3.30	.70
	306,123	168,951	46,941	137,172	461,093	437,121	23,972	2.74	3.30	.67
	305,143	167,068	43,488	138,075	463,081	439,560	23,521	2.77	3.34	.66

la are averages of monthly not seasonally adjusted figures.

/ adjusted, end of period.

nfilled orders at end of period to shipments for period; excludes industries with no unfilled orders. Annual figures relate to sea-
ed data for December.

a beginning 1958 are not strictly comparable with earlier data.

lartment of Commerce, Bureau of the Census.

TABLE B–56.—*Consumer price indexes for major expenditure classes, 1950–95*

[For all urban consumers; 1982–84=100]

Year or month	All items (CPI–U)	Food and beverages		Housing				Apparel and upkeep	Transportation	Medical care	Entertainment	Other goods and services	Energy[2]
		Total[1]	Food	Total	Shelter	Fuel and other utilities	Household furnishings and operation						
1950	24.1	...	25.4	...	...	...	...	40.3	22.7	15.1	...	...	...
1951	26.0	...	28.2	...	...	...	...	43.9	24.1	15.9	...	...	...
1952	26.5	...	28.7	...	...	...	...	43.5	25.7	16.7	...	...	...
1953	26.7	...	28.3	...	22.0	22.5	...	43.1	26.5	17.3	...	...	...
1954	26.9	...	28.2	...	22.5	22.6	...	43.1	26.1	17.8	...	...	...
1955	26.8	...	27.8	...	22.7	23.0	...	42.9	25.8	18.2	...	...	...
1956	27.2	...	28.0	...	23.1	23.6	...	43.7	26.2	18.9	...	...	...
1957	28.1	...	28.9	...	24.0	24.3	...	44.5	27.7	19.7	...	...	21.5
1958	28.9	...	30.2	...	24.5	24.8	...	44.6	28.6	20.6	...	...	21.5
1959	29.1	...	29.7	...	24.7	25.4	...	45.0	29.8	21.5	...	...	21.9
1960	29.6	...	30.0	...	25.2	26.0	...	45.7	29.8	22.3	...	...	22.4
1961	29.9	...	30.4	...	25.4	26.3	...	46.1	30.1	22.9	...	...	22.5
1962	30.2	...	30.6	...	25.8	26.3	...	46.3	30.8	23.5	...	...	22.6
1963	30.6	...	31.1	...	26.1	26.6	...	46.9	30.9	24.1	...	...	22.6
1964	31.0	...	31.5	...	26.5	26.6	...	47.3	31.4	24.6	...	...	22.5
1965	31.5	...	32.2	...	27.0	26.6	...	47.8	31.9	25.2	...	...	22.9
1966	32.4	...	33.8	...	27.8	26.7	...	49.0	32.3	26.3	...	...	23.3
1967	33.4	35.0	34.1	30.8	28.8	27.1	42.0	51.0	33.3	28.2	40.7	35.1	23.8
1968	34.8	36.2	35.3	32.0	30.1	27.4	43.6	53.7	34.3	29.9	43.0	36.9	24.2
1969	36.7	38.1	37.1	34.0	32.6	28.0	45.2	56.8	35.7	31.9	45.2	38.7	24.8
1970	38.8	40.1	39.2	36.4	35.5	29.1	46.8	59.2	37.5	34.0	47.5	40.9	25.5
1971	40.5	41.4	40.4	38.0	37.0	31.1	48.6	61.1	39.5	36.1	50.0	42.9	26.5
1972	41.8	43.1	42.1	39.4	38.7	32.5	49.7	62.3	39.9	37.3	51.5	44.7	27.2
1973	44.4	48.8	48.2	41.2	40.5	34.3	51.1	64.6	41.2	38.8	52.9	46.4	29.4
1974	49.3	55.5	55.1	45.8	44.4	40.7	56.8	69.4	45.8	42.4	56.9	49.8	38.1
1975	53.8	60.2	59.8	50.7	48.8	45.4	63.4	72.5	50.1	47.5	62.0	53.9	42.1
1976	56.9	62.1	61.6	53.8	51.5	49.4	67.3	75.2	55.1	52.0	65.1	57.0	45.1
1977	60.6	65.8	65.5	57.4	54.9	54.7	70.4	78.6	59.0	57.0	68.3	60.4	49.4
1978	65.2	72.2	72.0	62.4	60.5	58.5	74.7	81.4	61.7	61.8	71.9	64.3	52.5
1979	72.6	79.9	79.9	70.1	68.9	64.8	79.9	84.9	70.5	67.5	76.7	68.9	65.7
1980	82.4	86.7	86.8	81.1	81.0	75.4	86.3	90.9	83.1	74.9	83.6	75.2	86.0
1981	90.9	93.5	93.6	90.4	90.5	86.4	93.0	95.3	93.2	82.9	90.1	82.6	97.7
1982	96.5	97.3	97.4	96.9	96.9	94.9	98.0	97.8	97.0	92.5	96.0	91.1	99.2
1983	99.6	99.5	99.4	99.5	99.1	100.2	100.2	100.2	99.3	100.6	100.1	101.1	99.9
1984	103.9	103.2	103.2	103.6	104.0	104.8	101.9	102.1	103.7	106.8	103.8	107.9	100.9
1985	107.6	105.6	105.6	107.7	109.8	106.5	103.8	105.0	106.4	113.5	107.9	114.5	101.6
1986	109.6	109.1	109.0	110.9	115.8	104.1	105.2	105.9	102.3	122.0	111.6	121.4	88.2
1987	113.6	113.5	113.5	114.2	121.3	103.0	107.1	110.6	105.4	130.1	115.3	128.5	88.6
1988	118.3	118.2	118.2	118.5	127.1	104.4	109.4	115.4	108.7	138.6	120.3	137.0	89.3
1989	124.0	124.9	125.1	123.0	132.8	107.8	111.2	118.6	114.1	149.3	126.5	147.7	94.3
1990	130.7	132.1	132.4	128.5	140.0	111.6	113.3	124.1	120.5	162.8	132.4	159.0	102.1
1991	136.2	136.8	136.3	133.6	146.3	115.3	116.0	128.7	123.8	177.0	138.4	171.6	102.5
1992	140.3	138.7	137.9	137.5	151.2	117.8	118.0	131.9	126.5	190.1	142.3	183.3	103.0
1993	144.5	141.6	140.9	141.2	155.7	121.3	119.3	133.7	130.4	201.4	145.8	192.9	104.2
1994	148.2	144.9	144.3	144.8	160.5	122.8	121.0	133.4	134.3	211.0	150.1	198.5	104.6
1995	152.4	148.9	148.4	148.5	165.7	123.7	123.0	132.0	139.1	220.5	153.9	206.9	105.2
1994: Jan	146.2	144.3	143.7	142.9	158.1	121.6	120.5	130.4	131.6	206.4	148.5	195.1	101.3
Feb	146.7	143.6	142.9	143.7	159.1	122.4	120.4	132.4	131.9	207.7	149.1	195.2	102.0
Mar	147.2	143.9	143.2	144.1	159.8	122.4	120.6	136.1	132.2	208.3	149.6	195.5	101.9
Apr	147.4	144.0	143.4	143.9	159.6	121.6	120.6	136.4	132.6	209.2	149.7	196.4	102.0
May	147.5	144.1	143.5	144.1	159.6	122.2	121.1	135.6	132.8	209.7	149.9	197.1	102.9
June	148.0	144.2	143.5	144.9	160.1	124.2	121.4	133.8	133.8	210.4	149.8	197.6	105.7
July	148.4	144.8	144.2	145.4	160.8	124.3	121.5	130.9	134.6	211.5	150.2	198.0	106.8
Aug	149.0	145.3	144.8	145.9	161.7	124.3	121.4	131.1	135.9	212.2	150.2	199.4	108.5
Sept	149.4	145.6	145.0	145.8	161.6	124.2	121.4	134.2	135.9	212.8	150.7	201.4	108.2
Oct	149.5	145.6	145.0	145.7	162.0	122.4	121.4	135.2	136.1	214.0	151.0	201.9	105.8
Nov	149.7	145.9	145.3	145.5	162.1	121.8	121.1	134.2	137.1	214.7	151.6	202.3	105.7
Dec	149.7	147.2	146.8	145.4	161.8	122.0	120.8	130.5	137.1	215.3	151.2	202.4	104.7
1995: Jan	150.3	147.9	147.5	146.4	162.9	122.9	121.8	129.4	137.3	216.6	152.1	203.0	104.2
Feb	150.9	147.8	147.4	147.0	163.8	122.6	122.4	131.1	137.5	217.9	152.5	204.1	103.7
Mar	151.4	147.9	147.4	147.4	164.5	122.3	122.6	134.4	138.0	218.4	152.6	204.0	103.2
Apr	151.9	148.9	148.4	147.4	164.7	122.1	122.6	134.8	139.1	218.9	153.3	204.3	103.9
May	152.2	148.7	148.3	147.6	164.8	122.5	122.7	133.4	140.3	219.3	153.6	204.9	106.3
June	152.5	148.4	147.9	148.5	165.5	125.0	122.5	130.5	141.1	219.8	153.2	205.3	109.3
July	152.5	148.6	148.1	149.2	166.4	125.1	123.0	128.3	140.1	220.8	153.6	205.7	108.1
Aug	152.9	148.9	148.4	149.6	166.8	125.7	123.4	130.1	139.2	221.6	154.1	207.7	107.4
Sept	153.2	149.4	148.9	149.5	166.8	124.9	123.8	132.7	138.8	222.1	154.9	210.2	106.2
Oct	153.7	149.8	149.4	149.7	167.3	123.9	123.9	134.5	139.4	222.9	155.2	210.7	104.5
Nov	153.6	149.8	149.4	149.4	167.3	123.1	123.6	133.7	139.4	223.5	156.0	211.2	102.8
Dec	153.5	150.3	149.9	149.7	167.4	123.7	123.8	130.6	139.1	223.8	156.2	211.1	103.3

[1] Includes alcoholic beverages, not shown separately.

[2] Household fuels—gas (piped), electricity, fuel oil, etc.—and motor fuel. Motor oil, coolant, etc. also included through 1982.

Note.—Data beginning 1983 incorporate a rental equivalence measure for homeowners' costs.

Source: Department of Labor, Bureau of Labor Statistics.

Oil Shocks and the Macroeconomy: The Role of Price Variability*

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In this paper we argue that an oil price change is likely to have greater impact on real GNP in an environment where oil prices have been stable, than in an environment where oil price movement has been frequent and erratic. An oil price shock variable reflecting both the unanticipated component and the time-varying conditional variance of oil price change (forecasts) is constructed and found to be highly significant in explaining economic growth across different sample periods, even when matched against various economic variables and other functions of oil price. We find that positive normalized shocks have a powerful effect on growth while negative normalized shocks do not.

INTRODUCTION

In an influential paper, Hamilton (1983) found within a vector autoregression (VAR) framework that oil price change has a strong causal and negative correlation with real U.S. GNP growth from 1948 to 1980. Mork (1989) showed that when the sample period is extended to 1988:2 the correlation becomes only marginally significant, and more importantly that there is an asymmetry in effects: GNP growth has a definite negative correlation with oil price increases and a statistically insignificant correlation with oil price decreases.

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Burbidge and Harrison (1984) using somewhat different data and methods also found significant impacts of oil and energy shocks on real activity for the U.S.[1] Using annual data, Mory (1993) showed that increases and decreases in real oil prices have asymmetric effects on output and other macro-variables from 1951 to 1990, and on personal income and earnings in most industries from 1959 to 1989. Darby (1982) made international comparisons of oil shock impacts within a VAR framework and found for the U.S. that the estimated oil shock effect was much reduced if price controls during the 1970s were taken into account. Hooker (1994) found the predictive power of oil shocks on macrovariables diminishes as the sample is further updated. These studies generally show that the effect of oil price increases and decreases have asymmetric effects on the economy and that the effects vary across time and countries.

Table 1. Summary Statistics of Changes in Real Oil Prices

	50:1 - 86:1	50:1 - 92:3	73:1 - 79:3	86:1 - 92:3
Mean	1.1938	0.4241	16.7472	-8.0111
Std. Dev.	23.8877	35.7899	41.2152	75.2101
LM Test	26.2441	31.4915	4.4211	7.5542
(p-value)	(0.000)	(0.000)	(0.3520)	(0.1090)

Note: Std. Dev. denotes standard deviation of change in real oil price, z_t, defined as 400 times the log difference in the real price of oil. The Lagrange Multiplier (LM) test represents χ^2 test statistics with four degrees of freedom for joint correlation tests of residuals of mean regression of z_t (marginal p-values are in parentheses). The null hypothesis of no serial correlation in residuals is rejected for the long sample periods, marginally accepted for 86:1-92:3, and accepted for 73:1-79:3.

As noted by Mork, until the oil price collapse in late 1985 the major oil shocks since 1948 were price increases. Since 1986:1 a pattern of large price increases and decreases is reflected in a substantial rise in the volatility of real oil price as illustrated in Table 1. Wide swings in real oil price during 1986 and 1987 have continued into the 1990s. For example, real oil price fell by 20 percent in 1990:2, rose by about 40 percent and 30 percent in 1990:3 and 1990:4, and fell by 34 percent and 9 percent in 1991:1 and 1991:2. The real oil price in 1991:2 was almost back at the level one year earlier having almost doubled during the interim. More recently a fall in the real oil price of about 13 percent in 1992:1 was followed by a rise of about 13 percent in 1992:2.

1. They used monthly data in a VAR over 1962-82 to examine the impact of oil shocks in several OECD countries and found that the impact on industrial Production was larger for the U.S. and U.K. than that for other countries.

Our objective in this paper is to further explore the issue of causality of real oil price to the macroeconomy in the light of experience up to 1992. Unlike earlier periods, movements in real oil price and GNP during 1986:2-1987:3 and 1990:4-1992:3 have a positive correlation. This reversal in the relationship and large swings in real oil price provide an opportunity to further explore the relationship between oil price and GNP. A brief discussion of some results for different sample periods will help motivate the study.

Table 2 reports results for real GNP growth as the dependent variable in a vector autoregression (VAR) for three different sample periods. Results from a seven variable VAR show that real oil price change is significant at one percent during the period 1949:1-1986:1, but is not statistically significant for samples including more recent data. This result was noted by Mork for the period ending 1988:2. The seven variables are basically the same as those appearing in the seven variable system considered by Mork (1989): real GNP growth; GNP deflator inflation; 3-month Treasury bill rate; unemployment rate; wage inflation (average hourly earnings for production workers in manufacturing); import price inflation; and real oil price changes. As suggested in footnote 2, real oil price changes are calculated following Mork (1989). Data are from Citibase. Variables are in annual percentage terms. In summary, using Mork's model, we find similar results for the period considered by him, and further deterioration in the predictive power of oil price shocks for real GNP as the sample is further updated.

Results from an eight variable VAR show that real oil price increases are significant at 5 percent during 1949:1-1986:1 and 1949:1-1988:2 (the period considered by Mork), but not statistically significant at this level for the period 1949:1-1992:3.[2] In addition, formal tests of pairwise equality of coefficients for real oil price increases and decreases have p-values of 0.355 for 1949:1-1986:1, 0.042 for 1949:1-1988:2, 0.044 for 1949:1-1992:3. Thus the hypothesis of symmetry is not rejected for the early period, but is rejected at the 5 percent level for periods ending in 1988:2 and 1992:3.[3]

2. The F values are different from those appearing in Table 1 in Mork (1989). This is probably due to several factors. While Mork's method is followed in that refiners acquisition cost for crude oil is used rather than the PPI (because of the price controls of the 1970s) when possible, monthly oil price data is averaged to obtain quarterly observations rather than using a single monthly observation during a three month period to represent a quarterly observation as in Mork. In addition, the import price variable is exclusive of movement in the price of oil imports. Mork noted the decline in statistical significance of real oil price change when the sample is extended to 1988:2. However, for his data, real oil price change was marginally significant at the 7% level. Also, Mork found the oil price increase variable to be somewhat more statistically significant for the period 1949:1-1988:2 than that reported here.

3. The hypothesis of parameter stability for the asymmetric model for extension of the sample from 1986:1 to 1988:2 and from 1986:1 to 1992:3 cannot be rejected (p-values of Chow test are 0.466 and 0.852 for the two periods).

Table 2. Exclusion Tests: Real GNP Growth Rate is the Dependent Variable

Variable	49:1 - 86:1	49:1 - 88:2	49:1 - 92:3
Seven Variable System			
Real Oil Price Change	3.439	0.998	0.797
	(0.010)	(0.411)	(0.529)
Eight Variable System 1			
Oil Price Increases	2.820	2.591	2.043
	(0.028)	(0.040)	(0.092)
Oil Price Decreases	1.128	1.525	1.079
	(0.347)	(0.199)	(0.369)
	49:4 - 86:1	49:4 - 88:2	49:4 - 92:3
Eight Variable System 2			
Real Oil Price Change	1.765	2.662	0.979
	(0.141)	(0.036)	(0.421)
Oil Price Shocks (e)	2.426	2.574	1.353
	(0.052)	(0.041)	(0.254)

Note: The exclusion tests are for joint hypothesis of zero coefficient on all four lags of each variable using F distributions with four degrees of freedom in the numerator and appropriate degrees of freedom in the denominator. Numbers in parentheses denote marginal p-values obtained from asymtotic t values. The six variables not appearing in the Table are basically the same as those in Mork (1989); real GNP growth; GNP deflator inflation; 3-month T-bill rate; unemployment rate; wage inflation; import price inflation.

This paper claims that the real oil price has not lost predictive power for growth in real GNP if appropriate account is taken of oil shocks and the variability of real oil price movement. The basic idea is that an oil shock is likely to have greater impact in an environment where oil prices have been stable than in an environment where oil price movement has been frequent and erratic. The oil price shock variable proposed to be included in a VAR system reflects both the unanticipated component of real oil price movement and the time-varying conditional variance of oil price change forecasts. This variable can be thought of as being a measure of how different a given oil price movement is from the prior pattern.[4]

It is found that this variable is highly statistically significant in explaining GNP growth over different sample periods, even when matched in

4. The suggestion that the prior pattern of relative price change has real consequences is not new. It has been argued by Davis (1987) and Hamilton (1988b) that the predicted effects of a given change in real oil price (or relative material price) are quite different depending upon the previous pattern of oil price change.

a VAR against other functions of real oil price.[5] These results are consistent with the view that the effect of a change in real oil price depends upon whether it is an unusual event rather than merely an adjustment in response to a change in the previous month. An asymmetry is found to exist between the effects of positive and negative normalized shocks in all sample periods. Positive normalized shocks in real oil price are strongly related to negative real growth. Negative normalized shocks are not statistically significant. A generalized autoregressive conditional heteroskedasticity (GARCH) model is utilized to construct the conditional variation of oil price changes used to normalize unexpected movements in real oil price. This model is presented in the second section. Empirical results on the causal relationship between oil prices and GNP growth are presented in the third section. The impulse responses of GNP growth and unemployment over multiple horizons to normalized oil price shocks are discussed in the fourth section. Concluding remarks are made in the last section.

THE MODEL OF PRICE VARIABILITY

A distinguishing feature of the model employed in this paper from earlier work is incorporation of an oil shock variable normalized by a measure of oil price variability. A univariate GARCH error process is used to compute the unexpected component and conditional variance of real oil price.[6] These variables are then used to augment the VAR system of Hamilton and Mork.

A univariate regression with GARCH(p,q) error process in the quarterly rate of change in real oil price, z_t, can be represented as

$$z_t = \alpha_0 + \sum_{i=1}^{r} \alpha_i z_{t-i} + \sum_{i=1}^{s} x'_{t-i} \beta_i + e_t, \qquad (1)$$

where

$$e_t | I_{t-1} \sim N(0, h_t),$$

5. It should be emphasized that this outcome holds even for periods that exclude the mid and late 1980s and early 1990s.

6. See Engle (1982), Bollerslev (1986), Bollerslev, Engle, and Wooldridge (1988), and Bollerslev, Chou, and Kroner (1992), among others, for discussion of various ARCH and GARCH models.

and

$$h_t = \gamma_0 + \sum_{i=1}^{q} \gamma_i e_{t-i}^2 + \sum_{j=1}^{p} \gamma_{q+j} h_{t-j}. \qquad (2)$$

$\{x_{t-j}: j \geq 1\}$ denotes an appropriately chosen vector contained in information set I_{t-1}, $t = 1,\ldots,T$. β is a vector of coefficients. The conditional expectation of z_t, $\hat{z}_t = E(z_t | I_{t-1})$, is assumed to be a linear projection on the conditioning information. The unexpected part of the rate of change in real oil price is defined as $e_t = z_t - \hat{z}_t$.

The metric e_t does not reflect changes in conditional variability over time. When the data generating process is described by equations (1) and (2) a measure of an unexpected oil shock that does reflect the magnitude and the variability of the forecast error e_t might be defined as

$$e_t^* \equiv e_t / h_t^{1/2}. \qquad (3)$$

It is the central hypothesis of this paper that e_t^* can be expected to have a more systematic causal relation to the real GNP than either z_t or e_t. The intuition is that a given unexpected rate of change in real oil price will have a smaller impact on real activity when conditional variances are large since much of the change in real oil price will be regarded as transitory. The variable e_t^* can be thought of as being a measure of how different a given oil price change is from the historical pattern.

When changes in real oil price are regarded as exogenous shocks (e.g., Granger prior with respect to macroeconomic variables) the choice of right hand variables of equation (1) would seem to be limited to lagged values of the dependent variable. A search over alternative specifications for x_{t-1}, including various lag lengths, and the three month T-bill rate, rate of change in the GNP deflator, and the unemployment rate as possible explanatory variables did not result in finding a variable with statistical significance at the 5 percent level in explaining z_t. When z_t is regressed on its own lags, lags one to four and lag eight are significant at the 5 percent level. Since the first four lags alone make the Ljung-Box Q statistic with 36 lags statistically insignificant, only the first four lags are included.

Table 3. Parameter Estimates of Eqns (1) & (2), Data from 1949:3 - 1992:3

Parameter	Estimate	Std. Error	p-value
α_0	-1.986	0.670	0.003
α_1	0.436	0.144	0.002
α_2	-0.401	0.085	0.000
α_3	0.244	0.055	0.000
α_4	-0.238	0.066	0.000
γ_0	23.843	4.146	0.000
γ_1	2.208	0.385	0.000
γ_2	0.197	0.098	0.044

GARCH(1,1) was adopted as a parsimonious representation of the process of conditional variance of $\{e_t\}$ in equation (1) with $r = 4$ and $s = 0$.[7] Table 3 presents parameter estimates of equation (1). The GARCH(1,1) parameters are significant and have the correct sign.[8] The sum of $\hat{\gamma}_1$ and $\hat{\gamma}_2$ (2.405) indicates the conditional variance process is highly persistent, i.e., integrated GARCH with integration order higher than 1 (see Engle and Bollerslev (1986)).[9] It will be assumed that the usual asymptotic theories for integrated GARCH processes apply to the model.[10] An analysis of residuals does not suggest the presence of information unexploited by the model. The Ljung-Box Q test statistic with 36 lags yields 32.403 with marginal p-value 0.640 (based on a χ^2 distribution with 36 degrees of freedom). This model is used to generate e_t and e_t^*.

7. Bollerslev, Chou, and Kroner (1992; p. 10 and p. 20) argue in favor of low-order GARCH modeling, and especially for GARCH(1,1).

8. For the sample period 50:1-86:1 the coefficient on h_{t-1} is not significant although that of e^2_{t-1} is significant at the 5 percent level. For the sample period 50:1-88:2, both parameter estimates are significant. For all three sample periods, the parameter estimates of GARCH(1,1) indicate persistence in conditional variance of e. In the VAR results presented below a GARCH system is estimated for each sample period corresponding to the sample period over which each VAR is estimated. The VAR results do not substantively change if the model reported in Table 3 were used to generate e_t^* in all the VAR models.

9. When three dummies for structural shifts in the dates used are included in GARCH(1,1), the sum of $\hat{\gamma}_1$ and $\hat{\gamma}_2$ decreases to 1.30, and when an ARCH (4) is used the sum of the γ coefficients is reduced slightly. These alternative models of conditional variance of oil prices do not change the main results of the paper.

10. See Nelson (1990), Bougerol and Picard (1992), and Lumsdaine (1991) for discussion of the asymptotic properties of integrated GARCH models. It has been noted by several researchers that persistence in the conditional variance process could be due to misspecification of the variance equation. Lamoureux and Lastrapes (1990) found a substantial decline in the persistence in stock return variance when intercept dummies are included (see also Diebold (1986)).

The normalized oil price shocks in real oil price e_t^* usually assumes smaller magnitudes after 1974 relative to magnitudes assumed before 1974. In terms of Hamilton's (1983) oil price episode classification, an analysis of oil price change in terms of e_t^* rather than z_t raises the importance of the oil price rises of 1952-53, of those during the Suez crisis, and of those in 1969 and 1979 relative to the oil price shock of 1973-74 and the price rises since early 1986. These observations reinforce the view that oil price shocks have always been important in the macroeconomy and are not solely a phenomena of the 1970s.[11]

THE EMPIRICAL RESULTS

The consequence of introducing surprises in the rate of change in real oil price change normalized by their conditional standard deviation, e_t^*, to various VAR systems is reported in Table 4.[12] It can be seen from the second line of Table 4 that normalized oil price shock is highly significant for all three sample periods while real oil price change is insignificant. The issue of asymmetric effects of normalized positive oil price shocks is explored in the remainder of Table 4. Two variables are defined for normalized shocks in oil price equal to either the positive or the negative values of e_t^* and zero elsewhere. It can be seen from the exclusion tests for the nine and ten variable systems in Table 4 that positive normalized shocks are highly significant in all three sample periods. Negative normalized oil price shocks are not statistically significant in any of the VAR systems. In the presence of positive and negative normalized oil price shocks the variables oil price change and positive and negative oil price changes do not achieve statistical significance. [13]

11. An analysis of oil price change episodes in terms of unexpected oil price change (e_t) would lead to qualitative conclusions similar to that suggested by z_t. The correlation of e_t and z_t over 1949:3-1992:3 is 0.879, whereas the correlations of e_t^* with e_t and z_t are 0.696 and 0.608, respectively. It might be of interest to note that e_t achieves its largest value in 1990:3 (slightly higher than the second highest value achieved in 1974:1).

12. The effect of introducing unexpected oil price change (e_t) rather than e_t^* to the VAR system is reported at the bottom of Table 2. It can be seen that unexpected oil price change is not statistically significant. We also find that the predictive power of expected oil price change on GNP growth resembles that of the actual oil price change and is insignificant. The detailed results are not reported here.

13. The results are robust to alternative models of conditional variance. When the last column of Table 4 is reproduced with e^* obtained from a GARCH(1,1) with three intercept dummies, the following F statistics are obtained. Eight variable system 3: 1.684 (z, real oil price change) and 5.073 (e^*). Nine variable system: 0.852(z), 9.447 (e^{*+}) and 1.342(e^{*-}). Ten variable system: 0.852(z^+), 0.567(z^-), 7.878(e^{*+}), and 1.647(e^{*-}). The results obtained from an ARCH(4) are almost the same as above and are available upon request.

Table 4. Exclusion Tests: Real GNP Growth is Dependent Variable

Variable	50:3 - 86:1	50:3 - 88:2	50:3 - 92:3
Eight Variable System 3			
Real Oil Price Change	1.709	2.186	1.096
	(0.153)	(0.075)	(0.361)
Normalized Oil Price Shock (e^*)	6.769	7.489	5.449
	(0.000)	(0.000)	(0.000)
Nine Variable System			
Real Oil Price Change	1.668	2.100	0.872
	(0.162)	(0.085)	(0.483)
Normalized Positive Oil Price	7.313	10.154	7.660
Shocks (e^{*+})	(0.000)	(0.000)	(0.000)
Normalized Negative Oil Price	1.468	1.123	1.483
Shocks (e^{*-})	(0.217)	(0.349)	(0.211)
Ten Variable System			
Real Oil Price Increases	1.230	1.740	0.432
	(0.303)	(0.146)	(0.785)
Real Oil Price Decreases	1.546	1.962	1.330
	(0.194)	(0.105)	(0.262)
Normalized Positive Oil Price	6.012	7.178	6.193
Shocks (e^{*+})	(0.000)	(0.000)	(0.000)
Normalized Negative Oil Price	1.382	1.261	1.562
Shocks (e^{*-})	(0.245)	(0.289)	(0.188)

Note: Refer to the note of Table 2. Numbers in parentheses denote p-values obtained from asymptotic t values.

Table 5 reports lag coefficients for various normalized oil price shock variables. Results for an eight variable VAR (the six macro variables, z_t, and e_t^*) appear in the upper part of the Table. The coefficients on the normalized shock variable are negative. Results when positive and negative oil price changes replace z_t and positive and negative normalized shocks replace e_t^* appear in the lower part of Table 5. The coefficients on positive normalized shocks are all negative. For all sample periods the hypothesis of pairwise equality of the coefficients on normalized unexpected oil price increases and decreases can be rejected at the one percent level, as can the hypothesis of parameter change as the sample is extended from 1986:1 to later periods.

Table 5. VAR Results for Real GNP Growth Rate, Independent Variable is Normalized Oil Price Shock

	Lag Coefficient				Exclusion Tests	
Time Period	1	2	3	4	F-statistic	p-value
<u>Eight Variable 3</u>						
e^*						
50:3 - 86:1	-1.306	-0.454	-0.565	-2.005	6.769	0.000
	(0.459)	(0.401)	(0.397)	(0.430)		
50:3 - 88:2	-1.087	-0.515	-0.912	-1.909	7.489	0.000
	(0.423)	(0.392)	(0.384)	(0.403)		
50:3 - 92:3	-0.536	-0.003	-0.621	-1.738	5.449	0.000
	(0.381)	(0.380)	(0.370)	(0.377)		
<u>Ten Variable</u>						
50:3 - 86:1						
e^{*+}	-1.747	-0.736	-1.746	-2.106	6.012	0.000
	(0.584)	(0.6[illegible])	(0.594)	(0.629)		
e^{*-}	-1.021	-1.007	0.594	-1.395	1.382	0.245
	(1.148)	(0.992)	(0.944)	(0.928)		
50:3 - 88:3						
e^{*+}	-1.671	-0.639	-1.709	-2.319	7.178	0.000
	(0.556)	(0.558)	(0.548)	(0.598)		
e^{*-}	-0.875	0.250	0.221	-1.475	1.261	0.289
	(0.846)	(0.847)	(0.853)	(0.783)		
50:3 - 92:3						
e^{*+}	-1.219	-0.434	-1.528	-2.049	6.193	0.000
	(0.550)	(0.553)	(0.542)	(0.535)		
e^{*-}	0.538	0.536	0.160	-1.212	1.562	0.188
	(0.630)	(0.692)	(0.682)	(0.590)		

Note: Numbers in parentheses denote standard errors.

The above results are robust for variation in lag length and model specification. For example, if the import inflation variable is omitted, the asymmetry observed by Mork disappears, whereas the normalized shock is still significant. For the whole sample period, in the seven variable VAR system 1 in Table 2, the F-statistic (p-value) of oil price increases becomes 1.574 (0.182) (oil price decreases becomes 0.957 (0.433)) when the import price variable is excluded. Following this exclusion for the seven variable VAR system 3 in Table 4, the F-statistic (p-value) for oil price change becomes 0.988(0.416) and for e^* becomes 4.991(0.001). Similarly, while increases in lag length change some results, normalized shocks remain significant.[14] Table 6 reports results of a VAR model including only GNP growth and oil price changes. Results are similar to those reported above for larger VAR systems. Normalized oil price shocks provide significant information for GNP growth in all periods, and positive normalized shocks are more important than negative normalized shocks in explaining GNP growth.

As an additional check of the robustness of the predictive power of the normalized oil price shock variable we pursued a suggestion by James Hamilton that the relationship between the impulse response of real GNP growth obtained from a nonparametric kernel estimator and e_t^* be examined. We let a nonparametric kernel estimator $\mu_{t+n}(y_t,..y_{t-L})$ of the conditional expectation, $E(y_{t+n} \mid y_t,..y_{t-L})$, of GNP growth, y, be described by

$$\mu_{t+n}(y_t,..y_{t-L})=\sum_{l=L,l\neq t}^{T-n} y_{l+n}\kappa_{lt}$$

where κ_{lt} are the Gaussian kernel weights given by Pagan and Hong (1991):

$$\kappa_{lt}=\exp[-\sum_{k=0}^{L}(y_{l-k}-y_{t-k})^2/(2\psi_k^2)]/\sum_{j=L,j\neq t}^{T-n}\exp[-\sum_{k=0}^{L}(y_{j-k}-y_{t-k})^2/(2\psi_k^2)]$$

and the bandwidths ψ_k are set to be the sample standard deviations of y_{t-k} multiplied by $T^{1/(5+L)}$. The nonlinear impulse response (with L set to be 3) is defined as

$$\xi_{t+n}(y_t,\Delta)=\Delta^{-1}[\mu_{t+n}(y_t+\Delta,..y_{t-L})-\mu_{t+n}(y_t,..y_{t-L})].$$

14. For example, for the period ending 92:3, in the 8 variable VAR system 1 reported in Table 2 (not normalized variables) if lag is 6, F-statistic (p-value) for oil$^+$ is 1.107 (0.362), and oil$^-$ is 1.190 (0.316); if lag is 8, then oil$^+$ is 1.242 (0.282), and oil$^-$ is 1.021(0.425). In the 8 variable VAR system 3 reported in Table 4, if lag is 6, then the p-value for e^* is 2.601 (0.021), and if lag is 8 then it is 2.018 (0.052). In the 10 variable VAR in Table 4 with lag 6 e^{*+} is 3.112 (0.007) and e^{*-} is 0.993 (0.433), and with lag 8 e^{*+} is 2.305 (0.051) and e^{*-} is 0.696 (0.695).

Table 6. Exclusion Tests in Systems that Consist of GNP Growth and Oil Prices Only: Real GNP Growth is Dependent Variable

Variable	50:3 - 86:1	50:3 - 88:2	50:3 - 92:3
Three Variable System (growth, Real Oil, e^{*})			
Real Oil Price Change	1.649	1.908	0.791
	(0.166)	(0.113)	(0.532)
Normalized Oil Price Shock (e^{*})	6.509	7.661	4.448
	(0.000)	(0.000)	(0.002)
Four Variable System (growth, Real Oil, e^{*+}, e^{*-})			
Real Oil Price Change	1.869	2.068	0.872
	(0.120)	(0.089)	(0.483)
Normalized Positive Oil Price	5.517	8.351	7.660
Shocks (e^{*+})	(0.000)	(0.000)	(0.000)
Normalized Negative Oil Price	2.335	1.426	1.483
Shocks (e^{*-})	(0.059)	(0.228)	(0.211)
Five Variable System (growth, Real Oil+, Real Oil-, e^{*+}, e^{*-})			
Real Oil Price Increases	1.212	2.025	0.564
	(0.309)	(0.094)	(0.689)
Real Oil Price Decreases	2.860	1.895	0.909
	(0.026)	(0.115)	(0.460)
Normalized Positive Oil Price	3.958	5.691	4.317
Shocks (e^{*+})	(0.005)	(0.000)	(0.002)
Normalized Negative Oil Price	3.144	2.252	1.980
Shocks (e^{*-})	(0.017)	(0.067)	(0.100)

Note: Refer to the note of Table 2. Numbers in parentheses denote p-values obtained from asymptotic t values.

When regression equations were run with different forecasting horizons, n, with ξ_{t+n} as dependent variable and e^{*+} and e^{*-} as independent variables it was found that e^{*+} is significant for every n whereas e^{*-} is only marginally significant. (Other functions of oil price change were less significant if used in the same regression.) This is consistent with the strong statistical significance of positive normalized oil price shocks in predicting growth and the presence of asymmetry between positive and negative oil price shocks found in the VAR analysis. The nonparametric estimator of y uses no other information than the data in the real GNP series yet leads to results supportive of the VAR findings. It should be emphasized however, that experiments with alternative kernels suggested by a referee yielded statistically insignificant results. The details of the nonparametric models and results are available from the authors upon request.

Results consistent with those obtained above emerge when a variance decomposition metric is used as an alternative to F-statistics (see, for instance, Bernanke and Blinder (1992) for the pros and cons of the two metrics). The fractions of the variance of the forecasted GNP growth accounted for by nine elements (excluding the lags of growth itself) in the ten-variable VAR (in Table 4) at one-year horizon become 0.146 for the T-bill, 0.087 for oil price increases, and 0.253 for e^{*+}. The fraction attributable to e^{*+} is the largest among the nine variables despite the fact that e^{*+} and e^{*-} are placed last in the ordering of variables.[15]

IMPULSE RESPONSES OF OUTPUT AND UNEMPLOYMENT

The impact of e_t^* on GNP growth and unemployment over multiple horizons is investigated using orthogonalized impulse responses. The impulse responses are obtained form a moving average representation of a seven-variable VAR with variables placed in the following order: GNP growth, GNP deflator inflation, unemployment, the 3-month Treasury bill rate, real wage growth, import price inflation, and e_t^{*+}. The ordering of the VAR implicitly assumes that e^{*+} does not affect current GNP growth. The middle line in Figure 1 illustrates the response in GNP growth to a one-standard-error shock in e_t^{*+}. Five negative responses are followed by five positive responses, with the effect of the oil shock greatly diminished after ten quarters.[16]

In order to assess the significance of the impulse response, standard errors are also calculated from the variances of the posterior distribution of the orthogonalized impulse responses. One hundred random draws are made directly from the posterior distribution of the VAR coefficient. The solid lines above and below the line connecting the squares in Figure 1 represent plus and minus 2 standard errors obtained from the simulation. It turns out that only the impulse responses at horizons 3, 4, and 8 quarters are statistically significant. The sum of responses over 24 horizons is -0.65 which is (in absolute value) larger than one-half the largest negative impulse response obtained at the 4-quarter horizon. The negative sum suggests that there is a decline in the level of GNP over 24 horizons following an oil shock.

15. At a two-year horizon, the T-bill becomes slightly more important than e^{*+} in terms of variance decomposition (e.g., 26.11% for the T-bill and 24.86% for e^{*+}). At horizons of 3, 4, 5, and 6 years, however, the variance accounted for by e^{*+} attains values close to 27% while that of the T-bill is about 23.6%.

16. This finding is consistent with that of Burbidge and Harrison (1984) in that the oil shock variable does not help improve forecasting macroeconomic variables beyond a 3-year horizon.

Figure 1. Impulse Response of GNP Growth

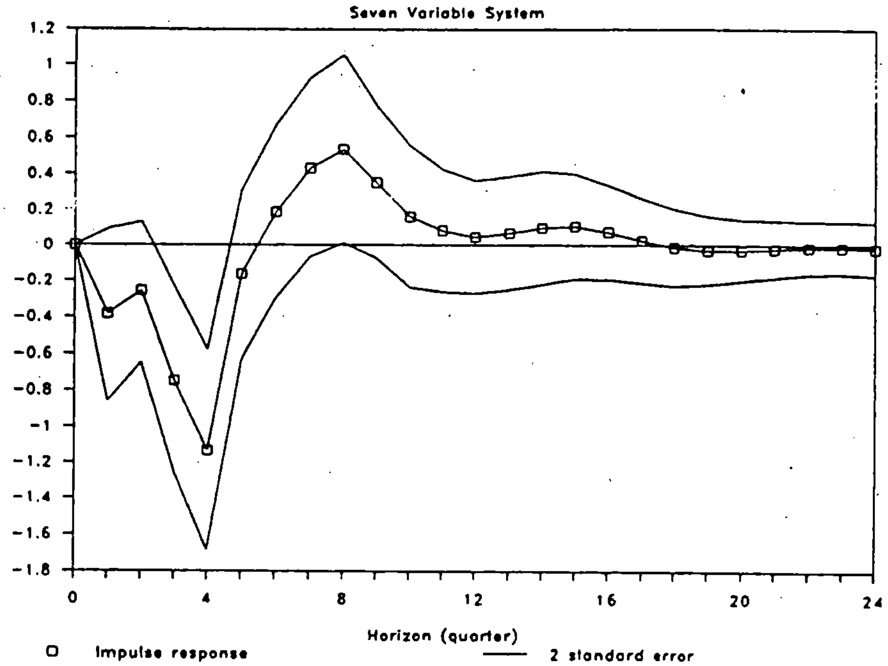
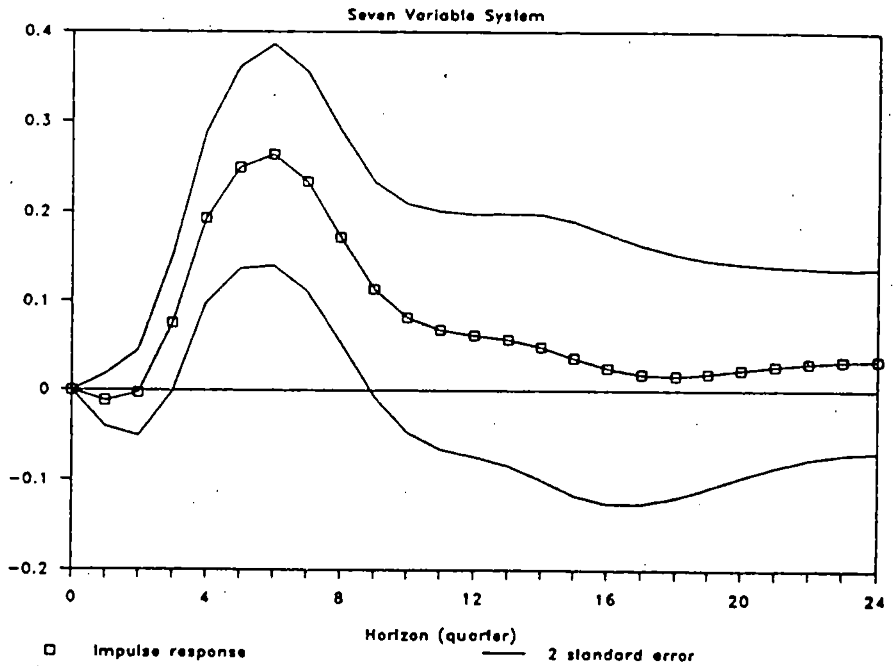


Figure 2. Impulse Response of Unemployment



The results for the unemployment rate are somewhat stronger. Except for the first two small negative responses, Figure 2 shows persistent positive responses of unemployment to a shock in e_t^{*+}. The sum of 24 responses is 1.86 and five responses are statistically significant, i.e., those at the 4 through 8 quarter horizons. This indicates a cumulative loss in employment that is not offset at later dates by subsequent increase in the GNP growth rate during the second and third years following an oil price shock. While the impulse of GNP growth reaches a positive peak at the 8-quarter horizon, the response of unemployment at the 8-quarter horizon is significantly different from zero. This might indicate that the recovery in output after an oil shock is mainly accounted for by an increase in productivity. This explanation may be consistent with the finding of Blanchard (1989) that the variance of productivity innovation is three times larger than the variance of labor force participation innovation.

CONCLUSION

This paper has presented results on the causal relationship of normalized oil price shocks to real GNP growth. Results suggest that a real oil price surprise has a greater impact on real GNP (and unemployment) the more stable has been the real price of oil prior to the innovation. An asymmetry in effects was found to exist in that only positive normalized oil price shocks were statistically significant. This specification was stable over time, fitting observations before and after 1985, and results were similar whether or not other variables (including other functions of real oil price change) were included.

The results obtained in the paper are potentially explicable in the context of models containing multiple sectors and resource reallocation costs, or models capturing recent developments in the theory of investment as surveyed by Dixit (1992). A rise in real oil price that is large relative to recent volatility will result in reallocation of resources and the lowering of aggregate output (at least during the transition). During periods of high volatility in real oil price, since current oil price contains little information about future oil price, rational agents will be reluctant to reallocate resources in the presence of real costs of doing so.[17]

The asymmetric effect of change in real oil price follows from a sectoral shifts story since a fall in real oil price also results in sectoral resource reallocation with unemployment and output effects that mitigate positive macroeconomic effects. The asymmetry would be further reinforced given an "uncertainty" effect based on the new investment theory. In this framework the increased degree of uncertainty associated with higher volatility in real oil prices would result in investment being postponed. Hence, the positive macro effect of an oil price decline would also be somewhat offset by depressing effects of increased uncertainty.

It would also probably be appropriate to expand the search for explanations of the way in which oil affects economic activity to models containing rigidities. One of the strong results in the work conducted in this paper is the effect of e_t^* on the level of unemployment. These results are as robust as those for output growth but qualitatively opposite. For example, in the unemployment equation in a ten variable VAR an exclusion test for positive normalized oil price shocks has a p-value of 0.000 for 1950:3-1992:3, a p-value of 0.007 for 1950:3-1988:2, and a p-value of 0.011 for 1950:3-1986:1.[18] It is likely that a model in which real wage rigidity plays a significant role in the adjustment of the economy to changes in the real price of oil (and of other inputs) might be able to provide a satisfactory explanation of the results reported here.[19] Development of a formal model that explains the results presented here

17. In equilibrium business cycle models fluctuation in the real price of oil has been treated as exogenous and subject to positive serial correlation. The result has been negative and lagged effects of real oil price on output growth. See Finn (1992) and Kim and Loungani (1992) for real business cycle models incorporating oil and Davis (1987), Hamilton (1988a), and Loungani and Rogerson (1989) for work on business cycle models with real costs for reallocating resources. The results in this paper suggest that analysis of the impact of oil shocks in real business cycle theory might gain from allowing for the time varying nature of the second moments of parameters driving the model. In a paper with a somewhat different focus Loungani (1986) found that for the period 1947-82 oil price change was the major factor in explaining the dispersion of employment growth across industries and that it was associated with unemployment.

18. The lag coefficients on the positive normalized shock variable for the period 1950:3-1992:3 in the unemployment equation in the 10 variable VAR are 0.0116(0.0444), 0.0025(0.0446), 0.1476(0.0438), and 0.1682(0.0432). Standard errors are in parenthesis. These results are consistent with arguments advanced by Mork and Hall (1980) concerning the effects of unexpected events in the presence of rigid wages. It is also worth noting that the unemployment variable in the GNP growth equation is statistically significant at the one percent level in all samples.

19. The application of models containing rigidities is also in part suggested by the results of Kim and Loungani (1992). Within a conventional RBC model they found only a relatively small contribution of oil price shocks to an explanation for variability in output. The content of this section of the paper owes a great deal to suggestions made by Knut Mork, particularly on the need to examine models containing rigidities.

and further investigation of the effect of oil price shocks in other economies remains on the agenda for future work.

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The 1990 Oil Shock is Like the Others[1]

*M. A. Adelman**

First I will set out what happened to prices in 1990, then review the long term prospects in the light of the change.

Challenge and response

Since 1912, and the first shipments out of the Persian Gulf, the world price of oil has been far above the finding/developing cost of creating new reserves. The result is a huge excess of potential production, which the owners must somehow dam up to maintain the price.

Since the OPEC nations took over 20 years ago, the process has been much more turbulent. First, their chief instrument for price-raising has been to provoke a crisis, or take advantage of one. Second, there has usually been not only potential excess supply but actual excess producing capacity. This makes the high price even more insecure.

THE RATCHET MODEL OF AN OIL 'CRISIS'

Stage 1: cut output to drive up the spot price

An output cut, or even the threat of one, frightens the market into panic buying and holding, for hoarding not use. Lack of fuel can shut down a refiner or user. Oil is a bargain if it is even a little cheaper than shutdown loss. Our old friend consumer surplus turns from Dr. Jekyll to Mr. Hyde.

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1. This essay summarizes a number of papers, published or in preparation, which comprise a project on the world oil market since 1970. The research has been supported by the National Science Foundation, grant #SES-8412971, and by the MIT Center for Energy Policy Research. But any opinions, findings, conclusions or recommendations expressed herein are those of the author, and do not necessarily reflect the views of the NSF or of any other person or group.

Expectation of a higher price is a self-fulfilling prophecy. Buyers demand more and sellers offer less. Both are trying to hoard in anticipation of the price rise. But once past the short run the price relapses to the level which equates production and demand for consumption not hoarding. Therefore the need for Stage 2.

Stage 2: raise official (contract) prices to follow spot

Each cartel nation raises its contract price (or, in 1973-74, its excise tax). They are merely "following the Market". In fact the market merely follows their production cuts and threats.

Stage 3: hold the higher price line despite deficient demand

On January 1, 1974, the take of the Persian Gulf governments was $7 per barrel. Markets turned weak in January, and by midyear there was massive excess current producing capacity, a new phenomenon in world oil. But because they restrained output, the OPEC nations could keep raising the excise tax, reaching $10.50 by end-1974.

In 1979-1981, there was a pose of being swept along by irresistible market forces. But at all times there was a large amount of deliberately withheld capacity. Despite assurances to the United States, the Saudis cut output in January 1979, and again in April. Prices exploded, then came down only slightly, because the OPEC nations avoided price rivalry and higher output.

The 1990 price explosion followed the ratchet script[2]

The year 1990 had been a normal cartel year. Prices were weak, the OPEC nations had failed in several attempts to reduce output and were quarrelling over who would cut back most. As late as end-June, the OPEC average or "basket" crude oil, target value $18, was plainly overpriced at $13 because offerings exceeded demand and inventories were bursting out of storage.[3] This had ruined the prospect for the normal autumn demand pick-up. "OPEC excesses pre-empt autumn stock build." [*PIW*:PMI 7-5-90:1] Exporters were "playing games" to hide discounts. [*PIW* 7-9-90:6] As late as July 16, "Markets teetering on edge of disaster again." [*PIW* 7-16-90:5]

First phase: output restriction in late July

At this point, Iraqi threats against overproducers became strident. Prices improved, especially when Saudi Arabia indicated its support of higher

2. The prices mentioned in the next paragraph are from *Petroleum Intelligence Weekly* (PIW).
3. This is shown not only by the data on inventories, but, as Philip K. Verleger Jr. has demonstrated, by the relation of spot to futures prices.

prices [*New York Times (NYT)* 6-28-90]; a year earlier it had isolated Kuwait by signing a non-aggression pact with Iraq. But the market's main concern was still "weathering another price slump". [*Oil and Gas Journal (OGJ)* 7-9-90] In early July "several heads of state suddenly are stepping in". [*Wall Street Journal (WSJ)* 7-10-90] When Saudi Arabia announced an output reduction, having succeeded in persuading others to do likewise, prices "surged". [WSJ, NYT 7-13-90] The basket went to $14.41. When Iraq issued a threatening blast against overproducers on July 17, the price rose to $16.09.

The next week, news of Iraqi deployment came at just the right moment to support the OPEC agreement on output reduction, and put the "basket" up to $17.27. The target was now increased from $18 to $21. In and out of OPEC, Iraq was hailed as the Enforcer. Still, markets were sceptical: "OPEC, facing bloated inventories, faces long wait for higher prices" [WSJ 7-30-90]

The Iraqi invasion and blockade

But then the Enforcer, like many Enforcers before him, decided to use his force to get a bigger piece of the action. On August 2 Iraq seized Kuwait and the basket price was up to $19.37. Even then, it was "a soft market...[The] OPEC accord...with demand soft and the world awash in oil stocks seemed more likely to collapse rather than support a $3 hike..." [OGJ 8-6-90]

On August 5 Europe and Japan joined the blockade of Iraq-Kuwait, and by August 31 (as this paper is completed) the "basket" is above $25. Arab Light, a better measure of market trends, went from $12.50 to nearly $30.

The contrived shortage

The blockade of Iraq and Kuwait exports does not suffice to explain the final price jump. It required also the deliberate inaction of the other OPEC producers.

Iraq and Kuwait had exported 4 million barrels a day (mbd), but about 0.5 had been going into inventory during the second quarter.[4] The net difference was about 3.5 mbd.

Under competitive conditions it would all have been promptly replaced. Excess capacity among the largest five producers (Iran, Iraq, Kuwait, Saudi Arabia, UAE) was reckoned in July by a Saudi Aramco Exploration & Production vice-president at 6 million [OGJ 7-23-90]. At least 4 mbd must have been available outside Iraq/Kuwait, and mostly in Saudi Arabia. Venezuela had another half-million, and other members had about

4. According to EIA, *International Petroleum Statistics Report*, July 1990, the increase in private OECD stocks was 0.3 mbd in the quarter. In the rest of the market economies consumption is about half of OECD. Hence total private stocks rose by nearly half a million bd.

400,000. [NYT 8-29-90:D6] There was also a small amount of non-OPEC excess capacity.

For perhaps a month, as they increased output, production would have been less than consumption, but inventories were very high and could easily take the strain. Under competition there would have been, at most, a small price bump, quickly reversed. But the OPEC nations refused to increase output. The Saudis talked of no more than 2 mbd additional output -- some day. They all carefully dithered, seeking OPEC unanimity which they did not need.

A week after the invasion, the International Energy Agency estimated the September shortfall at between 0.6 and 2.5 mbd. But on August 20, they revised their estimate to between 1.4 and 3.2 mbd. The reason: "little evidence that any additional oil has actually been pumped to replace the lost output of Iraq and Kuwait." [NYT 8-21-90]. As in 1974 and in 1979, the chief concern of the OPEC nations was to nail down the higher prices. They would rather err on the side of producing too little rather than too much. As they waited and demurred and excused, buyers' fear drove up the price. The ratchet model worked again.

On August 27, one report [WSJ 8-28-90:A3] was that a majority of the OPEC nations would permit only an additional 3 mbd, with 1 mbd deficit left for cleaning out the inventories which made it so much harder to maintain the cartel price. Another report [NYT 8-28-90:D6] mentioned 3.6 mbd. They had still to decide how high they wanted to drive the price.

The OPEC nations have inflicted heavy damage on the world economy, but they had no hostile intent. Business is business. Like good commanders in war, they seized an opportunity. This conduct accords well enough with a model of the cartel, explored below.

The helpful role of the USA and other consuming nations

Ten years ago, in an IAEE Presidential address, I explained what the role of the Strategic Petroleum Reserve should be:

> "The government should be the oil seller of last resort, just as a central bank is a lender of last resort. We ought to adopt Victorian financial wisdom for handling panics: lend freely and without limit, but charge all the traffic will bear ... [The object is] prevention, not cure....With no demand for hoarding, we would have quiet spot markets and a repeat of the 1980 non-crisis." [*The Energy Journal*, vol. 3, no. 2, 1982, pp. 1-13]

Other economists have made similar suggestions. But the Bush Administration has simply sat on the Strategic Petroleum Reserve, reserving it for a "real physical shortage". This is nonsense. Shortage can happen to an individual. It is the basis for panic. But for the whole market a "shortage" is impossible. Price rises to equate the amount offered with the amount demanded. The economic damage is done by the runaway price increase, which timely use of the SPR prevents.

But use of the SPR to prevent a price rise is considered as interfering with free markets. If so, the Federal Reserve System should be prohibited from increasing *or* decreasing the money supply, since that affects the price of credit (the interest rate) directly and all other prices indirectly. Higher *or* lower taxes, deregulation *or* re-regulation, antitrust enforcement *or* neglect, all affect supply or demand, hence prices, and should all be condemned. A foolish premise leads to nonsense results. Perhaps the Administration cannot reveal their true reason, and must offer these jewels of economic illiteracy.

Had the SPR been used early on, there might have been a mild and reversible price increase, but no explosion. The cartel nations felt free to go ahead and engineer one, because they rightly expected no counter-measure.

THE CARTEL OF SOVEREIGN STATES

Every cartel needs to: (1) to fix the best price-quantity combination, to maximize wealth, and (2) to divide up the market. There is no permanent solution to either problem. A temporary agreement lasts a while, breaks down, is patched up, then replaced by a new one. It is endless collusion and conflict, trial and error. But a cartel of sovereigns is a better approximation than any private group to the abstract model of a wealth-maximizing cartel.

A cartel unleashed

No private companies residing in a modern industrial state would dare to raise the price of oil by a factor of 15 (inflation adjusted), as the cartel did in 1970-1981. They would harm interest groups far more numerous and politically powerful than themselves, who would make short work of them.

But in a small exporting less-developed country (LDC), the benefits of a higher price all go to the local economy; the burden is all borne by foreigners. Hence the sovereign-owners are free to seek all the traffic will bear. They are also free to make mistakes, to raise the price so high that it actually lowers revenues. There is an outstanding example.

Monopoly target

The target price set by the Long Term Price Policy Committee of OPEC in 1978-1980 was the cost of synthetic liquid fuels. That is a clear example of monopoly profit maximizing. But only when oil no longer competes with oil can its price approach the cost of a new substitute technology. The interwar private cartel never dared even dream of such a goal.

The OPEC nations found out the hard way that the true ceiling happened to be lower than the cost of synthetics. It was set by consumer resistance: substitution away from oil and other energy sources. Nobody could have known this in advance. But all could agree that consumer response was very uncertain as to size and timing. A wise policy was to go step by step, raising the price in small amounts to test the waters each time.

Now OPEC's Committee had recommended just that. Why could not the OPEC nations follow their own sound doctrine?

Short Time Horizons and High Discount Rates

(a) No diversification

The producing governments cannot wait because their economies are so dependent on oil. "Non-oil" sectors exist mostly to serve the oil sector and those who draw oil income. This was true even in Kuwait, where earnings from foreign assets became substantial. Elsewhere, there is little additional income from the hundreds of billions spent on weapons; infrastructure; subsidized industries; or subsidized agriculture depleting fossil water deposits at ever rising cost, to export wheat costing eight times the world price.

Undiversified owners of oil deposits cannot easily cope with fluctuating incomes. But that is only half the story.

(b) Uncertainties and dangers

First, OPEC is the swing producer group, restricting oil production to maintain the price. Hence fluctuations in OPEC sales amplify fluctuations in total worldwide oil sales.

Second, these governments are mostly despotic, and opposition works only by violence and conspiracy. They are also unruly to each other. At the Gulf, Persians and Arabs and Kurds; Sunni versus Shia; religious against secular; and so on. Moreover, the flood of petrodollars has allowed large arms purchases. The occupation of Kuwait may prove to be a splendid return on Saddam Hussein's investment, but it is too early to tell.

Domestic and foreign instability may be additive. The revolution made Iran look like easy pickings for Iraq in 1980. In 1989, Saudi Arabia signed a non-aggression pact with Iraq. Kuwait began to overproduce for fear of invasion; how right they were.

Not as Arabs or Muslims or some other irrelevancy, but as rational economic actors, the OPEC countries must take the money and run. Fifty-five years ago, producers made an emphatic case to an oilman, which he summarized for his company: "The future leaves them cold. They want money now." Their current-account balances showed it in the 1950s and 1960s, but above all after 1973.

A flood of imports washed away the huge 1974 OPEC current-account surplus in four years. The larger 1980 surplus became a deficit in

1982. Saudi Arabia acquired about $140 billions of foreign assets when the wealth poured in too fast to be spent. Since 1981, about two thirds of it has slipped away. In 1988 they began borrowing. Let the reader imagine: your whole income is from a single company. You cannot diversify by selling off any shares. You overspend your income and are heavily committed to friends to reward and enemies to buy off. You live in a neighbourhood where you must always fear attack. Of course you will grab for more income now, even if it may cost you much more later.

In theory the cartel should raise prices faster and farther than an unrestrained private monopoly -- as they have done.

LOSS OF THE COMPANY BUFFER

Before expropriation, the companies, without collusion, had determined the level of output: whatever was demanded at the current price. They divided the market as they had done for decades: by inertia, a well-honed instinct for not upsetting each other, non-price rivalry in consumer markets, plus the smallest possible price response to the competitive fringe. With good profit margins, they could absorb crude price differentials getting out of line with product prices. True, they tended to overlift the more profitable crudes and underlift the less profitable. But these conflicts were muted by their desire not to lose their valuable concessions.

It was a sloppy system, which did not optimize anybody's anything, and probably could not be reduced to formal rules, let alone numbers. But it worked, and provided a buffer between any two governments.[5]

Without the companies, price differentials became an immediate menace because companies as buyers would quickly shift their purchases. The governments' market shares were now more unstable, and they needed to confer and wrangle openly about them.

Governments needed now to invest their own funds. The amounts were, and are, quite small relative to revenues, but the revenues were quickly overcommitted, and capital spending became the accidental result of which domestic pressure groups had the most clout.

THE VACILLATING CARTEL MODEL

When a price is fixed above the competitive level the largest firms tend to lose market share. Small firms shade prices and expand output, nibbling at the bigger ones, who are in a dilemma. If they retaliate, they risk

5. In the long run it was untenable because it allowed competition to seep in, enough to lower the price (inflation-adjusted) by over 80 percent in 25 years.

a general price collapse. If they are permissive, they keep losing market share.

Thus a cartel swings between two models. (a) The largest firm(s) bear the burden of restriction, making up the difference between total demanded and production of the smaller firms. Or (b) all firms together set total output, then divide it. Variant (a) is easier to manage, (b) is more rewarding. Both are unstable: in (a), the dominant firm will push toward (b), to make others share the burden; in (b), cheating may force the dominant firm willy-nilly into (a).

In 1975-1982, the Saudis maintained model (b). They deliberately lagged in raising prices. By discounting, they kept their market share high, at the expense of their rivals. But as others began to undercut them, the Saudis yielded ground, lapsing into model (a). But since mid-1985, the financial straits mentioned earlier have made them refuse to be the patsy "swing producer" and bear everyone's burden.

Large versus small OPEC producers

We still hear about the "high absorbers", with large populations and small reserves, who want high prices now; versus the "low absorbers", with large reserves and small populations, who look far into the next century, and want lower prices. This is fiction. As already seen, nearly all absorb more than they earn -- hence the chronic deficits.

We hear that the Saudis do something, or refrain from doing something, *because* their reserves will last into the next century, etc. This begs the question. We should ask: *why* do they extract so little of their underground asset, operating only 15 out of 52 "commercial" fields?

Moreover, the large-reserve producers have lower costs. To have high-cost producers expand at the expense of low-cost is upside-down economics under competition, but it is orthodox cartel economics. As we pointed out, large firms tend to lose market share because they are ultimately responsible for limiting production to maintain the price; the Saudis and others restrict output despite overabundant reserves.

THE 1990 CONSENSUS REVISED

The 1990 consensus was that in the long run, the non-OPEC and the small OPEC producers would empty out their reserves, while the big ones worked off their excess capacity. By the mid-1990s the surplus would be gone, and prices would resume their long-deferred but inevitable rise. I think the consensus was mistaken even with \$15 oil, *a fortiori* with \$25 to \$30.

Oil Reserves and Production

Oil reserves are not a one-time stock to be used up, but an inventory, always being consumed and replenished by investment, in new and especially in old fields.

Paradigm USA

The USA (excluding Alaska) is the extreme example of the very old oil province. In 1930, "remaining recoverable reserves" were 13 billion barrels. In the next 59 years, the "lower 48" produced not 13 but 123 billion, and had 20 billion left. Equally important, there was no increase in real cost before 1973; and much of the increase since then was due to the inefficiency and waste of a frantic investment boom.

No great new discoveries replenished USA inventory after 1930. Discoveries declined, but many small fields were found, and the old ones continued to expand, some amazingly so. Oil in the USA is probably on the downgrade because of rising cost; natural gas seems on the upgrade.

The non-OPEC world outside USA

The rest of the non-OPEC world is not as drilled up as was the USA in 1930. They can expect larger expansion of old oil fields, and larger discoveries. Production has continued to rise throughout nine years of declining prices. Even since the crash of 1986, non-OPEC reserves have kept rising, and more reserves today mean more production tomorrow. Multinational companies based in the USA are now spending more overseas than at home, and have larger reserves there, nearly all non-OPEC.

Lower prices helped investment

Before 1981, rising oil prices were extrapolated and governments demanded the earth of oil companies seeking development rights. Bad economics was reinforced by xenophobia and sentiment: "the oil is ours", a family heirloom, not a vulgar asset.

The price decline after 1981 was like a bucket of cold water. Everywhere terms have been improved. *Petroleum Intelligence Weekly* said recently [PIW 7-16-90:E1]: "Companies find themselves in a position not experienced for almost 20 years: spoiled for choice". Countries accounting for over half of world production have welcomed them back for exploration and development. Some, though not all, will offer enough inducement to invest. The world is painfully re-learning respect for contracts. Progress will continue, as the slower learners watch the quicker ones.

Real ("technical") cost is not the important barrier. At "low" mid-1990 prices, much oil is cheap to develop, *ex-tax*. Slowly the taxes have been adjusting. In some countries, the higher oil prices of mid-1990 will have some damping effect, as a license to continue the old wasteful ways. But on the whole, higher prices will speed up the rate at which non-cartel output will rise.

Natural gas

Natural gas is a sleeping giant beginning to stir. In the USA, 1988 reserves-added were the second highest ever, exceeded only in 1956.[6] Production today is clearly demand-, not supply-, limited.

Canada once required 25 years of reserves before permitting exports. With no export market, there was less investment and reserve-additions. This "proved" Canada was running out of gas, which strengthened the refusal to export. In 1980, the government barred exports at $5 per thousand cubic feet (mcf). But Canada discarded the fetish, and gas exports are climbing, at not much over a $2 border price. Gas reserves are growing. In Norway, $7 was once demanded for "high-cost Troll gas". It will be profitably sold at less than half that price.

In Europe and the Pacific rim, the gas era is just beginning. Border prices in Europe fell by 55 percent from 1985 to 1989 (money of the day), and give no sign of revival. Gas will no longer be a "boutique fuel", but a bulk fuel.

Most of the increased demand for hydrocarbons would have bypassed OPEC even with $15 oil. The 1990 price jump makes it certain. Consumption will grow less than had been expected, and non-OPEC production will grow more. The cartel's environment will be much less friendly. A return by Kuwait and Iraq to the world market will generate much more pressure. The higher revenues will make it easier to resist the pressure for lower prices, but only as long as the current account surplus will last.

THE BOGEY OF INSUFFICIENT CAPACITY

There was little or no excess capacity when the world oil industry was much more competitive than it is today. Of course the 8 per cent annual growth rate would quickly have dissolved any surplus which might accidentally appear.

Since 1973 there has been much OPEC excess capacity. Yet in the consumer countries there is an obsessive fear of insufficient capacity. In the 1970s, the United States State Department, the Central Intelligence Agency (CIA), the Department of Energy (DOE), and others, kept warning us of gaps ahead, 20 million barrels daily, 8 million, whatever.

6. This fact was masked by the removal of 25 trillion cubic feet in Northern Alaska–which should never have been counted as reserves in the first place.

The $60-billion hoax

Of late we have been repeatedly warned that the world must have another 6 million OPEC barrels daily, installed in the next five years. To provide this, OPEC is said to need $60 billion, or $10,000 per daily barrel, and where will they ever find the money? This rising chorus should make us stop and think.

First, at a $15 price, the annual return is about half of the asserted investment.[7] A 50 percent rate of return seems sufficient inducement to invest.

Second, $10,000 per daily barrel is "in the ball park" -- for the USA and the UK North Sea. (A recent Soviet estimate is $11,000.) For Venezuela, not the lowest cost OPEC producer, it is 5-6 times too high. Saudi Arabia has announced plans for increasing capacity by 7 million barrels daily, spending $13 billion. This overstates, because it includes an inflation factor and covers much gas gathering, infrastructure, and a pipeline. Even so, it is only one-fifth of the fabled $10,000.

That number deserves to be laughed right out of court. Its constant repetition shows how badly off-track is discussion of world supply.

Permanent excess capacity

Despite current excess capacity, which is the only reason why prices were coming down until July, all OPEC nations are expanding capacity. Of course, projects carried out will be considerably less than announced, but capacity will exceed anything they can sell.

Why do the OPEC nations overbuild? It is hard to raise even small amounts of money because it is dangerous to reduce the incomes of their constituents or to let foreign capital enter for some production ventures. But they have no choice.

With no excess capacity, a cartel member gets no respect. Bargaining power depends upon its ability to create a nuisance or danger, by overproducing to put prices in danger, if it is not treated "right". Therefore every member must provide some surplus capacity, if only to make a credible threat of overproduction. Each member must protect itself by doing what is bad for the group. The excess will never disappear so long as the cartel remains. Hence even high demand for OPEC oil will not stabilize the price.

"Reintegration" = "Netbacking"

"Netback pricing" is the sale of crude oil at a price determined by the market price of products. Thereby the producer can sell some or conceivably

7. Assuming the OPEC blended price at $15, and operating expenses at $1, annual receipts per barrel of capacity operated are $5110. Elsewhere, expenses are much higher, and the investor must reckon with taxes. Hence the rate of return is much lower.

all of his quota without price competition at the crude oil level. It automatically matches any rival's lower crude prices, which are speedily translated into lower product prices.

Netbacking subverted cartel discipline in 1986. The Saudis used it only as a last resort, to whip their partners back into line. But downstream integration, such as ownership of refining-marketing facilities, is permanent structural netback pricing. As the integrated governments use it to hold market share, the non-integrated will retaliate by reducing spot and term prices.

THE CARTEL REMAINS

Just as we heard in 1979 that OPEC had been swept away by market forces, so now do we hear that it is fatally injured by dissension. With such "defeats", what need of victories?

The rewards of monopolizing the world oil industry have been so huge that the OPEC nations will make strenuous violent efforts to maintain it. The Iran-Iraq war was a great help in a difficult decade. So is the Iraqi aggression, which has shut down two major producers. If the cartel collapses, it will reappear, perhaps with a partly different membership. Whenever they settle their differences they can cut production, and raise the price.

The clumsy cartel

The volatility since 1970 shows how difficult it is to hold the price line and rein in production. One cannot fine tune with coarse instruments and incomplete knowledge. Consumption is unknown for months. Inventories in the hands of companies are imperfectly known, and downstream stocks are a statistical black hole. Members do not always release accurate production numbers even to each other. The cartel has been flying blind, with several hands grabbing at the controls. Moreover, short time horizons and high implicit discount rates make them overreact.

I said in 1971 that "the genie is out of the bottle". He still is. The OPEC nations learned some caution after 1980, but these lessons wear off. In July, Iraq was the "extremist" in wanting a $25 price. As of end-August, the "moderates" have succeeded in ratcheting it higher than that. We will see whether they are more cautious.

Models based on demand and "supply" are not relevant. A monopoly has no supply curve but a perverse reaction: the higher the price, the less investment. From 1973 to 1988, as prices rose by hundreds of percent, Saudi oil wells drilled fell by 96 percent.

Challenge and response

Challenge and response holds in the short run as in the long. The challenge of excess supply *raised* prices, by concentrating the minds of the cartel members. When its new enforcer became greedy and took himself and a principal competitor out of the market, the rest saw their opportunity and took it.

At the end of August the question is: how long does it take before Kuwait and Iraq are back in the market? The ideal condition for the survivors would be a permanent stalemate, with two major competitors suppressed. But if they both return soon, we are back to early July or even June, when the market was weak even with Arab Light at $12.50. Demand will be less, and supply greater. Excess supply will be more burdensome than ever, and then the challenge may be too great. But I think it more likely that the cycle will continue: meetings -- quotas -- firm prices -- cheating -- price declines -- threats and promises -- meetings ... with here and there some more drastic political-military moves.