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Are Energy Prices Cyclical?

MACK OTT and JOHN A. TATOM

From 1981 to 1984, oil and energy prices generally fell relative to prices of other goods and services. Many analysts have associated these decreases with the 1980 and 1981-82 U.S. and world recessions.[1/] Such a view arises from an incomplete application of the theory of the firm. A more inclusive theoretical framework would allow for the planning behavior of a foresighted firm and market structure characteristics. Within this framework as the relevant microeconomic theory, the cyclical view is subject to strong doubts. Moreover, macroeconomic considerations suggest that the link between oil or energy prices and business cycle developments is just the reverse of competitive microeconomic considerations. That is, energy price developments influence future cyclical movements of the economy rather than reflecting past cyclical movements in the economy.[2/]

The cyclical view of recent energy price developments obscures not only the cause of recent energy price declines but also their impact on the economy. More important, the implications of the cyclical view for the prospects for future price changes and related macroeconomic developments are misleading, at best. There is little reason, in theory, to expect oil and energy prices to be cyclical, and there is no evidence to support such a view, either pre-OPEC or since 1973. Recent oil and energy price developments have been largely associated with U.S. energy policy changes and developments in the Iran-Iraq war. The price declines, attending deregulation of the U.S. crude oil market and, since 1981, partial restoration of pre-1979 production levels in Iran and Iraq, have had beneficial effects on the U.S. economy. Both the decline in oil and energy prices to date and their long-term macroeconomic effects are permanent; that is, they have not been, nor will they likely be, reversed by the cyclical recovery in the U.S. or the world economy.

In this paper we examine the question of whether energy prices are cyclical. We begin with an examination of why the price of any good would be cyclical. The simple model of optimization over the business cycle postulated in this discussion illuminates the intuitive presumption that a decline in demand for a product, induced, say, by a cyclical downturn in the economy, will lead to a price reduction. This presumption arises from the presence of adjustment and storage costs in competitive markets. In contrast, in markets where prices are set by dominant producers or monopolists or where adjustment and storage costs are unimportant, cyclical prices do not occur. Indeed, it is theoretically possible in such markets for product prices to move countercyclically. These implications for energy prices are tested on U.S. data covering most of the Post-WWII era. With few explainable and largely insignificant exceptions, we find that energy prices are not responsive to the U.S. business cycle. Thus, we conclude that crude oil and producer energy prices are not cyclical, that is, they do not move in response to current or past temporary or cyclical movements of real GNP. Instead, we find that the evidence supports the reverse causation hypothesis--energy price changes tend to cause business cycles.

## THE MICROECONOMICS OF CYCLICAL PRICES

The notion that the price of any good is cyclical depends, implicitly, on three assumptions: that demand is shifted by transitory income changes occurring over the cycle, that the relevant supply function is not shifted, and that it is upward sloping. Thus, as illustrated for a typical good in Figure 1, when the demand curve shifts from $D_h$ to $D_\ell$, the supply curve is unaffected, and both price and quantities decline from cyclical high to low levels.[3/] The argument illustrated in Figure 1 is that when income falls, the rate of purchases at any price falls but, in contrast, suppliers adjust production according to an unaltered production schedule moving to a lower selling price and quantity along that schedule.

This scenario is intuitively appealing and does accord with observations in some markets. For example, in capital intensive services, equipment leasing, or consumer durables it is reasonable to expect that storage costs are relatively high so that holding the goods in inventory until demand shifts out again with economic expansion is less profitable than selling currently at a lower price.[4/] Conversely, the rate of production could fluctuate along with the shifts in demand. Thus, if the supply curve is relatively flat and if the costs of changing the rate of production are relatively small[5/], prices would tend to be more stable, and sales and output less so. For example, labor intensive services (e.g. temporary help agencies), made-to-order goods, or durable goods produced with relatively labor-intensive methods (e.g. housing) are industries of this character. The relatively smaller changes in per unit production costs and the costs of changing the rate of production lead to larger cyclical variation in quantity produced than in price. Assuming that the essence of the business cycle is the shifting of demand along relatively stable supply functions, whether market adjustments to cyclical demand are principally in price, quantity, or both will be determined primarily by supply behavior.

This is not to suggest that the shape of the demand functions, their price elasticities, or the magnitude of the demand shift is unimportant.

The implications of adjustment and storage costs in a given industry apply not just at the final goods stage, but at each stage of production affecting the demand for inputs of its material suppliers. That is, if an industry did not vary its output over the cycle--whether due to low storage costs or high costs of production rate adjustment--it would not present its input suppliers with a demand shift. Consequently, input suppliers to this industry would vary neither output nor price. Hence, the parameters of demand as well as supply are relevant to analyzing cyclical price and quantity movements in an industry over the cycle. Moreover, especially in markets where price-setting behavior by firms or groups of firms is possible, suppliers' behavior will be influenced more by the elasticity of demand than by the position of the demand curve.

The focus, then, of an investigation of cyclical prices must begin with the supply curve. Low storage costs or low costs of changing production rates imply a more elastic--flatter--supply curve and, hence, relatively larger adjustments in quantity, sold than in price, while high storage costs or high costs of altérations in production rates imply a less elastic--steeper--supply curve and, hence, relatively larger price than quantity adjustments. As shown in Figure 2, for the same cyclical decline in demand, an industry with an elastic supply function ($S^E$) will substantially reduce the quantity sold but adjust its price relatively little (from $P_h$ to $P_\ell^E$); in comparison, an industry with an inelastic supply function ($S^I$) will largely maintain its sales volume by making a more substantial reduction in price (from $P^h$ to $P_\ell^I$).

To isolate the role of each of these elements, consider the quantity-to-be-sold (Q) and the quantity-to-be-produced (q) as two different decision variables that the firm selects to maximize its profit across a business cycle. The cycle is denoted, as in Figures 1 and 2, by the subscripts h and $\ell$ for high- and low-demand periods, respectively. The firm can produce more than it sells in periods of low demand ($Q_\ell < q_\ell$) and carry the difference, ($I_\ell$), as inventory into the subsequent period of higher demand, selling more, in that period, than it produces ($Q_h > q_h$). While the firm must take into account the unit cost of storing goods in inventory ($\sigma$), even if inventory cost per unit of output is relatively high, a firm may still not reduce output in the low demand period if the cost of adjusting the rate of output ($\alpha$) is also relatively high. Marginal (variable) costs of production other than these adjustment costs, $C'(q)$, are assumed to be increasing, $C''(q) > 0$, but this condition is relaxed below to allow $C''(q)=0$, the case of constant marginal cost. For the analysis of purely cyclical variation, we constrain output to equal sales over the two-period cycle and we ignore discounting of future flows. The constrained profit function is[7/]:

$$(1)\ \Pi = Q_h P_h(Q_h) + Q_\ell P_\ell(Q_\ell) - C(q_h) - C(q_\ell) - \sigma I_\ell - \alpha(q_h - q_\ell)^2 +$$

$$\lambda_1(I_\ell - Q_h + q_h) + \lambda_2(q_\ell - Q_\ell - I_\ell) + \lambda_3(q_\ell + q_h - Q_\ell - Q_h),$$

The firm is presumed to maximize (1) by choice of $Q_h$, $Q_\ell$, $q_h$, $q_\ell$, and $I_\ell$ over the cycle; it makes these choices through its <u>ex ante</u> knowledge of its market demand which shifts between the two periods--$P_h(Q_h)$ and $P_\ell(Q_\ell)$--and its cost function, which does not shift. The maximization implies that marginal revenue (MR) and marginal cost ($C'(q)$) are equated in each period and that between periods of high and low demand we have the following relationships[8/]:

$$(2)\ MR_h = MR_\ell + \sigma$$

$$(3)\ C'(q_h) = C'(q_\ell) + \sigma - 4\alpha(q_h - q_\ell),$$

(4) $MR_h = C'(q_h) + 2\alpha(q_h - q_\ell)$

(5) $MR_\ell = C'(q_\ell) - 2\alpha(q_h - q_\ell)$

where, for $i = \ell, h$,

(6) $MR_i = P_i(Q_i)(1 + \frac{1}{\eta_i(Q_i)})$,

(7) $\eta_i = \frac{P_i}{Q_i}\frac{\partial Q_i}{\partial P_i}$.

These marginal revenue and marginal cost conditions are the implicit rules for choosing output and sales--hence, price--in each period subject to the no-inventory-change-over-the-cycle condition. An examination of (2) and (3) supports the conjectures advanced in discussing Figures 1 and 2. In general, the higher is the cost of changing the quantity sold--including either the cost of inventory accumulation or of changing the production rate--the more cyclical will be price as measured by $P_h/P_\ell$. Moreover, higher storage costs ($\sigma$) tend to lessen the discrepancy between sales (Q) and (q) production; thus, sales become less procyclic and production more procyclic the larger is unit inventory cost. Conversely, the lower is storage cost, the less cyclic will be price or production and the more cyclic will be sales; in the limit, if storage is costless, production and price will be constant in a competitive industry. Finally, equation (3) indicates that, for a given $\sigma$, the larger is $\alpha$, the smaller will be the difference between $C'(q_h)$ and $C'(q_\ell)$; but, since we assume $C''(q) > 0$, this implies a smaller excess of $q_h$ over $q_\ell$; that is, higher adjustment costs ($\alpha$) tend to lessen cyclical swings in production.

The final element that is important for influencing cyclical price variation is the price elasticity of demand. A convenient method for analyzing its effect as well as the other factors discussed above, is to note that from equation (6), the ratio of high period to low period prices may be written as

$$(8)\quad \frac{P_h}{P_\ell} = \frac{MR_h}{MR_\ell}\left(\frac{1 + 1/\eta_\ell(Q_\ell)}{1 + 1/\eta_h(Q_h)}\right).$$

Substituting for $MR_h$ and $MR_\ell$ from (4) and (5) and for $C'(q_h)$ from (3) and rearranging, we obtain

$$(9)\quad \frac{P_h}{P_\ell} = \left[\frac{C'(q_\ell) + \sigma + 2\alpha(q_h - q_\ell)}{C'(q_\ell) - 2\alpha(q_h - q_\ell)}\right] \left[\frac{\eta_h(1 + \eta_\ell)}{\eta_\ell(1 + \eta_h)}\right] .$$

Equation (9) aptly summarizes the effects of storage and production-rate adjustment costs and price elasticity for cyclic price movements. Specifically, in the case of a competitive industry, each firm faces an indefinitely large elasticity so that the term in brackets is unity; thus:

- $P_h/P_\ell$ will be larger the larger is storage cost ($\sigma$) or adjustment cost;
- $P_h/P_\ell$ will be unity if the storage cost (6) is zero;[9]
- $P_h/P_\ell$ will be unity if adjustment and storage costs are zero and, contrary to our assumptions, marginal cost is constant--$C''(q)=0$[10].

If the industry's price is determined by price-searching firms ($\eta \neq \infty$), then (9) further implies that, ceteris paribus,

$P_h/P_\ell$ will tend to be unaffected by the own-price elasticity if it, in turn, is unaffected by the cycle (the result is identical to the competitive case); will tend to be less than one (prices rise during recessions--(countercyclical price movements)), if the own-price elasticity falls during recessions; and will tend to exceed one, regardless of storage adjustment costs, if the elasticity of demand rises during recessions.[11/]

In summary, by means of this simple model, we have isolated the effects of three determinants of cyclical movements in price--storage costs, production rate adjustment costs, and the elasticity of demand facing a monopolistic industry.

The results indicate that cyclical prices are least likely in markets dominated by price-searching producers in which the elasticity of demand falls in recessions or where storage costs and marginal (fixed and variable) are relatively small. We hypothesize that these factors are characteristic of the crude oil market so that cyclical prices should not, a priori, be expected. Moreover, if the cost of crude oil is a major share of the cost of oil products, then, by implication storage and adjustment costs are not. The implication, of course, is that oil products would not be cyclical either. Given substitutability between energy sources and the relatively high energy-intensity of energy products, the case for cyclical energy prices is, in principle, quite weak.

ENERGY PRICES AND THE BUSINESS CYCLE: THE EVIDENCE

To examine the possibility of cyclical movements in relative prices of energy goods, major monthly indexes for such goods were selected from the detailed breakdown of the producer price index (PPI) and consumer price index for all urban consumers (CPI). The series examined are listed in table 1. Relative prices were constructed by deflating each component price index by the PPI for finished goods in the case of PPI indices, or the CPI for all urban households for the CPI components. The beginning date of availability for each data series is also indicated in table 1.

The first price series in the table, nonfood materials excluding fuel, was chosen because it includes crude petroleum. Indeed, crude petroleum directly accounts for about half (51.2 percent) of this commodity group. The first two series in the table make up the index for nonfood crude materials for further processing, which is primarily energy (about 68 percent); energy products contribute about half their weight through the fuels index and about half through the crude petroleum included in the first series, non-food materials excluding fuel. Lower down in the table, an adjusted PPI for crude petroleum is also given, as well as the PPI for crude petroleum.[12/]

Monthly Data on Cyclical Prices

Monthly percentage changes in each relative price, measured by changes in the natural logarithm, were correlated with current and past changes in two cyclical measures: the monthly change in the unemployment rate for the civilian labor force and the monthly change in the Federal Reserve Board index of capacity utilization in manufacturing.[13/] The correlations were examined for two periods: from the beginning of the data series for prices to December 1973, and from January 1973 to December 1980.[14/] Subsequent data are not included in the tests below, since the post-1980 data gave rise to the cyclical hypothesis and there are competing theories that explain recent developments. Since the central purpose here is to test the cyclical hypothesis, the appropriate neutral ground is the historical data prior to the recent declines in energy prices.

The break in the data before and after 1973 was chosen to control for differences that could arise from OPEC control of energy prices. However, even prior to the imposition of OPEC control over world oil prices, U.S. oil and energy markets were not perfectly competitive. An effective quota system on crude oil imports and the operation of the pro-rata system by the Texas Railroad Commission combined to effectively determine oil prices by another form of cartel action. Thus, the relation of prices and output in the earlier period need not reflect the presence of a competitive market any more than in the latter period. Nonetheless, there is no reason to believe that price behavior is the same pre- and post-1973.

The criterion for selection of significant correlations was a 95 percent confidence level. A two-tail test was used since, according to the maintained hypothesis from the theory, any sign configuration is possible. The cyclical view, however, asserts that current and/or past increases in the unemployment rate, or decreases in the capacity utilization rate, reduce energy demand and energy prices. Thus, current energy prices should be positively correlated with current or past changes in capacity utilization and negatively correlated with unemployment rate changes.[15/] Since the results for both measures of the cycle are similar, only the results for the unemployment rates are presented in the tables or emphasized in the text below.

Up to twenty-four lagged values of the change in the cyclical variable were examined. The significant correlations of monthly energy price changes with past unemployment rate changes are given in table 2.[16/] For the period 1974-80, only one price strongly indicates movements consistent with the cyclical view: non-food materials excluding fuel which is significantly negatively correlated with the unemployment rate contemporaneously and at a one month lag. Crude petroleum is not significant at this lag, however, so that the cyclical result indicates that it is the other components of non-food materials that are apparently cyclical. Crude fuel price changes are correlated with unemployment rate changes 9 months earlier. The absence of earlier or later significant correlations suggests that this is likely to be spurious. Consumer prices for housing fuel also have a significant relationship to unemployment increases one month earlier, but that correlation has the wrong sign.

At lags of one year and over, eight other prices have significant correlations during the 1974-80 period. At a fifteen-month lag, refined petroleum and, at 12 and 17 months, its gasoline component (both not seasonally adjusted) are significantly negatively correlated with unemployment changes. The seasonally adjusted producer prices for gasoline and refined petroleum prices are not significantly correlated with unemployment changes, however. Crude petroleum price changes are significantly (negatively) related to unemployment changes 13 months earlier only. The crude petroleum and crude fuel results carry through to crude energy materials which is significantly correlated with unemployment rate changes 9, 13 and 15 months earlier. Finished energy goods SA, and residual fuel SA show a significant correlation with unemployment changes only at fifteen months earlier. Their not-seasonally-adjusted data show no significant lagged correlations for either series. Finally, consumer prices for gasoline are significantly correlated with unemployment changes at a lag of 15 months for the seasonally adjusted series, but not for the unadjusted data.

Of twenty-six series examined, half show some significant correlation with a current or past unemployment rate change. Except for non-food materials excluding fuel and consumer fuel, which has the wrong sign, however, these significant correlations occur at distant lags and usually in only one lagged month. Thus, the results suggest that at least from 1974-80, energy prices are neither positively nor negatively related to the cycle. The notable exception is that for non-food materials excluding fuel, but this result apparently arises from its non-energy components.

Of the twenty-six series in table 1, data for sixteen exist prior to 1974. Of these, only five series--consumer housing fuel (SA and NSA), and producer prices for light distillate, middle distillate and residual fuel--show no significant current or lagged cyclical movements (table 3). The most noteworthy aspect of table 3 is the extent to which prices appear to move countercyclically. Five price series show countercyclical movement: crude fuel, coal, electric power, industrial power and crude petroleum. The electric power and industrial power results are identical since industrial power used by large industrial users is a major component of the former, and it is subject to declining block rate pricing which would be expected to yield the positive correlations. Block rate pricing is apparently not significant in the later period. Similarly, the crude fuel and coal results are probably the same because coal is a major component of crude fuel.

Procyclic movements are significant for non-food materials excluding fuel contemporaneously and with one lag; this direction of correlation is reversed for cyclical movements at longer lags. The result for crude petroleum, the only energy component of non-food materials excluding fuel, suggests these correlations arise for non-energy related reasons. Four other prices exhibit correlations that suggest that past cyclical increases (decreases) in unemployment reduce (raise) energy demand and prices. These prices are: fuel, related products and power (14 month lag), refined petroleum (6 and 19 month lag), and consumer gasoline, SA and NSA (5 and 11 month lags).

As in the post-1973 period, the correlations in table 3 from the pre-1974 era are not strongly indicative of cyclical energy prices. Where cyclical movements in energy prices do occur in the pre-1974 period, they are frequently in the opposite direction from that hypothesized by proponents of the cyclical view. Moreover, it should be emphasized that most of these significant correlations disappear after 1973, regardless of the sign of the relationship.

There are only two results consistent across both period. The first is a short-term relationship between non-food materials excluding fuel and contemporaneous and lagged cyclic unemployment changes; yet, this does not arise due to the inclusion of crude petroleum in the price measure. The second is the significant negative relationship of the producer price for gasoline and unemployment changes 12 months earlier. The absence of earlier or surrounding significant correlation casts doubt on the importance of this correlation. A third result that approaches consistency is that for consumer gasoline which is also significantly negatively correlated with past cycle movements, at a longer lag than before 1973, but this result is subject to the same criticism as above.

Reverse Causation in Monthly Data

In light of macroeconomic developments during OPEC's era, it is perhaps more useful to digress briefly to examine the reverse causation hypothesis: that a rise in real energy prices leads to future cyclical movements in the economy.[17/] If real wages (product prices, given nominal wages) adjust with a lag to shifts in productivity and labor demand induced by energy price changes, then exogenous shocks to energy prices give rise to business cycles. The evidence for GNP and its deflator indicates roughly a six-quarter adjustment process for a change in the relative price of fuel, power and related products, during which period, some rise in the unemployment rate temporarily occurs (Tatom (1981), pp. 10-16).

The same correlation tests were conducted for current changes in the table 1 energy prices and future movements in the cyclical variables. The range of leads on energy prices was again 0 to 24 months, the same as investigated for the lags reported in tables 2 and 3. The leads, where significant correlations for changes in each energy price and future change in the unemployment rate occur, are listed in table 4 for both the pre- and post-1974 sample periods used above.

Two essential features characterize the test of the hypothesis that energy prices lead the cycle. First, almost all of the energy prices exhibit significant positive correlations with future unemployment rate changes. The only exception in the 1974-80 sample period is that for crude fuel. The exceptions in the pre-1974 period are producer prices of electric power and gasoline. The second feature is that, unlike the lag correlations, there are typically runs of several consecutive months of significant correlations of energy price changes and future unemployment rate changes rather than the single isolated months reported in tables 2 and 3. These runs in the 1974-80 period encompass significant positive unemployment changes seven to fourteen months following an energy price change. In the pre-1974 period, runs of significant positive correlations usually appear with a longer lead, from about eleven to fifteen months.

Several prices in the 1974-80 period exhibit the longer-lagged cyclical adjustment suggested by macroeconomics. The hypothesis entails a dominant supply response to an energy price rise, which, during some period, results in unemployment, as producers cut output by more than the productivity loss, followed by a supply response to the lagged adjustment of product prices which restores employment.

While not reported in tabular form, the capacity utilization results reinforce both parts of this hypothesis in the 1974-80 period: all energy prices, except crude fuel again, have the significant negative correlations predicted by the reverse causation hypothesis that occur in runs from about seven to twelve months later. The difference is that twenty-one of the twenty-six prices show two or more significant positive correlations about 14 to 19 months later. This result indicates that the recessionary impact of an energy price rise that initially depresses utilization is reversed later by significant increases in utilization.

Quarterly Data on Cyclical Prices

Since monthly changes contain considerable noise, the experiments reported above were also conducted for quarterly average data. Leads and lags up to eight quarters (corresponding to the 24 months used in the monthly data) were included. The results are summarized in table 5. All of the prices examined for the 1974-80 period exhibit significant positive leading correlations with unemployment. In the pre-1974 period, all but electric and industrial power prices show significant positive correlations. For the 1974-80 period, these leading relationships are clustered at two to four quarters ahead. In the earlier period, the positive leading correlations occur with a slightly longer delay, roughly four to six quarters. The significant negative correlations in the early period tend to occur contemporaneously and one period ahead and, for crude oil, eight quarters ahead.

Few of the quarterly price changes exhibit any significant correlations with past cyclical movements. In the 1974-80 sample, only finished energy goods SA (5 quarter lag), residual fuel SA (5 quarter lag), crude energy materials (4 and 5 quarter lag), and producer gasoline (4 and 5 quarter lag), exhibit significant negative correlations with past unemployment rate changes. For the earlier period, refined petroleum (1 lag) and consumer gasoline (2 lags) exhibit significant correlations. With the exception of the first price in the table, the two significant contemporaneous correlations are in accord with the dominant lead relationship (positive). In the earlier period, all five significant contemporaneous correlations are negative, suggesting support for the cyclical view. In only two of the five cases, however, are any other lags significant, while in all five cases there are significant positive leads.[18/]

The quarterly data indicate even more clearly that broad measures of energy goods purchased by producers, especially fuel power and related products, and the base measure, crude petroleum, do not react to past cyclical movements in the unemployment rate. Goods purchased by final users such as finished energy goods, refined petroleum, and, more specifically gasoline, show limited correlations with past cyclical changes, but since 1973 the significant lags are over a year, suggesting that they may be spurious. In addition, the quarterly evidence is quite favorable to the macroeconomic hypothesis that energy price changes affect future cyclical movements.[19/]

While table 5 provides substantial evidence that energy prices are not determined or influenced by the business cycle, but rather influence the cycle, further analysis can be brought to bear on the exceptional cases in the table. Specifically, a Granger-causality test was performed for each of the asterisked prices in table 5. In addition, since we are most interested in the broadest measure of energy prices paid by producers, that for fuel, related products and power, and that for crude oil, the same test was performed for these series.[20/]

The essence of the test is to examine whether <u>past</u> cyclical changes add significant statistical information to an autoregressive model of the variable in question; if such past changes do add significantly, then it is said that the cycle "causes" energy prices. To establish unidirectional causality, the same regression analysis is conducted for an autoregressive model of changes in the cyclical variable, the unemployment rate, to investigate whether <u>past</u> energy price changes "cause" current changes in unemployment. The equations estimated for each relative price, $p_i$, are

$$(10)\ \dot{p}_{i,t} = \beta_o + \sum_{j=1}^{m} \beta_j \Delta UN_{t-j} + \sum_{k=1}^{n} \gamma_k \dot{p}_{i,t-k} + \epsilon_t,$$

$$(11)\ \Delta UN_t = \beta^*_o + \sum_{j=1}^{m^*} \beta^*_j \dot{p}_{i,t-j} + \sum_{k=1}^{m^*} \gamma^*_k \Delta UN_{t-k} + \delta_t,$$

where $\dot{p}$ is $\Delta \ln p$, $\Delta UN$ is the change in the unemployment rate, and the i-subscript on $\dot{p}$ indicates the price series utilized. Such tests are often conducted by arbitrarily selecting four or eight lagged values of the dependent variable <u>and</u> the causal variable in question. For the tests here, we examined from one to six lags of each of the right-hand-side variables: the lagged dependent variable (the autoregressive process) and the causal variable.

The results for the energy prices are summarized in table 6. For each price, the sample period examined is indicated. The F-statistic to test the null hypothesis that unemployment rate changes, $\Delta UN$, do not cause price changes, $\dot{p}$, is not reported, since it was below the critical value for all combinations of lagged unemployment rates (lags from one to six quarters), regardless of the autoregressive process (the inclusion of zero to six quarters of lags on the energy price in question). That is, in no case did the test reject the hypothesis that past unemployment rate changes do not cause energy price changes.

The first four entries in the table are for the four prices where significant correlations were found for the 1974-80 period in table 5. For the causality test, three of the four prices have limited degrees of freedom when the sample period ends in IV/1980. Nonetheless, in none of these tests was the unemployment rate found to be significant for any of the lag specifications considered. Data for producer gasoline prices exist before 1974, so this data was subjected to the same causality test. At least since 1973, none of the likely candidates for cyclical prices from table 5 stands up to the test.

The two prices for which correlations in table 5 indicated significant lagged relationships for the period before 1974 were similarly tested. For the pre-1974 period the null hypothesis of no causation could not be rejected for either variable. These prices were also examined for the post-1973 data. Finally, for the broadest measure of energy prices and for crude oil paid by producers and for crude oil, no significant explanatory power was observed for past unemployment changes over either period.

Conversely, consider the results for reverse causation. With few exceptions, for all eight prices in table 6 and for the periods indicated, the hypothesis that the energy price does not cause future cyclical movements can easily be rejected. The exceptions are producer gasoline and fuel related products and power for the pre-1974 period, and crude energy materials for the 1974-80 period. The results for these prices, over these periods, indicate the absence of causality in either direction. Generally, however, the result of these tests is support for unidirectional causality running from prices to unemployment, except in three instances where the absence of causality in either direction cannot be rejected.

Quarterly Data on Nominal Prices

Some analysts focus on nominal price changes as having micro and macro content, so that the relative price discussion above may appear, to them, to lack content.[21/] To placate their concern but without joining a debate on the relevant measure, we have also conducted the quarterly correlation and causality tests using nominal prices.

The analog of table 5 is given for nominal prices in table 7. The results for significant lags are little different. Crude fuel, intermediate energy goods, and fuel oil #2 to resellers (SA and not SA) join the list of significant negative 5 quarter lagged correlations with past unemployment changes during the 1974-80 period, while refined petroleum drops out. In the earlier period, a second lagged quarter for refined petroleum enters the list of significant lags, as does producer gasoline at both 1 and 2 quarter lags. The difference in the lead results is the most notable difference between tables 5 and 7. For nominal prices, the significant and persistent correlations with future cyclical changes exhibited for all the relative prices in table 5 disappear. Note, also, that in the 1974-80 period the significant correlations of current price changes and future unemployment rate changes, where present, are negative, in contrast to the table 5 results and the macrotheoretic expectation.

The Granger causality test for the cyclical energy price hypothesis was repeated for the eleven prices where significant lagged correlations are reported in table 7 and for the crude petroleum price, adjusted crude petroleum price, and the fuel, power and related product index. The tests again examined lags on the dependent variable and on past unemployment changes up to six quarters earlier. For the fourteen prices examined for IV/1975 to IV/1980, or for the seven prices examined over the earlier period, none exhibit causality running from past cyclical changes to current price developments.

When the hypothesis that current cyclical movements are influenced by past energy price developments is tested, the results are not as mixed as the table 5-table 7 comparison suggests. For three of the seven price series examined over the period IV/1949-IV/1973, the F-test for the addition of lagged nominal price changes to a $\Delta$ UN equation, which contains 0 to 6 lagged values of $\Delta$ UN on the right-hand-side, indicates unambiguously that at least one set of past prices adds significantly to the unemployment equation. These are: non-food materials excluding fuel, crude fuel, and crude petroleum. Only the refined petroleum price unambiguously shows no causality for future cyclical movements. Tests for prices of producer gasoline and fuel power and related products, and consumer gasoline (IV/1969 to IV/1973) indicate that the absence of causality can be rejected for some lags and sets of lagged dependent variables. Thus, for lag lengths where these prices add significantly to the $\Delta$ UN equation, the optimal (in the sense of statistically significant information) autoregressive structure was searched. For example, the absence of causality for producer gasoline prices on unemployment can be rejected for various lags of the price, if the optimal autoregressive structure includes no lagged dependent variable ($\Delta$ UN) or 1 lagged value of $\Delta$ UN. Two lagged values of $\Delta$ UN add significantly, however, for any set of past prices, and, with these variables, prices do not add significantly. (Longer autoregressive structures are rejected.) Thus, past producer gasoline prices do not provide significant statistical information for current unemployment.

For consumer gasoline, causality is sometimes indicated with 6 and 7 lagged values of the price change, but the optimum structure appears to be seven lags of the price with no lagged changes in the unemployment rate. Thus, consumer gasoline prices exhibit significant causality for unemployment rate changes. Finally, fuel power and related products show causality with zero and first-order autoregressive processes with 3 to 8 lagged price changes. The optimum autoregressive structure, however, for these lags on nominal energy prices is two or three past values of $\Delta$ UN depending on the lagged prices considered. Thus, fuel, power and related product prices do not appear to add significantly to equations explaining unemployment. Of the seven prices examined over the earlier period, four show significant information for unidirectional causality of past price changes influencing unemployment developments; three prices do not indicate causality running in either direction.

In the 1974-80 period, the addition of the past price changes to the change in unemployment equation yielded unambiguous significant improvements in the unemployment equation (regardless of the set of lagged dependent variables) for the prices of:

non-food materials excluding fuel
crude fuel
finished energy goods, SA
intermediate energy goods, SA
fuel, related products and power
crude petroleum
adjusted crude oil
refined petroleum
producer petroleum
fuel oil #2, to resellers
fuel oil #2, to resellers, SA
consumer gasoline

Residual fuels, SA, exhibits no causality for up to 6 lags of $\dot{p}$ and $\Delta$ UN. One other price was ambiguous over this period: crude energy materials. The optimal autoregressive structure, independent of the set of lagged crude energy material prices, is 0 lags on $\Delta$ UN. With this structure, lagged prices exhibited significant causality for one significant and positive lag on crude energy materials prices. Thus, we conclude that even nominal prices are not cyclical, and the tests are favorable to the reverse causation hypothesis.

## CONCLUSION AND SUMMARY

Economic theory suggests that in competitive industries, where storage costs or incremental costs of changing the rate of output--either rising marginal variable cost or costs of changing production schedules--are important, procyclical relative prices occur. In the absence of such cost factors, or in industries where price-setting is controlled by dominant firms, other cartel arrangements, or monopolists, relative prices are less likely to fall in recessions or rise in general economic expansions. We argue that these conditions are likely to characterize the crude oil and, indirectly, energy market.

The evidence presented is unambiguous for energy prices paid by producers and for crude oil. We do present some evidence, however, supportive of the cyclical view for some periods and for some prices, notably those goods where storage costs seem relatively high such as gasoline and, perhaps, refined petroleum.

The evidence is considerably stronger for the reverse causation view. Energy prices, however measured, tend to cause cyclical changes in the economy. While this is not the central issue here, it does provide a more appropriate focus for the discussion of the economic performance-energy price linkage.

FOOTNOTES

1/ Such observations are not limited to the popular press. The importance of energy demand variations in energy price determination is critical in some models in the literature. For example, see Verleger (1982) and Nordhaus (1980).

2/ A competing view of the microeconomics of the oil market, not discussed here, explains recent oil and energy price developments as largely arising from the decontrol of the U.S. crude oil market early in 1981 and the continuing effects of phased decontrol of the natural gas market that began in 1978. See Tatom (1979, 1982), and Ott and Tatom (1982a,b).

3/ We assume, without loss of generality, that goods are normal throughout this analysis, so that demand shifts to the left during cyclical downturns and to the right during cyclical expansions. Whether demand for various products has different income elasticities for such transitory income variations than for permanent real income changes is also not explored here. It is sufficient for our purposes, that transitory income elasticities are positive.

4/ For example, Miller (1971, p. 21) argued that five of the six industries in his study with negligible inventories did so "because of obsolescence costs":

Men's and boy's suits and coats,
Men's and boy's shirts,
Women's and misses' junior outerwear,
Newspaper publishing and printing,
Footwear, except rubber.

Conversely, Miller found industries producing goods with low obsolescence or storage costs to hold large inventories (relative to production rates):

Cigarettes,
Cigars,
Sawmills and planning mills,

Tires and inner tubes,
Leather tanning and finishing,
Blast furnaces and basic steel production.

5/ The adjustment cost referred to here is a one-time cost of changing the rate of production--e.g. changing nozzle size, altering schedules, recalling or laying-off labor, etc. Thus, it is separate and additional to the marginal variable of output in terms of a long production run--$C'(q)$. The adjustment cost is part of what Alchian (1977), pp. 276-278) refers to as the volume or length-of-the-production-run effect.

6/ Recessions in this model are fully anticipated; while this useful simplification might affect the optimal inventory, the absence of uncertainty does not create a relation between costs and production which would be absent in a riskier world. Consequently, the points isolated are relevant even under uncertainty.

7/ Note that interest cost is ignored for simplicity, but must be considered to be implicit in the inventory holding cost, $\sigma$. Also, we have assumed a quadratic adjustment cost function--$\alpha\ (q_h - q_\ell)^2$; this is purely for expository convenience in order to avoid using absolute values. A more general form would be $\alpha\ (|q_h - q_\ell|)^\gamma$ with $\beta$ and $\gamma$ being determined empirically.

8/ The explicit first order conditions obtained from maximizing (1) are:

$$\text{(i)} \quad \frac{\partial \pi}{\partial Q_h} = P_h(Q_h)(1 + \frac{1}{\eta_h(Q_h)}) - \lambda_1 - \lambda_3 = 0$$

$$\text{(ii)} \quad \frac{\partial \pi}{\partial Q_\ell} = P_\ell(Q_\ell)(1 + \frac{1}{\eta_\ell(Q_\ell)}) - \lambda_2 - \lambda_3 = 0$$

$$\text{(iii)} \quad \frac{\partial \pi}{\partial q_h} = -C'(q_h) + \lambda_1 + \lambda_3 + 2\alpha(q_h - q_\ell) = 0$$

$$\text{(iv)} \quad \frac{\partial \pi}{\partial q_\ell} = -C'(q_\ell) + \lambda_2 + \lambda_3 + 2\alpha(q_h - q_\ell) = 0$$

(v) $\frac{\partial \pi}{\partial I_\ell} = -\sigma + \lambda_1 - \lambda_2 = 0$

(vi) $\frac{\partial \pi}{\partial \lambda_1} = I_\ell - Q_h + q_h = 0$

(vii) $\frac{\partial \pi}{\partial \lambda_2} = q_\ell - Q_\ell - I_\ell = 0$

(viii) $\frac{\partial \pi}{\partial \lambda_3} = q_\ell - q_h - Q_\ell - Q_h = 0$

The three multipliers—$\lambda_1$, $\lambda_2$, $\lambda_3$—determine the marginal profit produced if their respective constraints were relaxed; thus, at the solution levels of output and sales, profit would rise by $\lambda_1$, for each increment of sales, $Q_h$, if they could be made without drawing on inventory ($I_\ell$) or high period production ($q_h$). Profits would rise by $\lambda_2$ for each increment of inventory which did not require a reduction in low period sales ($Q_\ell$) or an increase in low period production ($q_\ell$). Finally, $\lambda_3$ is the increment to profit if sales in either period could increase without an increase in production in either period. From (v), we see that storage cost is equal, at the optimum, to the difference between $\lambda_1$, and $\lambda_2$; this result combined with (i) and (ii) and definition (4) yields (2). The optimum $\sigma$ from (v) combined with (iii) and (iv) yields (3).

9/ This follows from (3). With $\sigma = 0$,

$C'(q_h) - C'(q_\ell) = -4\alpha(q_h - q_\ell)$, which, since $C''(q) > 0$ and $\alpha > 0$, can only hold for $q_h = q_\ell$.

10/ The result of the optimization procedure would then imply, in place of (9),

$$\frac{P_h}{P_\ell} = \frac{c + \sigma + 2\alpha(q_h - q_\ell)}{c - 2\alpha(q_h - q_\ell)}$$

where c is the constant marginal cost. With $\alpha = 0$ by assumption, this expression suggests that $P_h/P_\ell$ would be greater than unity if $\sigma$ is positive; however, with constant marginal cost and no adjustment costs, $\sigma$ cannot be positive as can be seen by considering (iii), (iv), and (v) in note 5. With marginal constant at c and $\alpha=0$, (iii) and (iv) imply $\lambda_1=\lambda_2$ which, by (v), can only be if $\sigma=0$. The implicit constraint is that if the production rate can be costlessly adjusted and if the marginal cost of production is the same at any production rate, a positive storage cost is inconsistent; that is, output in effect can be stored costlessly in the production function.

11/ This is Joan Robinson's well-known result (1933, pp. 70, 72-72). The importance of the own-price elasticity of demand for pricing in contrast to the position of the demand curve, for a "dominant firm" is emphasized in Tatom (1979, 1982), and Ott and Tatom (1982a,b). See also Plaut (1981), Smith (1981), and Loderer (1982).

12/ The PPI for crude oil is adjusted to reflect the actual cost of oil to refiners rather than domestic selling prices after 1973. The difference arises from the entitlement system. The entitlement adjustment involves adding the difference between the logarithm of the composite refiner acquisition cost of crude oil, the average and marginal cost of a barrel of oil under the entitlement program, and the domestic refiner acquisition cost, the price of domestic oil, to the logarithm of the PPI for crude oil. Before 1974, the series is simply the PPI for crude oil.

13/ Desirable statistical properties are obtained by conducting such correlation tests using such differenced data, particularly, the avoidance of highly autocorrelated residuals. See Plosser and Schwert (1978).

14/ Nominal prices were examined in the same fashion to check that the results were not affected by possible cyclicality introduced by the deflation process.

15/ Thus the use of the two-tail test biases the criterion in favor of the cyclical view.

16/ The same experiment was conducted using nominal prices but the results are nearly the same. For example, all of the significant correlations shown in table 3 hold for nominal price movements. In addition, significant lags at 14 to 16 months also appear for several prices.

17/ See Tatom (1981), for example, for a theoretical development of this hypothesis as well as supporting evidence. Hamilton (1983) also provides evidence supporting this hypothesis for nominal crude oil changes over the period 1948 to 1972.

18/ Moreover Tatom (1981) indicates that contemporaneously and one period ahead, an energy price increase reduces aggregate supply relative to demand, at unchanged prices, resulting in reduced unemployment temporarily. Thus, the interpretation of contemporaneous correlations is ambiguous. The significant correlations for lagged unemployment do not systematically occur later than those for capacity utilization, as would be expected if unemployment were more of a lagging indicator than changes in the capacity utilization rate.

19/ When the capacity utilization rate is used for the correlations in table 5 (instead of the unemployment rate), the significant lags occur at the same lags for each price, except that, in addition, in the 1974-80 period, fuel power and related products, crude petroleum, refined petroleum, and producer gasoline SA all show significant position correlations with unemployment changes five quarters earlier. Three of these four prices are included in table 6, however, and when the tests performed there are conducted using the capacity utilization rate, the results are the same. That is, the hypothesis that past capacity utilization is not statistically informative for the energy prices cannot be rejected.

20/ See Granger (1969). Hamilton (1983) examines the issue of causality of nominal oil prices and real GNP and rejects causality running from real GNP to nominal oil prices. As he notes, following Jacobs, Leamer, and Ward (1979), the correct inference is not one of causality, but rather whether, in our context, the business cycle is statistically informative about future energy prices or energy prices are statistically informative about future cyclical developments. We take exception to Hamilton's use of nominal oil prices (especially, controlled domestic ones after 1971), but our results are not at odds with his. Hamilton (p. 245) notes some statistical problems that arise from the use of nominal prices. The relevant theory, as developed in Rasche and Tatom (1977 and 1981) indicates that the relative price is the relevant variable. Moreover, testing the hypothesis against real GNP does not allow for the separation of permanent or transitory (cyclical) real output effects of energy shocks.

21/ The emphasis on nominal prices, in particular that for crude oil, can be found in Hamilton (1983). Darby (1982) finds quite dissimilar results using the real price of crude oil. The difference in results appears to arise from differences in the models used, however, instead of the oil price measure.

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Table 1

Selected Producer and Consumer Energy Prices[1/]

| Producer Price Index | Data Series Begins |
|---|---|
| **Stage of Processing Indices:** | |
| Non-Food Materials Excluding Fuel, (includes crude petroleum) | January 1947 |
| Crude fuel, (excludes crude petroleum) | January 1947 |
| Finished Energy Goods, (SA) | January 1974 |
| Intermediate Energy Goods, (SA) | January 1974 |
| Crude Energy Materials | January 1974 |
| **Selected Commodities** | |
| Fuel and Related Products and Power | January 1946 |
| Coal | January 1947 |
| Electric Power | January 1958 |
| Industrial Power | January 1958 |
| Adjusted Crude Petroleum | January 1974 |
| Crude Petroleum | January 1947 |
| Refined Petroleum | January 1947 |
| Gasoline, (SA)[2/] | January 1947 |
| Light Distillate | January 1947 |
| Middle Distillate | January 1947 |
| Fuel Oil #2, to resellers, (SA)[2/] | January 1974 |
| Residual Fuels, (SA) [2/] | January 1947 |
| Consumer Price Index (All Urban Consumers) | |
| Housing-Fuels, (SA)[3/] | January 1967 |
| Gasoline, (SA) | January 1967 |

1/ All series are not seasonally adjusted, except where indicated by (SA). Where seasonally adjusted data are available, both series were examined.

2/ Seasonally adjusted series begins in January 1974.

3/ Fuels component of the housing price index within the CPI.

Table 2

STATISTICALLY SIGNIFICANT CORRELATIONS OF MONTHLY ENERGY PRICE CHANGES
WITH CURRENT AND PAST MONTHLY UNEMPLOYMENT RATE CHANGES
(January 1974 to December 1980)

| Energy Price | Lag on Unemployment Rate (months) | Correlation | Significance Level |
|---|---|---|---|
| Non-Food Materials Excluding Fuel | 0 | −0.34 | 0.2% |
| | 1 | −0.23 | 3.7 |
| Crude Fuel | 9 | −0.28 | 1.1 |
| Crude Petroleum 1/ | 13 | −0.26 | 1.8 |
| Refined Petroleum | 15 | −0.22 | 5.0 |
| Gasoline (Producer) | 12 | −0.22 | 4.6 |
| | 17 | −0.26 | 1.8 |
| Fuel oil #2, to resellers SA | 13 | −0.22 | 4.5 |
| Residual Fuel SA | 15 | −0.22 | 5.0 |
| Crude Energy Materials | 9 | −0.27 | 1.2 |
| | 13 | −0.22 | 4.3 |
| | 15 | −0.23 | 3.6 |
| Finished Energy Goods, SA | 15 | −0.24 | 2.9 |
| Consumer Price, housing fuel SA | 1 | +0.23 | 3.7 |
| Consumer Price, housing fuel NSA | 1 | +0.23 | 3.7 |
| Consumer Price, Gasoline, SA | 15 | −0.22 | 4.5 |

1/ The result for adjusted crude petroleum is identical.

Table 3

STATISTICALLY SIGNIFICANT CORRELATIONS OF ENERGY PRICE CHANGES AND CURRENT AND PAST UNEMPLOYMENT RATE CHANGES

(Period Ending December 1973)1/

| Producer | Significant Correlation [Lag(s) (sign)] |
|---|---|
| Non-Food Materials Excluding Fuel | 0,1(-);11,13,15,17 to 19(+) |
| Crude Fuel | 5(+) |
| Fuel and Related Products and Power | 14(-) |
| Coal | 5(+) |
| Electric Power | 1,3,5,7,9(+) |
| Industrial Power | 1,3,5,7,9(+) |
| Crude Petroleum | 3(+) |
| Refined Petroleum | 6,19(-) |
| Gasoline, NSA | 12(-);13(+) |
| Light Distillation | None |
| Middle Distillation | None |
| Residual Fuel | None |
| **Consumer** | |
| Housing fuel, SA | None |
| Housing fuel, NSA | None |
| Gasoline, SA | 5,11(-) |
| Gasoline, NSA | 5,11(-) |

1/ For beginning of period for each series, see Table 1.

Table 4

SIGNIFICANT CORRELATIONS OF MONTHLY CURRENT ENERGY PRICE CHANGES AND FUTURE MONTHLY CHANGES IN UNEMPLOYMENT

| Energy Price | Period Ending December 1973 1/ [(sign): lead(s)] | January 1974-December 1980 1/ [(sign), lead(s)] |
|---|---|---|
| Non-Food Materials excluding fuel | (-):0 to 5;(+):13,15,16 | (-):0 to 2;(+):11,14 |
| Crude Fuel | 7,14,15 | None |
| Finished Energy Goods | NA | 7 to 11 |
| Finished Energy Goods, SA | NA | 7 to 12 |
| Intermediate Energy Goods | NA | 7 to 11 |
| Intermediate Energy Goods, SA | NA | 6 to 12 |
| Crude Energy Materials | NA | 4,7,9,11 |
| Fuel and Related Products and Power | 7,11 to 18,21 | 7 to 12 |
| Coal | 7, 13 to 15 | 3, 5 to 7, 9;(-)16 |
| Electric Power | (-)17,22 | 9;(-)21 |
| Industrial Power | 12;(-):17,22 | 1,7,9;(-)21 |
| Crude Petroleum 2/ | 11 to 14;(-):17,22 | 10,11,12,14;(-)18 |
| Refined Petroleum | (-)3;(+):12 to 15 | 7 to 12 |
| Gasoline | None | 8 to 12 |
| Gasoline, SA | NA | 7 to 12 |
| Light Distillate | (-)2,4;(+):14,22 | 7 to 12 |
| Middle Distillate | (-)2;(+):12,14,22 | 7 to 13;(-)17 |
| Fuel Oil #2, to Resellers | NA | 7 to 11,13:(-)17 |
| Fuel Oil #2, to Resellers, SA | NA | 7 to 13;(-)17 |
| Residual Fuels | (-)1,3;(+):11 to 15 | 9 to 12 |
| Residual Fuels, SA | NA | 9 to 12 |
| Consumer Housing Fuels | 12 to 14;(-):19,21 | 10, 11 |
| Consumer Housing Fuels, SA | 12 to 14;(-):19,21 | 8 to 11;(-)22 |
| Consumer Gasoline | (-)4;(+):11,13,14 | 8 to 13 |
| Consumer Gasoline, SA | (-)4;(+):7,11,13,14 | 8 to 13 |

1/ Sign is positive unless indicated; NA indicates data not available in early (pre-1974) period.

2/ Results are identical for adjusted crude petroleum.

Table 5

SIGNIFICANT CORRELATIONS OF QUARTERLY ENERGY PRICE CHANGES AND PAST (LAGS) AND FUTURE (LEADS) QUARTERLY CHANGES IN UNEMPLOYMENT

| Energy Prices | Period Ending IV/1973 1/ | | I/1974 to IV/1980 | |
|---|---|---|---|---|
| | Leads | Lags | Leads | Lags |
| Non-Food Materials Excluding Fuel | (-):0,1,2;(+)5,6,7 | (-),1;(+)4 to 7 | (-)0;(+)4,5 | |
| Crude Fuel | (+)4,5 | | (+)1,2 | |
| Finished Energy Goods | NA | NA | (+)2 to 4 | |
| Finished Energy Goods, SA | NA | NA | (+)2 to 4 | (-)5* |
| Intermediate Energy Goods | NA | NA | (+)2,3 | |
| Intermediate Energy Goods, SA | NA | NA | (+)2,3 | |
| Crude Energy Materials | NA | NA | (+)1 to 3 | (-)4,5 |
| Fuel, Power and Related Products | (+)3 to 5 | None | (+)2 to 4 | |
| Coal | (+)3 to 5 | | (+)1 to 3 | |
| Electric Power | None | | (+)0 to 3 | |
| Industrial Power | None | | (+)0 to 3 | |
| Crude Petroleum | (+)4 to 6;(-)8. | | (+)2 to 4 | |
| Refined Petroleum | (-)0,(+)4 to 6 | (-)1* | (+)2 to 4 | |
| Gasoline | (+)4,5 | | (+)3,4 | (-)4,5 |
| Gasoline, SA | NA | NA | (+)3,4 | |
| Light Distillate | (-)0,1;(+)5 | | (+)2 to 4 | |
| Middle Distillate | (-)0,1;(+)4,5 | | (+)2 to 4 | |
| Fuel oil, #2, to resellers | NA | NA | (+)2 to 4 | |
| Fuel oil, #2, to resellers, SA | NA | NA | (+)2 to 4 | |
| Residual Fuels | (-)0;(+)4,5 | | (+)3,4 | |
| Residual Fuels, SA | NA | NA | (+)3,4 | (-)5* |
| Housing Fuel | (+)5 | | (+)3,4 | |
| Housing Fuel, SA | (+)5 | | (+)2 to 4 | |
| Consumer Gasoline | (+)4 to 6 | (-)2* | (+)3, 4 | |
| Consumer Gasoline, SA | (+)4,5 | | (+)3,4 | |
| Adjusted Crude Oil | (+)4 to 6; (-)8 | | (+)3,4 | |

1/ NA indicates data not available.

Table 6

CAUSALITY TESTS FOR CYCLICAL ENERGY PRICES

($H_o$: $\Delta UN \nrightarrow \dot{p}$; Equation 10: $\beta_i = 0$; i = 1 to 6)

95 Percent Confidence Level

| Change in Energy Price ($\dot{P}$) | Sample Period | Lags ($\Delta UN, \dot{P}$) | F-statistic |
|---|---|---|---|
| Finished Energy Goods, SA | IV/1975 to IV/1980 | All 1/ | -:Cannot Reject |
| Crude Energy Materials | IV/1975 to IV/1980 | All | -:Cannot Reject |
| Producer Gasoline | I/1974 to IV/1980 | All | -:Cannot Reject |
| | IV/1949 to IV/1973 | All | -:Cannot Reject |
| Residual Fuels, SA | IV/1975 to IV/1980 | All | -:Cannot Reject |
| Refined Petroleum | IV/1949 to IV/1973 | All 2/ | -:Cannot Reject |
| | I/1974 to IV/1980 | All | -:Cannot Reject |
| Consumer Gasoline | IV/1968 to IV/1973 | All | -:Cannot Reject |
| | I/1974 to IV/1980 | All | -:Cannot Reject |
| Fuel and Related Products and Power | IV/1949 to IV/1973 | All | -:Cannot Reject |
| | I/1974 to IV/1980 | All | -:Cannot Reject |
| Crude Oil 3/ | IV/1949 to IV/1973 | All | -:Cannot Reject |
| | I/1974 to IV/1980 | All | -:Cannot Reject |

1/ All refers to each set of lags ($\Delta UN$, $\dot{p}$) for lag values from 1 to 6 quarters for $\dot{p}$, and 0 to 6 quarters for $\Delta UN$.

2/ The F-statistics, for the lag set (0,1) and (0,2) are significant, where the first entry indicates the autoregressive lag length and the second is the lag length on past unemployment rate changes. The addition of $\dot{p}_{t-1}$ is included, $\Delta U$ is insignificant at all lags.

3/ The results for the composite cost of oil to refiners after 1973 are the same, but the sample period is IV/1975 to IV/1980.

Table 7

SIGNIFICANT CORRELATIONS OF CHANGES IN NOMINAL ENERGY PRICES AND PAST (LAGS) OR FUTURE (LEADS) OF UNEMPLOYMENT RATE CHANGES

| | Period Ending IV/1973 1/ | | I/1974 to IV/1980 | |
|---|---|---|---|---|
| | Leads | Lags | Leads | Lags |
| Non-Food Materials Excluding Fuel | (-):0 to 3 | (-),1;(+)4 to 7 | (-)0:0,5 | |
| Crude Fuel | | | (-)2 | (-)5 |
| Finished Energy Goods | NA | NA | | |
| Finished Energy Goods, SA | NA | NA | | (-)5 |
| Intermediate Energy Goods | NA | NA | | |
| Intermediate Energy Goods, SA | NA | NA | | (-)5 |
| Crude Energy Materials | NA | NA | | (-)4, |
| Fuel, Power and Related Products | (-)0;(+)8 | | | |
| Coal | | | | |
| Electric Power | (+)1 | | (+)0 | |
| Industrial Power | | | (+)0 | |
| Crude Petroleum | (+)8 | | (-)1 | |
| Refined Petroleum | (-)0,4;(+)8 | (-)1,2 | | |
| Gasoline | (-)0 | (-)1,2 | | |
| Gasoline, SA | NA | NA | | |
| Light Distillate | (-)0;(+)8 | | | |
| Middle Distillate | (-)0;(+)8 | | | |
| Fuel oil, #2, to resellers | NA | NA | | (-)5 |
| Fuel oil, #2, to resellers, SA | NA | NA | | (-)5 |
| Residual Fuels | (-)0,4,5;(+)1,8 | | | |
| Residual Fuels, SA | NA | NA | | (-)5 |
| Housing Fuel | | | (-)1 | |
| Housing Fuel, SA | | | (-)1 | |
| Consumer Gasoline | | (-)2 | | |
| Consumer Gasoline, SA | | | | |
| Adjusted Crude Oil | NA | NA | (-)1 | |

1/ NA indicates data not available.

Figure 1

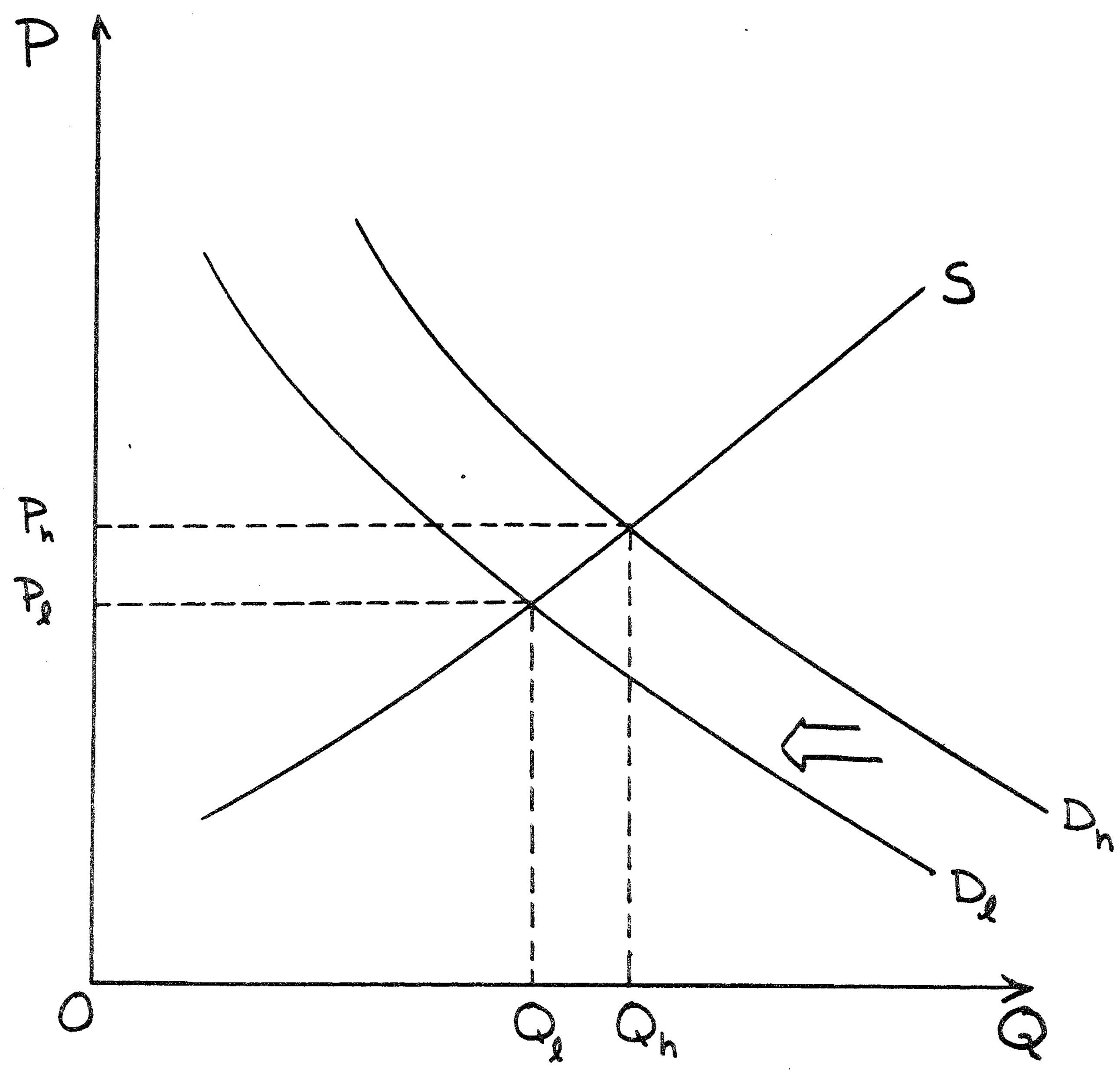

Figure 2