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Energy Prices and Short-Run Economic Performance

JOHN A. TATOM

THE sharp energy price increases that have occurred since late 1978 have profoundly affected the U.S. economy. In particular, the increase in the price of energy resources relative to the price of business output has reduced potential output and productivity, raised the general level of prices, and lowered the optimal capital intensity of U.S. production which, in turn, will temporarily slow real business investment in the early 1980s. Higher energy prices have also had temporary effects on total spending and employment.

The purpose of this article is to explain and assess the magnitude of these energy price effects. Empirical tests are conducted using a reduced-form model for nominal GNP, the price level and the unemployment rate. Real GNP growth is determined implicitly in such a model as the difference between nominal GNP growth and the rate of price increase. This model emphasizes the link between money stock growth and economic activity. The sample period for estimating the relationships ends in the third quarter of 1978 to provide an opportunity to test the stability of the relationships over the past two years, when energy prices increased sharply. Also, major changes in economic policy have occurred since 1978 that may have affected fundamental relationships that explain spending, inflation, output and unemployment. The empirical results, including simulations from the fourth quarter of 1978 to the third quarter of 1980, strongly support the hypotheses developed below concerning energy price effects. An assessment of the size of the effects of recent energy price increases is obtained from the empirical estimates.

The estimates indirectly imply that, once energy price effects are taken into account, no significant shift in the relationship between the money stock and major measures of economic performance has occurred over the last two years. Neither the shift in focus toward greater emphasis on controlling monetary aggregate growth announced in November 1978, nor a shift in policy procedures in October 1979, appear to have exerted independent impacts on the linkages between money and the principal measures of economic performance.

THEORETICAL CONSIDERATIONS

A simple aggregate supply and demand model will clarify the analysis.[1] In figure 1, the economy initially is in equilibrium with price level, P_0, and real GNP level, X_0, at point A. The aggregate demand curve, AD, is constructed given levels of such other relevant determinants of demand as current and past monetary and fiscal actions. The aggregate supply curve, SS, is constructed given such other determinants of supply as expected nominal wages, the size of the labor force, the existing capital stock, the relative price of energy, and technology. The price of energy (instead of a quantity of energy) enters the model indicating that the economy in figure 1 is "open;" energy resources can be imported or exported at prices set in a world market.[2] The aggregate supply curve is constructed with increasing slope to show that at some real output level, it becomes difficult to increase real

[1]For a more detailed discussion of the theoretical foundation used here, as well as a discussion of alternative macroeconomic approaches and empirical evidence from several nations supporting the theory, see Robert H. Rasche and John A. Tatom, "Energy Price Shocks, Aggregate Supply and Monetary Policy: The Theory and International Evidence," forthcoming in the *Carnegie-Rochester Conference Series on Public Policy,* Volume 14, 1981.

[2]It is important to note that the effects of a higher relative price of energy due to exogenous energy market developments *do not* depend upon the net trade status of the economy.

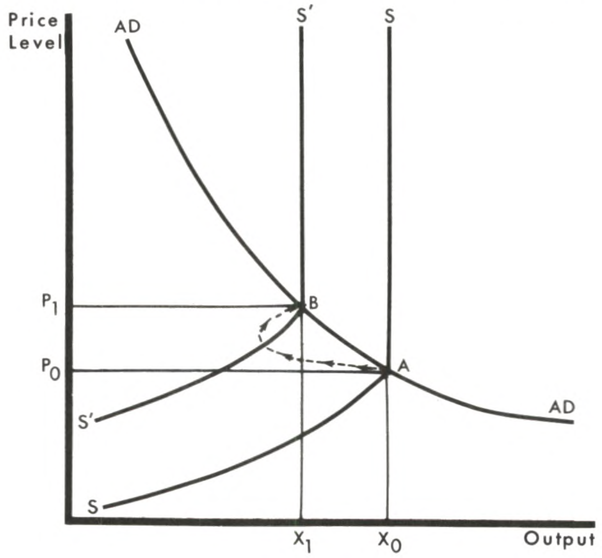
output despite increases in the general level of prices. At this output level, the economy achieves full employment, utilizing available capital and labor resources. Suppose that such full-employment conditions occur at the initial equilibrium, point A.

When the relative price of energy resources increases, the aggregate supply curve shifts to S′S′. The employment of existing labor and capital with a given nominal wage rate requires a higher general price for output, if sufficient amounts of the higher-cost energy resources are to be used. Of particular interest, however, is the level of output and price level associated with full employment of existing labor and capital. This point is indicated in figure 1 at point B. Given the same supply of labor services and existing plant and equipment, the output associated with full employment declines as producers reduce their use of relatively more expensive energy resources and as plant and equipment become economically obsolete. The productivity of existing capital and labor resources is reduced so that potential real output declines to X_1. In addition, the same rate of labor employment occurs only if real wages decline sufficiently to match the decline in productivity. This, in turn, happens only if the general level of prices rises sufficiently (P_1), given the nominal wage rate.[3]

The new equilibrium for the economy occurs at point B. For aggregate demand to equal X_1 at price level P_1, the aggregate demand curve must be unit-elastic with respect to the price level. In the context of the equation of exchange, $MV=Y$ (where M is the money stock, V is its velocity and Y is nominal GNP), this means that velocity is unaffected by a rise in the price level, a standard long-run proposition in monetary theory.[4]

The economy may not adjust instantaneously to point B, even if point B is the new equilibrium. For example, price rigidities due to costly information or other transactions costs can keep nominal prices from adjusting quickly. The immediate incentive to cut production and employment indicated by the leftward shift in the aggregate supply curve need not be accompanied immediately by the price level adjustment sufficient to ensure the maintenance of full employment. In this event, disequilibrium GNP will be dominated by the reduction in output before the equilibrium B (and full employment) is achieved. Consequently, output and prices can move along an adjustment path such as that indicated by the arrow in figure 1. The evidence below is consistent with this adjustment process and the hypothesis that GNP is independent of energy price changes, once the adjustment is completed.

Figure 1
The Effect of a Higher Relative Price of Energy on Output and the Price Level



EVIDENCE ON POTENTIAL OUTPUT AND PRODUCTIVITY

The theory and existing evidence on which this article draws deals with isolating the permanent impact of a higher relative price of energy on potential output, productivity, the desired capital-labor ratio and the price level. Before analyzing the dynamics of the short-run adjustment process, it is useful to review the evidence from a production function approach. Assume that output in the private business sector (Q_t) is a function of hours of employment (h_t), the utilized capital stock (k_t), technological change and the relative price of energy (p_t^e). The production function can be written as:

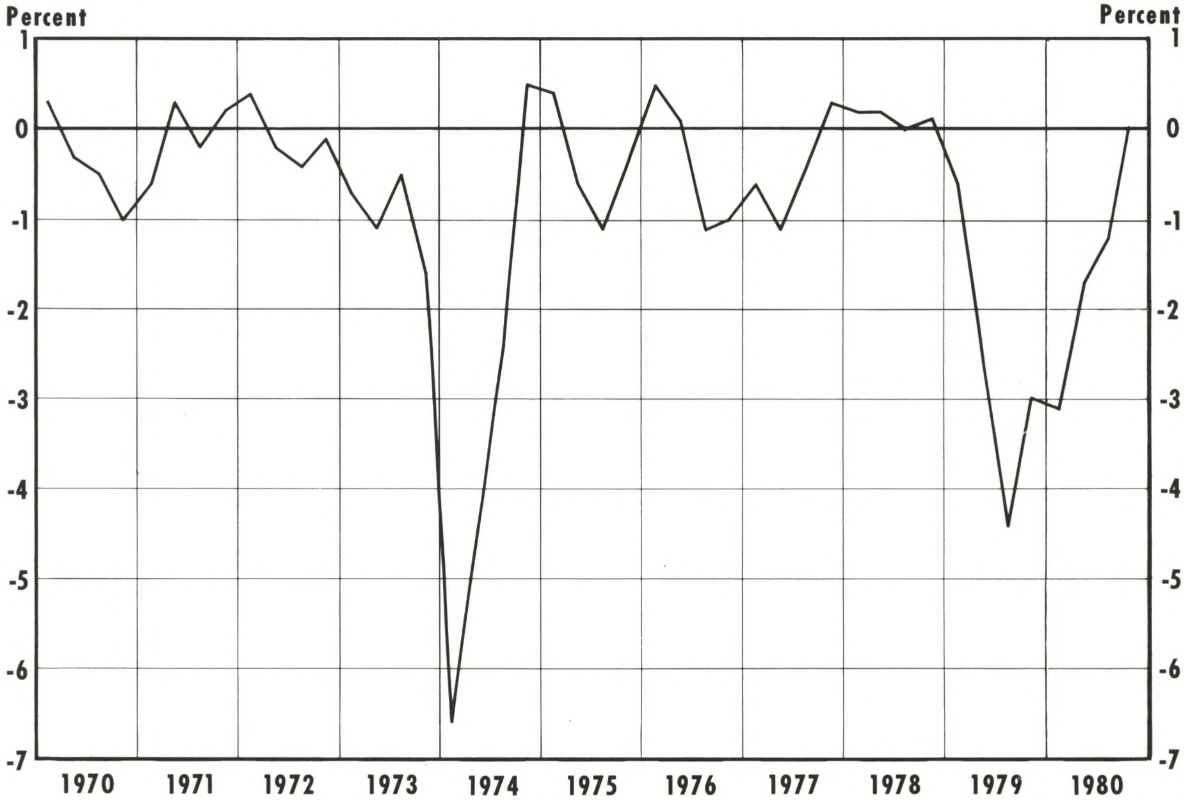
(1) $\ln Q_t = \beta_0 + \beta_1 \ln h_t + \beta_2 \ln k_t + \beta_3 \ln p_t^e + \beta_4 t$

[3]The percentage rise in the price level (percentage decline in the real wage) will equal the decline in productivity, given employment, if the marginal productivity of labor is proportional to its average productivity. This proportionality holds for a Cobb-Douglas production function. The general case is derived by Rasche and Tatom, "Energy Price-Shocks," Appendix 1.

[4]The results when some of the assumptions used here are relaxed, especially the short-run invariance of nominal spending to changes in the price level, are discussed by Rasche and Tatom, "Energy Price Shocks."

Chart 1

Impact of Energy Price Changes (I/1970—III/1980) on Potential Output Growth in the Private Business Sector [1]



Source: Equation 1

[1] Percentage changes are measured in the logarithm of the level of potential output.
Latest data plotted: 4th quarter

where t is a time trend.[5] When this equation is estimated for the private business sector over the period I/1955-III/1978, the result is:

$$(2)\quad \ln Q_t = \underset{(14.14)}{1.464} + \underset{(18.10)}{0.705} \ln h_t + \underset{(7.59)}{0.295} \ln k_t - \underset{(-5.06)}{0.093} \ln p_t^e + \underset{(13.04)}{0.004t}.$$

$\bar{R}^2 = 0.97$ S.E. $= 0.007$ D.W. $= 2.03$ $\rho = 0.81$

This estimate is virtually identical to those reported for earlier periods.[6]

Chart 1 shows the direct impact on the annual growth rate of potential output from I/1970 to III/1980 using the energy price coefficient in equation 2. The relative price of energy measure is calculated by deflating the producer price index for fuels and related products and power by the price deflator for private business sector output. Equation 2 indicates that a 40 percent ($\Delta\ln$) change in the relative price of energy, as occurred from III/1973 to III/1974 or from IV/1978 to II/1980, will permanently reduce potential output and productivity in the private business sector by 3.7 percent.[7]

[5]Rasche and Tatom, "Energy Price Shocks," and "Energy Resources and Potential GNP," this *Review* (June 1977), pp. 10-24 derive equation 1 assuming that the production function is Cobb-Douglas and explain the interpretation of the β coefficients in terms of output elasticities of inputs. They also describe tests for breaks in the time trend and for the Cobb-Douglas restrictions.

[6]For example, see Rasche and Tatom, "Energy Resources and Potential GNP." The sample period conforms to that used for the equations estimated below.

[7]Although tests conducted to detect statistical biases in estimates such as equation 2 have failed to find any, it is possible that quarterly estimates are affected by lagged responses of inputs to output that would result in downward biased estimates of the coefficient on the relative price of energy (in absolute size). For example, the estimate of this coefficient using annual data for the period 1949-75 is 11.3 percent, implying a 4.5 percent reduction in potential output when energy prices rise 40 percent.

A rise in the relative price of energy will also reduce the desired capital-labor ratio, temporarily reducing business investment. The theoretical underpinnings and magnitude of the effect of the 1973-74 energy price increases on investment are discussed elsewhere.[8] Based on that methodology and the coefficient estimates in equation 2, the capital-labor ratio can be expected to decline by 5.3 percent due to energy price increases that occurred from IV/1978 to III/1980.[9] Productivity growth will tend to be slower than it would have been during the years of adjustment to this decline.

The production function estimates provide evidence that the permanent aggregate supply effects of energy price changes occur quickly. A broader model encompassing aggregate demand considerations is required, however, to assess actual quarter-to-quarter adjustments in spending, output and prices.

THE EFFECT OF ENERGY PRICES ON THE MONEY-GNP LINK

To examine the temporary adjustments of nominal GNP to changes in the relative price of energy, a variant of the Andersen-Jordan equation from the St. Louis model is used.[10] This reduced-form equation relates GNP to money stock and high-employment federal expenditure variables. It is usually expressed as:

$$(3)\quad \dot{GNP} = \beta_0 + \beta_1 \sum_{i=0}^{n} w^{o}_{t-i}\, \dot{M}_{t-i} + \beta_2 \sum_{j=0}^{m} w^{1}_{t-j}\, \dot{E}_{t-j}$$

where $\dot{GNP}$, $\dot{M}$ and $\dot{E}$ are annual growth rates (400·Δln) of GNP, the money stock (M) and high-employment federal expenditures (E). The coefficients on current and lagged $\dot{M}$ and $\dot{E}$ variables are estimated using Almon polynomials. The polynomial degree, lag length and constraints for $\dot{M}$ and $\dot{E}$ coefficients are those used in the model — fourth degree polynomials with five lags and head and tail constraints.

Since major strikes temporarily reduce and subsequently increase GNP growth, a variable is included to capture these temporary influences.[11] This variable, S_t, is the change in the quarterly average of "days lost due to strikes," deflated by the civilian labor force.

Monetary aggregates have been revised to reflect the existence of transactions balances not held either as currency or demand deposits at commercial banks. The new measure of the money stock that can be used directly for transactions purposes is M1B, but data on this measure exist only since 1959. The difference in this measure and the old measure, M1, is very small in 1959. More important, the growth rates of both M1 and M1B are roughly the same until the early 1970s. Consequently, the growth of the money stock M1 is used in the estimation of equation 3 for quarters in the sample period prior to 1959. This practice is further supported by the fact that the properties and coefficients of the estimated equation are virtually identical to old estimates using M1 for sample periods prior to the rapid growth of transactions balances in savings accounts with the automatic transfer service.

The GNP equation, estimated for the period I/1955 to III/1978 is:

$$(4)\quad \dot{GNP}_t = \underset{(3.35)}{2.662} + \underset{(7.50)}{1.103} \sum_{i=0}^{4} w^{o}_{t-i}\, \dot{M}_{t-i} + \underset{(0.04)}{0.003} \sum_{j=0}^{4} w^{1}_{t-j}\, \dot{E}_{t-j} \underset{(-3.64)}{-0.471}\, S_t.$$

$\bar{R}^2 = 0.46$ S.E. $= 3.18$ D.W. $= 1.88$

The equation has the usual properties that the sum of the coefficients on money stock growth is not significantly different from one, and that the sum of expenditure effects is not significantly different from zero. The strike variable is significant and has the right sign; the mean value of the strike variable is

[8]See John A. Tatom, "Energy Prices and Capital Formation: 1972-1977," this *Review* (May 1979), pp. 2-11.

[9]Assuming that the price of capital goods relative to business output is unaffected by a rise in energy prices, the elasticity of the desired capital-labor ratio with respect to the relative price of energy is $(-\frac{\gamma}{\alpha})$, where γ and α are the output elasticities of energy and labor, respectively. Given the estimates in equation 2, $\gamma = 8.5$ percent and $\alpha = 64.5$ percent. Thus, the estimated capital-labor ratio elasticity is 13.2 percent. This figure merely suggests the magnitude, however. When the sample period is lengthened or annual data is used, the estimate is over 15 percent, not significantly different in a statistical sense, but larger nonetheless. Moreover, it is likely that higher energy prices raise the relative price of goods, further depressing the capital-labor ratio.

[10]See Leonall C. Andersen and Jerry L. Jordan, "Monetary and Fiscal Actions: A Test of their Relative Importance in Economic Stabilization," this *Review* (November 1968), pp. 11-24; Leonall C. Andersen and Keith M. Carlson, "A Monetarist Model for Economic Stabilization," this *Review* (April 1979), pp. 7-25; and Keith M. Carlson, "Does the St. Louis Equation Now Believe in Fiscal Policy?" this *Review* (February 1978), pp. 13-19.

[11]See Leonall C. Andersen, "A Monetary Model of Nominal Income Determination," this *Review* (June 1975), pp. 9-19, for an example of using strike dummies in such a GNP equation.

0.017, so that the mean strike effect is only –0.008 percent.

To examine the impact of the relative price of energy on GNP, current and lagged values of the annual growth rate of the relative price of energy are added to equation 4. A search was conducted for the optimal lag length using F-tests for each additional lagged value of the growth of the relative price of energy and for additional groups of lagged values (up to five at a time). The criterion for including lags is the 5 percent significance level. Up to 16 lagged values were examined. The same examination was conducted using polynomial distributed lags up to the fourth degree, with and without end-point constraints. The results are virtually identical to those reported below and the polynomial restriction is unimportant. The polynomial distributed lag results are discussed in the appendix.

The optimal lag length includes the current and six past values of the growth in the relative price of energy. The equation estimate with the unrestricted distributed lag for energy prices is:

$$(5)\quad \dot{GNP}_t = \underset{(3.20)}{2.677} + \underset{(7.49)}{1.138} \sum_{i=0}^{4} w^{o}_{t-i} \dot{M}_{t-i} - \underset{(-0.11)}{0.009} \sum_{j=0}^{4} w^{1}_{t-j} \dot{E}_{t-j}$$

$$- \underset{(-3.54)}{0.443}\, S_t - \underset{(-1.32)}{0.050}\, \dot{p}^{e}_{t}$$

$$+ \underset{(1.12)}{0.050}\, \dot{p}^{e}_{t-1} - \underset{(-0.66)}{0.029}\, \dot{p}^{e}_{t-2} - \underset{(-0.51)}{0.022}\, \dot{p}^{e}_{t-3} - \underset{(-1.09)}{0.048}\, \dot{p}^{e}_{t-4}$$

$$+ \underset{(0.28)}{0.012}\, \dot{p}^{e}_{t-5} + \underset{(2.83)}{0.106}\, \dot{p}^{e}_{t-6}.$$

$\bar{R}^2 = 0.52$ S.E. $= 2.97$ D.W. $= 1.91$

An F-test (5 percent significance level) of adding the energy price terms to equation 4 rejects the hypothesis that each of the energy price coefficients is zero ($F_{7,80} = 2.63$). The coefficients on the variables in equation 4 are not changed significantly in estimating equation 5.

The coefficients on the relative price of energy can be used to determine the effect on nominal spending of an increase in the growth rate of energy prices or of a once-and-for-all rise in energy prices. The sum of the coefficients on the rate of increase in energy prices indicates the long-run effect on the growth of nominal GNP of a 1 percentage-point increase in the annual rate of energy price increases. This sum also indicates the effect on the level of GNP of a once-and-for-all rise in the relative price of energy. Consider an x percent rise in the relative price of energy in the current quarter. Such a rise affects GNP in the current quarter and results in a difference in the logarithm of GNP. An effect on GNP continues, according to equation 5, for six more quarters, even though the change in the relative price of energy is zero in subsequent quarters. The pattern of coefficients on the energy price terms indicates that a current-quarter rise in the relative price of energy tends to reduce nominal GNP for six quarters, then increases it.

In order to test the hypothesis that a change in the relative price of energy has no lasting effect on nominal GNP, equation 5 is estimated with the sum of the energy price coefficients constrained to zero. The F-statistic for the addition of the freely estimated coefficient in equation 5 is $F_{1,80} = 0.13$, which is not significant at the 1 percent level. The constraint that the sum of the relative price of energy effects on GNP is zero cannot be rejected. The constrained equation is:

$$(6)\quad \dot{GNP}_t = \underset{(3.32)}{2.567} + \underset{(7.70)}{1.147} \sum_{i=0}^{4} w^{o}_{t-i} \dot{M}_{t-i} + \underset{(0.05)}{0.004} \sum_{j=0}^{4} w^{1}_{t-j} \dot{E}_{t-j}$$

$$- \underset{(-3.57)}{0.444}\, S_t - \underset{(-1.49)}{0.054}\, \dot{p}^{e}_{t} + \underset{(1.10)}{0.049}\, \dot{p}^{e}_{t-1}$$

$$- \underset{(-0.73)}{0.031}\, \dot{p}^{e}_{t-2} - \underset{(-0.58)}{0.025}\, \dot{p}^{e}_{t-3} - \underset{(-1.16)}{0.050}\, \dot{p}^{e}_{t-4}$$

$$+ \underset{(0.22)}{0.010}\, \dot{p}^{e}_{t-5} + \underset{(2.87)}{0.101}\, \dot{p}^{e}_{t-6}.$$

$\bar{R}^2 = 0.53$ S.E. $= 2.95$ D.W. $= 1.91$

The F-statistic for the addition of the six independently estimated variables in equation 6 to equation 4 is $F_{6,81} = 3.08$, which exceeds the critical F-statistic at the 1 percent significance level, so that the hypothesis that each of the relative price of energy coefficients is zero is again rejected. None of the coefficients in equation 6 is significantly different from those in equation 5. Equation 6 not only supports the hypothesis that there is no permanent effect of the relative price of energy on GNP, it also provides evidence on the adjustment process with price rigidities. Initially, nominal GNP is reduced by an increase in the relative price of energy, as nominal GNP is dominated by the real output effect discussed above. Only later do price level effects reverse this nominal GNP development. After six quarters, the transitory movements in GNP have washed out. The theoretical proposition that the shift in aggregate supply due to energy price changes leaves nominal demand unchanged is supported by the estimated equation.

Energy price changes have been substantial since the end of the sample period for equations 4 - 6. Moreover, the growth of the money stock has been erratic since the end of the third quarter of 1978,

Table 1
Simulation of Equation 6

One-quarter period ending	Actual $\dot{GNP}$	Simulated $\dot{GNP}$	Error[1]
IV/1978	14.6%	14.6%	0.0%
I/1979	11.9	10.9	–1.0
II/1979	5.8	8.3	2.5
III/1979	11.5	11.5	–0.1
IV/1979	8.5	12.3	3.9
I/1980	11.9	9.0	–2.9
II/1980	–1.1	3.4	4.5
III/1980	11.2	5.6	–5.5
		Mean error =	0.17

Root-mean-squared error = 3.18%

[1]Figures may not add exactly due to rounding.

Table 2
Simulation of Equation 4

One-quarter period ending:	Simulated $\dot{GNP}$	Error[1]
IV/1978	12.6%	–1.9%
I/1979	10.7	–1.2
II/1979	9.7	3.9
III/1979	12.8	1.2
IV/1979	12.6	4.1
I/1980	11.6	–0.3
II/1980	5.8	6.8
III/1980	7.7	–3.4
	Mean error =	1.2

Root-mean-squared error = 3.50%

[1]Figures may not add exactly due to rounding.

especially in 1980. Thus, the ability of equation 6 to simulate the post-sample experience is a strong test. Using actual data for money stock, federal expenditures, and relative price of energy growth rates for the period IV/1978-III/1980 results in the predicted growth rates of nominal GNP shown in the second column of table 1. Column 1 shows the actual GNP growth rates. The third column shows the simulation errors (simulated growth minus actual growth).

Equation 6 tracks extremely well in the eight-quarter post-sample period. The errors in the last two quarters, however, suggest that the credit control program in the second quarter and its removal in the third quarter had an impact. Over the eight quarters, the mean error is 0.05 percent and the root-mean-squared error (RMSE) is 3.2 percent, only slightly larger than the standard error of the equation. For the first six quarters of the simulation, the mean error is 0.33 percent and the RMSE is 2.23 percent, less than the standard error in equation 6.

The importance of the temporary energy price effects emerges from the same simulation experiment using equation 4, which ignores energy prices. The simulated GNP growth rates and residuals are shown in table 2. Ignoring *temporary* energy price effects leads to over-estimates of GNP growth. The mean error is 1.2 percent for the eight quarters and 1.0 percent for the first six quarters, much larger than in table 1. The size of each of the residuals in table 2 is generally larger than in table 1. The RMSE is larger than the standard error in equation 4 and larger than in table 1.

Despite the quality of the simulation results for equation 6, it must be noted that the economy has seldom been forced to adjust to large changes in the relative price of energy. Thus, the estimates in equations 5 and 6 may be heavily influenced by the particular events surrounding 1973-75 developments. To examine this possibility, the sample period for equations 4 - 6 is extended to III/1980. A search for the optimal lag structure was conducted again, using the criterion and selection procedure described above. The optimal lag structure is the same, the current and six lagged values of the growth of the relative price of energy. The sign pattern, magnitude and significance of all the coefficients, including the relative price of energy terms, are essentially unchanged when the sample period is extended. The equations have about the same adjusted R^2 and standard error when the sample period is extended. Estimated over the longer sample period, equation 6 is:

$$(6')\quad \dot{GNP}_t = \underset{(3.31)}{2.708} + \underset{(8.05)}{1.165} \sum_{i=0}^{4} w^o_{t-i} \dot{M}_{t-i} - \underset{(-0.03)}{0.002} \sum_{j=0}^{4} w^1_{t-j} \dot{E}_t$$

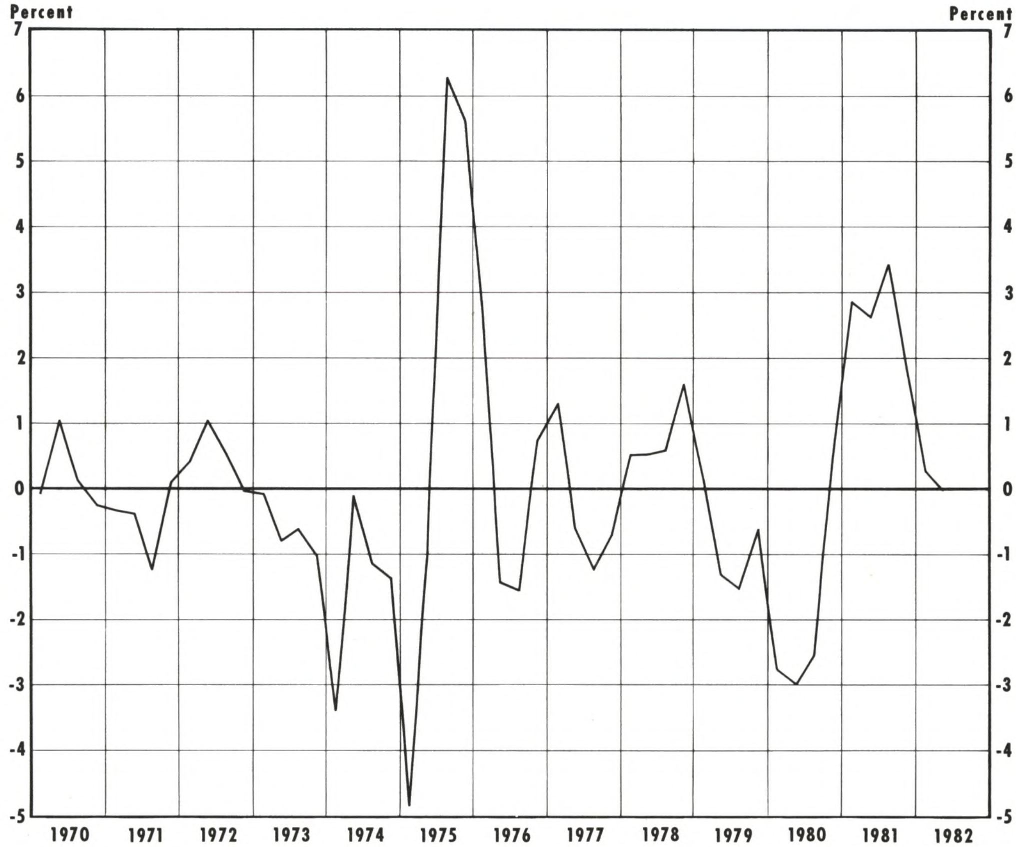
$$- \underset{(-3.71)}{0.453}\, S_t - \underset{(-1.93)}{0.062}\, \dot{p}^e_t$$

$$+ \underset{(0.77)}{0.032}\, \dot{p}^e_{t-1} - \underset{(-0.08)}{0.003}\, \dot{p}^e_{t-2} - \underset{(-1.08)}{0.045}\, \dot{p}^e_{t-3} - \underset{(-0.76)}{0.032}\, \dot{p}^e_{t-4}$$

$$+ \underset{(0.24)}{0.010}\, \dot{p}^e_{t-5} + \underset{(2.93)}{.099}\, \dot{p}^e_{t-6}.$$

$\bar{R}^2 = 0.54$ S.E. = 2.96 D.W. = 1.99

Chart 2
Contribution of Energy Price Changes (I/1970—III/1980) to GNP Growth [1]



Source: Equation 6

[1] Percentage changes are measured by changes in the logarithm of the level of the gross national Product.
Latest data plotted: 4th quarter

When equation 4 is estimated over the same sample period (I/1955-III/1980), it too does not change significantly (the standard error is 3.18 percent). The F-statistic for the addition of the relative price of energy terms, $F_{6,89} = 3.47$, is significant at the 1 percent level. The lag structure, size and significance of the energy price effects in equation 6 do not appear to be artifacts of the 1973-75 experience.

To provide a longer perspective on the relative price of energy's impact on GNP, as well as a more balanced perspective on recent developments, chart 2 provides estimates of the impact of actual energy price developments on GNP growth for each quarter from I/1970 to II/1982 using the coefficients in equation 6. These estimates span three diverse periods from a statistical view: the period I/1970-III/1978 is within the sample period for equation 6; the period IV/1978-III/1980 is that of the post-sample simulation of equation 6; and the estimates for IV/1980-II/1982 are based on the assumption that the relative price of energy does not change in IV/1980-II/1982. The chart shows that current and past energy price changes exerted large negative impacts on GNP growth from I/1974 to I/1975 and from II/1979 to III/1980. In the first instance, these changes were offset by the subsequent positive effects of past energy price increases in III/1975-I/1976. It remains to be seen whether the large offsetting reactions of GNP growth to past energy price changes shown from IV/1980-IV/1981 will materialize.[12]

[12] An important caveat is necessary. The *assumption* that the relative price of energy remains unchanged after III/1980 is included to illustrate the presence, size and pattern of lagged effects of past energy prices on future GNP growth. It is well known that the relative price of energy will rise over the year III/1980-III/1981 due to U.S. energy policy. The quarterly timing of this increase, however, is not known with a high degree of certainty.

ENERGY PRICES, THE MONEY-PRICE LINK AND REAL GNP DEVELOPMENTS

The effect of a change in the relative price of energy on the general level of prices can be examined in the context of a simple reduced-form equation that focuses on the link between money and prices. In particular, the rate of increase in the GNP implicit price deflator is primarily determined by growth in the stock of money. Prior evidence indicates that the growth of the money stock over the past 20 quarters (five years) is a significant determinant of the rate of increase in prices.[13] The period of wage-price controls, which falls within the sample period, had a significant impact on prices. Controls temporarily reduced price increases, then temporarily raised the rate of increase. Dummy variables are included in the price equations estimated here to account for these effects.[14]

To investigate the effect of changes in the relative price of energy on the price level, current and lagged values of the rate of change in the relative price of energy are added to the reduced-form relationship between money growth and rate of price increase P_t. The basic price equation, without energy price variables, for the period I/1955-III/1978 is:

$$(7)\quad \dot{P}_t = \underset{(27.57)}{1.020} \sum_{i=0}^{20} w_{t-i}\, \dot{M}_{t-i} \underset{(-3.99)}{-2.045}\, D1 + \underset{(5.30)}{2.625}\, D2.$$

$\bar{R}^2 = 0.75$ S.E. $= 1.21$ D.W. $= 1.66$

[13]See Denis S. Karnosky, "The Link Between Money and Prices: 1970-76," this *Review* (June 1976), pp. 17-23. Karnosky shows the permanent impact of a higher relative price of energy on the price level, and the absence of a permanent wage and price control effect. The approach below differs slightly. The relative price of energy is used in the price equation instead of a dummy variable for the energy price effect, and the timing of wage and price control effects is different. Also, Keith M. Carlson, "The Lag from Money to Prices," this *Review* (October 1980), pp. 3-10, argues that since 1970 the length of the lag for past money growth has shortened to 12 quarters. This result does not hold for equation 8 below. The optimal lag length for the period I/1970-III/1978 for this equation is 22 quarters, virtually the same as used here.

[14]For the control period, III/1971-I/1973, the dummy variable D1 has a value of unity, and zero in other periods. The dummy variable D2 has a value of unity in I/1973-I/1975 and zero otherwise, to capture the effects of the ending of price controls. The choice of the periods for control and decontrol effects is largely motivated by the findings reported by Alan S. Blinder and William J. Newton, "The 1971-1974 Controls Program and the Price Level: An Econometric Post-Mortem," National Bureau of Economic Research, Inc., Working Paper No. 279 (September 1978). Their results, for the monthly consumer price index, support the view that the retarding effects of controls on inflation ended in early 1973 and that these effects were offset by "catch-up" inflation that began at that time and continued until the first quarter of 1975. Earlier experiments with varying the timing of this specification resulted in higher standard errors for the price equations 7 and 8.

Table 3
Simulation of Equation 8

One-quarter period ending	Actual $\dot{P}$	Simulated $\dot{P}$	Error[1]
IV/1978	9.3%	6.1%	–3.2%
I/1979	8.1	6.2	–1.9
II/1979	7.5	6.5	–1.0
III/1979	7.5	7.5	0.0
IV/1979	7.8	8.6	0.7
I/1980	8.9	9.2	0.3
II/1980	9.4	8.4	–0.9
III/1980	8.8	9.6	0.8
		Mean error =	–0.7

Root-mean-squared error = 1.48%

[1]Figures may not add exactly due to rounding.

Since a constant is not significant in any of the price equations estimated, it is omitted. The sum of money growth coefficients is not significantly different from unity; the price control dummy variables are significant and have the correct sign. A test of the hypothesis that price controls had no permanent impact on the price level could not be rejected at the 5 percent significance level, although that constraint is not imposed here. Twenty lagged money growth rates were included because, for a variety of sample periods examined previously, this lag length is optimal (minimum standard error). A third-degree polynomial distributed lag with a tail constraint is used to estimate the current and lagged money growth coefficients.

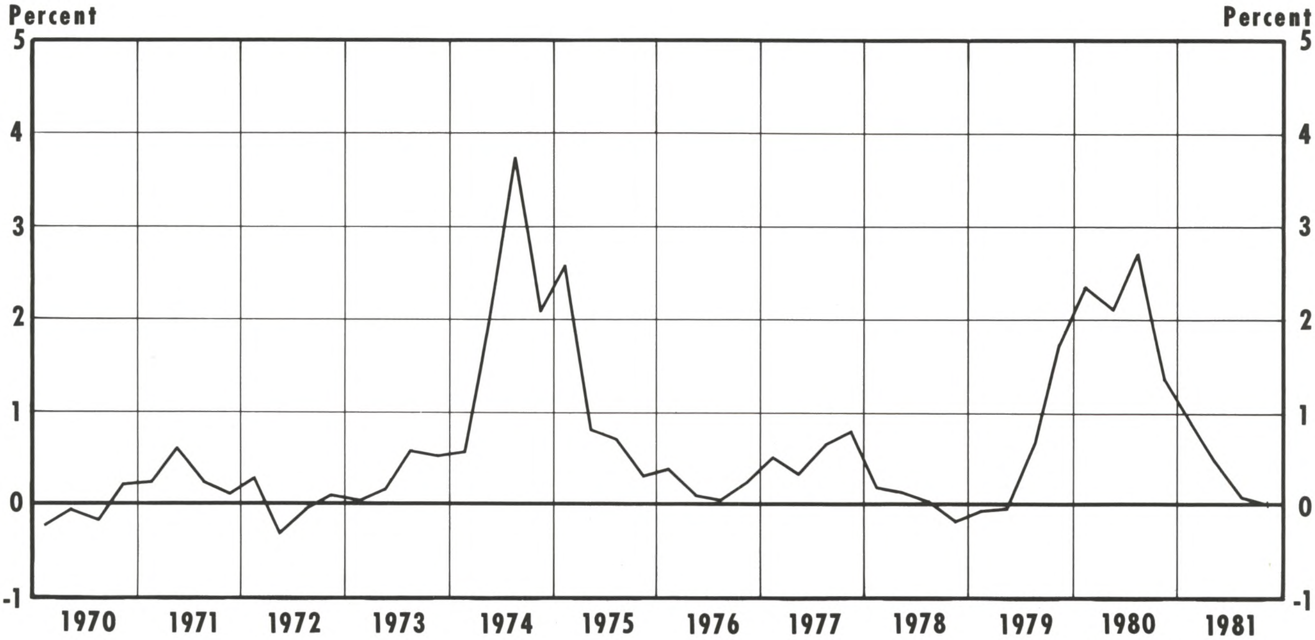
Up to 16 lagged values of the rate of change in the relative price of energy were examined using an unrestricted distributed lag. An F-test (5 percent significance level) was used for the significance of additional lagged values and sets of lagged values. In no case is the current energy price variable significant (generally its t-statistic is less than one-half in absolute value and usually has a negative sign), so it is dropped. The optimal lag structure includes four lagged values of the rate of increase in the relative price of energy. This equation is:

$$(8)\quad \dot{P}_t = \underset{(27.50)}{0.990} \sum_{i=0}^{20} w_{t-i}\, \dot{M}_{t-i} \underset{(-3.89)}{-1.895}\, D1 + \underset{(2.28)}{1.388}\, D2$$
$$+ \underset{(0.90)}{0.014}\, \dot{p}^e_{t-1} + \underset{(2.62)}{0.044}\, \dot{p}^e_{t-2} \underset{(-0.72)}{-0.012}\, \dot{p}^e_{t-3} + \underset{(2.07)}{0.029}\, \dot{p}^e_{t-4}.$$

$\bar{R}^2 = 0.78$ S.E. $= 1.15$ D.W. $= 1.74$

Chart 3

Contribution of Energy Price Changes (I/1970—III/1980) to the Rate of Increase of Prices [1]



Source: Equation 8

[1] Percentage changes are measured by changes in the logarithm of the level of the gross national product deflator.

Latest data plotted: 4th quarter

The F-statistic for the addition of the four lagged energy price terms to equation 7, $F_{4,86} = 3.63$, is significant at the 5 percent level.[15]

The sum of the energy price effects on the level of the GNP deflator in equation 8 is 0.075 (S.E. = .0235). For the sample period I/1955-III/1978, the elasticity of potential private business sector output with respect to the relative price of energy is –0.093, according to equation 2. The price level elasticity of the relative price of energy in equation 8 is not significantly different from this estimate. Thus, the hypothesis that the price level effect is the same as the decline in potential output is not rejected. This reinforces the earlier result that a rise in the relative price of energy has no permanent effect on nominal GNP.

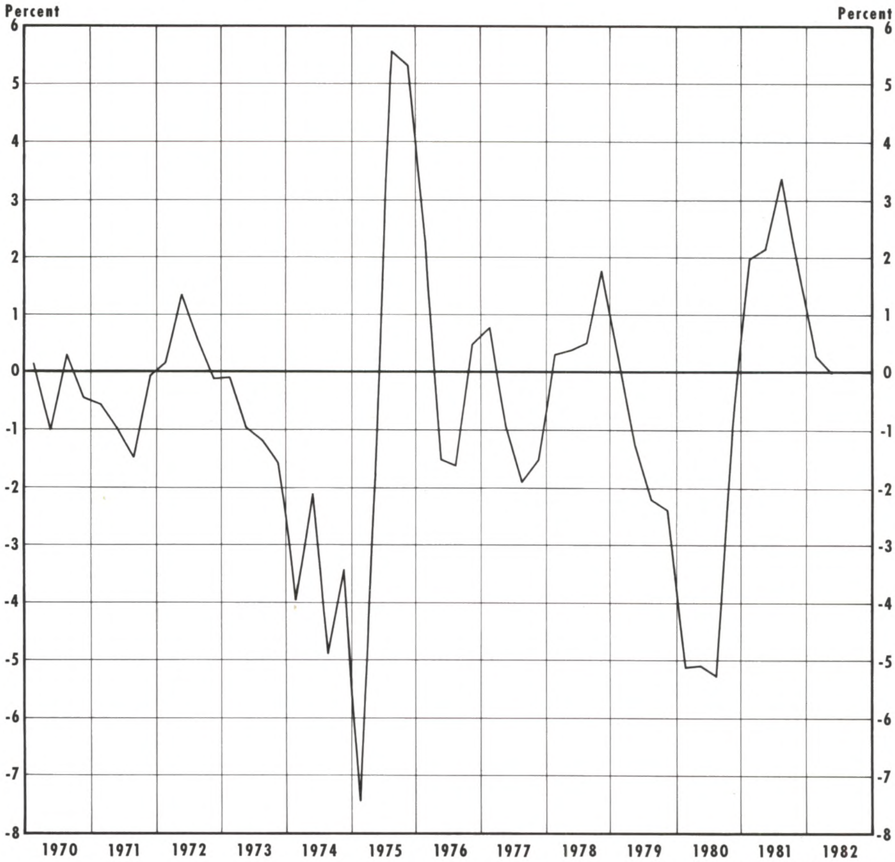
The results of a post-sample simulation of equation 8 are shown in table 3. The rate of price increase is underestimated during late 1978 and early 1979. Beginning in II/1979, however, the errors are quite small. The average error for the last six quarters in the post-sample period is –0.01 percent. For the eight-quarter period, the average error is –0.7 percent. The RMSE of 1.5 percent is not significantly larger than the standard error during the sample period.[16] These results contrast sharply with a simulation of equation 7, which omits energy price

[15]Since the GNP and the price estimates are reduced-form equations, the exogenous variables in each are potentially the same. When the wage and price control dummies and the additional lagged money terms included in equation 8 are added to the GNP equation 6, none of the coefficients is significant individually or as a group at the 5 percent significance level. Thus, these variables are not included in equation 6. Also, when the strike variable and expenditure variables included in equation 6 are added to the price equation 8, they too are insignificant (all t-statistics are less than 0.4 in absolute value), so they are omitted. It can be concluded that equations 6 and 8 are drawn from the same model with a common set of exogenous variables.

[16]When equations 7 and 8 are reestimated through the third quarter of 1980, there are no important changes in the optimum lag length, the coefficient estimates or the fit of the equations. The standard error of equation 8 rises to 1.169 and the adjusted R^2 rises to 0.80. The pattern of energy price coefficients remains the same and the sum effect for a rise in the relative price of energy is 0.066, essentially the same as above. The sum of the money growth coefficients (1.015) remains essentially unity. The F-statistic for the addition of the energy price coefficients is $F_{4,94} = 4.46$, which is significant at the 1 percent level.

Chart 4

Contribution of Energy Price Changes (I/1970–III/1980) to Real GNP Growth [1]



Source: Equations 6 and 8

[1] Percentage changes are measured by changes in the logarithm of the level of real gross national product.

Latest data plotted: 4th quarter

changes. For the same eight-quarter period, the simulation of equation 7 underestimates inflation in every quarter by an average of 1.8 percent (RMSE = 1.93). The differences are particularly large beginning in the third quarter of 1979 when the simulation error for equation 7 is –0.8 percent; thereafter, the error is –0.9 percent, –1.9 percent, –2.6 percent and –1.7 percent, respectively.

The impact of energy price changes on prices and observed real output can be found from equations 8 and 6. Chart 3 shows the contribution of changes in the relative price of energy to the rate of price increase from I/1970-IV/1981 under the assumptions used above for the effects on GNP growth. Changes in the relative price of energy have had negligible impacts on the GNP deflator except following the two periods of sharp increases. In the first instance, the rate of increase in the GNP deflator was raised on average by over 2 percentage points during the four quarters from I/1974 to I/1975. The same result occurred from III/1979 to III/1980. On an annual basis, the price level impact exceeded 0.6 percentage points in only three years: 1974 and 1980, when the impact was an additional 2.1 percentage points, and 1975, when it was 1.1 percentage points.

The GNP and price level effects are combined in chart 4 to obtain real GNP effects. In general, chart 4 shows the negative permanent impact of the sharp increase in relative energy costs in 1973-74 and 1979-80. This effect, however, is mixed with the transitory impact associated with the dynamic adjustments of output and prices due to the supply shock.

In table 4 the cumulative impact of a 40 percent increase in the relative price of energy in the current quarter is indicated for GNP, prices, and the difference, real output.[17] Note that after six quarters, there is no effect on GNP, the price level is 3.0 percent higher and real output is 3.0 percent lower. These developments illustrate the permanent effects of the energy price increase. During the transition, however, GNP is relatively lower and prices are affected somewhat less than their permanent changes. Real output does not fall as much as its permanent decline until two quarters after the energy price rise. Subsequently, real output overshoots its ultimate decline, then returns to the level of the permanent decline. If the permanent effect on real output is taken to be an estimate of the immediate potential output effect, the gap between potential output and actual real GNP initially narrows so that the unemployment rate for the labor force declines. Subsequently, actual output is reduced relatively more than its permanent decline so that the unemployment rate will temporarily rise. After six quarters, the decline in real GNP is the permanent change. According to the theory, the permanent decline arises because of a fall in potential output and productivity. Consequently, the unemployment rate would not be expected to change beyond the period of transition.

Table 4

The Effects of a 40 Percent Increase in the Relative Price of Energy

Quarter	GNP	Prices	Real output
0	–2.14%	0 %	–2.14%
1	–0.20	0.54	–0.74
2	–1.45	2.31	–2.32
3	–2.44	1.82	–4.26
4	–4.45	3.00	–7.45
5	–4.06	3.00	–7.06
6	0	3.00	–3.00
7	0	3.00	–3.00

ENERGY PRICES, THE MONETARY GROWTH-UNEMPLOYMENT RATE LINK

Transitional unemployment can be examined using a reduced-form equation similar to those above. The general theoretical considerations that are useful here are (1) that the economy tends to full-employment equilibrium unless disturbed by shocks such as policy-induced fluctuations in aggregate demand or supply, and (2) that demand-stimulus, especially through changing the rate of money stock growth, can temporarily reduce the unemployment rate. These considerations have been explored to a limited extent in a reduced-form framework.[18] The hypothesis that the unemployment rate equals the full-employment unemployment rate plus a component that reflects the past history of money growth that leads to temporary departures of the economy from full-employment could not be rejected.

For the hypothesis examined here, changes in the excess of the unemployment rate (U) over a full-employment unemployment rate (U_F) are taken as the dependent variable, ΔUN, where $UN = (U - U_F)$. The full-employment unemployment rate is that developed by Clark (1977).[19] Changes in excess unemployment are potentially a function of the exogenous variables considered above.

An examination of such a relationship yields the following results. First, the federal expenditure growth variables and strike variable that enter the GNP equation 6 are not significant in any of the equations estimated. While the coefficient estimates for current and past federal expenditure growth variables have the expected sign pattern — initially negative, then positive — none of the t-statistics for the individual coefficients or sum coefficients is larger than 0.4 in absolute value. In addition, the F-statistic for the set of federal expenditure variables is less than 0.1, so they are omitted below. Also, the strike variable in equation 6 and the wage and price control dummy variables in the price equation 8 do not have t-values in excess of one in any of the unemployment equation estimates, so they too are omitted.[20] Finally, a constant term was not significant in any of the estimated equations, so it is omitted.

[17]A once-and-for-all rise in the relative price of energy of 40 percent is equivalent to a 160 percent increase during the current quarter, when measured at an annual rate. The GNP effect is found by summing the energy price coefficients times 160 in equation 6, and dividing by four to obtain quarterly differences. The price effects are found by summing the coefficients in equation 8, and again multiplying by 40(160/4).

[18]See John A. Tatom, "Does The Stage of the Business Cycle Affect the Inflation Rate?" this *Review* (September 1978), pp. 7-15.

[19]See Peter K. Clark, "Potential GNP in the United States, 1948-80," *U.S. Productive Capacity: Estimating the Utilization Gap*, (St. Louis: Center for the Study of American Business, Washington University, 1977), pp. 21-66.

[20]This is in sharp contrast to the view that controls distorted the observed relation of unemployment to output growth expressed by Michael R. Darby, "Price and Wage Controls: The First Two Years," "Price and Wage Controls: Further Evidence" in Karl Brunner and Allan H. Meltzer, eds., *The Economics of Price and Wage Controls,* Carnegie-Rochester Conference on Public Policy Series, supplement to the *Journal of Monetary Economics,* Volume 2 (1976).

A search for the optimum lag structure for energy price changes and monetary growth was conducted. The criterion for the optimum lag for energy prices was an F-test at the 5 percent significance level for the addition of past energy price changes. This test was conducted for several specifications of the lag length (6 to 30 quarters) for current and past money growth effects. In every case, the optimum structure includes the past six quarters of relative energy price changes. Since the current-quarter effect never has a t-value as large as 0.5 in absolute value, it is omitted. The criterion for selecting the optimum lag structure for a third degree polynomial lag of current and past money growth is to minimize the standard error of the equation estimated with the six past energy price terms, with and without the other variables discussed above. The optimum lag structure in every case includes the current and nine past money growth rates.

The choice of the 10-quarter period for money growth effects is highly suspect, but fortunately it does not affect the energy price estimates. In particular, changes in the unemployment rate are expected to be a function of changes in the "GNP gap" in an Okun's Law framework. Changes in the GNP gap, in turn, are a function of the growth rate of potential output and the growth rate of actual output. According to the GNP and price results above, the growth rate of actual output is affected by money stock growth for about five years, so changes in the excess unemployment rate would be expected to have the same lag structure. In searching the lag space, equations with 22 lagged money growth rates had a local minimum standard error for lags from 10 to 30 quarters, and this standard error is 0.8 percent higher (0.264 for equation 9) than with nine lagged terms. None of the properties of equation 9 are altered when 22 lagged values of money growth are included. In particular, the optimum lag, sign pattern, magnitude and t-statistics for the individual energy price terms are identical, as is the F-test for the addition of these terms. The difference is that after the ninth lag, money growth coefficients are initially small and positive, then small and negative with a sum that is not significantly different from zero. Because of the criterion adopted for selection of the optimum lag structure, and the independence of the energy price effects to the lag structure choice, the shorter lag for money growth is used here.

The unemployment rate equation 9 is presented in table 5. Note that an increase in the rate of money growth has a transitory effect, leading to reductions in the excess unemployment rate for five quarters. Subsequently, the excess unemployment rate is restored to its initial level. The energy price terms add significantly to the equation, while the sum effect is not significantly different from zero, as hypothesized above; the F-statistic for the addition of the lagged values of the change in the relative price of energy is $F_{6,86} = 6.25$, which is significant at the 1 percent level. Finally, as hypothesized above, a once-and-for-all rise in the relative price of energy initially reduces the unemployment rate. According to equation 9, the sum of the coefficients for period t-1 and t-2 is negative; thereafter, the cumulative sum is positive until period t-6, when the sum is positive but not significantly greater than zero.

Table 5
The Unemployment Equation

(I/1955-III/1978)

Dependent variable: $\Delta(U_t - U_{F,t})$

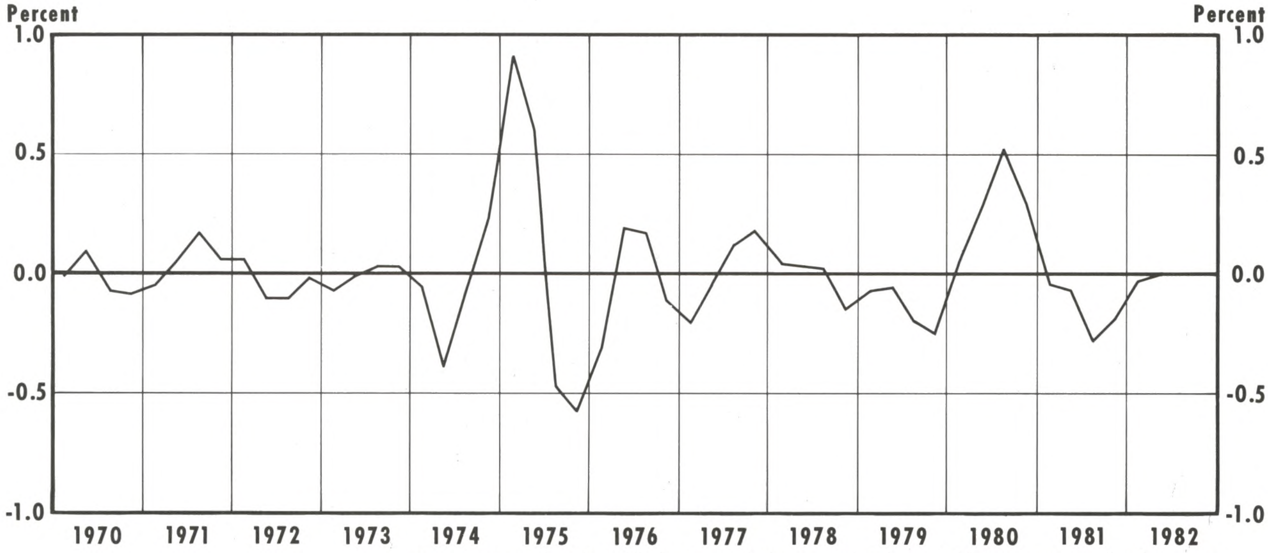
Independent variable	Coefficient	t-statistic
$\dot{M}_t$	–0.021	–2.02
$\dot{M}_{t-1}$	–0.026	–4.65
$\dot{M}_{t-2}$	–0.023	–4.18
$\dot{M}_{t-3}$	–0.015	–2.71
$\dot{M}_{t-4}$	–0.005	–0.98
$\dot{M}_{t-5}$	0.007	1.80
$\dot{M}_{t-6}$	0.017	3.95
$\dot{M}_{t-7}$	0.024	4.23
$\dot{M}_{t-8}$	0.025	4.06
$\dot{M}_{t-9}$	0.017	3.87
$\sum_{i=0}^{9} \dot{M}_{t-i}$	–0.001	–0.07
$\dot{p}^e_{t-1}$	–0.006	–1.95
$\dot{p}^e_{t-2}$	0.005	1.49
$\dot{p}^e_{t-3}$	0.005	1.46
$\dot{p}^e_{t-4}$	0.010	3.19
$\dot{p}^e_{t-5}$	0.005	1.57
$\dot{p}^e_{t-6}$	–0.010	–3.10
$\sum_{j=1}^{6} \dot{p}^e_{t-j}$	0.009	1.36

$\bar{R}^2 = 0.59$ S.E. = 0.262 D.W. = 1.82 $\rho = 0.41$

Equation 9 was also estimated with the sum of the energy price coefficients set equal to zero. The F-statistic for this constraint is $F_{1,86} = 1.85$ which is not significant at the 5 percent level. Thus, the hypothesis

Chart 5

Portion of the Change in the Unemployment Rate Due to Energy Price Changes (I/1970—III/1980)



Source: Equation 9, with the sum of the energy price coefficients constrained to zero

Latest data plotted: 4th quarter

that the significant effects of a rise in the relative price of energy are temporary cannot be rejected. The individual coefficient estimates, with t-statistics, for the past six quarters are: –0.008(–2.77), 0.004(1.13), 0.003(1.05), 0.009(2.89), 0.004(1.24) and –0.011 (–3.81).[21]

A post-sample simulation of equation 9 tracks changes in the excess unemployment rate from IV/1978 to III/1980 very well. The mean error for the eight quarters is –0.015 percentage points. The RMSE is 0.323, which is large relative to the standard error of equation 9. However, in II/1980 and III/1980 there are relatively large errors reflecting unusually slower, then faster, GNP growth and so an unusually larger, then smaller, rise in the unemployment rate. For the first six quarters of the simulation, the RMSE is only 0.177 percentage points, which is much smaller than the standard error of equation 9. The mean error for the first six quarters is the same as for the eight quarters. This fit is also supported by extending the sample period for equation 9 through the third quarter of 1980. The adjusted R^2 is 0.58 and the standard error is 0.267. The sum statistics, and the pattern, magnitude and t-statistics for the individual coefficients are virtually the same as for the earlier period. The same results apply to the constrained version of equation 9.

Chart 5 shows the impact of actual increases in energy prices on the change in the excess unemployment rate since the first quarter of 1970. The coefficients from the constrained version of equation 9 are used to compute these effects. Generally the effects are trivial, except in 1974-75 and in 1979-81. During the first three quarters of 1974, the cumulative impact of the energy price increase was to reduce the unemployment rate by 0.5 percentage points. During the next three quarters, the excess unemployment rate rose 1.7 percentage points, and the difference was

[21]The estimates and tests for equation 9 were also conducted using an Almon polynomial to estimate the impact of energy price changes. A second degree polynomial with no end-point constraints proved superior to higher order polynomials (third and fourth) for the energy price effect. The optimal lag is again six quarters for energy prices, and 10 quarters for money growth. The standard error of the equation is slightly lower, 0.261. Only the significance of the energy price coefficients are noticeably changed by such an estimation procedure. These coefficients from t–1 to t–6, with t-statistics, are –0.006(–2.40), 0.004(2.86), 0.009(5.82), 0.009(5.60), 0.003(2.12) and –0.003(–3.28). The adjusted R^2 for this equation is 0.59. A local minimum standard error occurs with 21 lagged values of money growth (S.E. = 0.263) for lags up to 30 quarters.

largely offset in the last two quarters of 1975. On average, the unemployment rate was 0.3 percentage points lower in 1974 and 0.7 percentage points higher in 1975 due to the 1973-74 energy price increases. For the recent round of energy price increases, the estimates indicate that the unemployment rate was lowered by about 0.3 percentage points in 1979, was unaffected on average in 1980 and will be 0.3 points higher in 1981 due to the economy's dynamic adjustment to higher energy prices.

Note that if the 1973-74 episode is dated from the first quarter of 1974 to the first quarter of 1976, the positive cumulative impact of the sharp increase in energy prices occurs only in the four quarters of 1975 when it is 0.6, 1.2, 0.8 and 0.2 percentage points, respectively. This period begins at the trough quarter of the recession. In the second instance, if the impact is summed beginning in the first quarter of 1979, the cumulative impact is not positive until the third quarter of 1980, when it is 0.3 percentage points, and in the next three quarters, when it is about 0.5 percentage points. After mid-1981, the temporarily higher unemployment rate is quickly eliminated by the dynamic functioning of the product and labor markets.

In each instance, the temporary increase in the unemployment rate does not occur until the worst part of the output reduction is complete and the economy is apparently recovering on its own. Second, in each case, when the unemployment rate is temporarily high, the energy-price-induced component is a relatively small part of the total. Finally, in each case the highest levels of positive cumulative unemployment impacts associated with energy price developments have been quickly reversed. Of course, these conclusions provide no support for exercising monetary restraint in the face of sharp energy price and price level surges. On the other hand, they do not warrant even temporary demand stimulus.

SUMMARY AND CONCLUSION

The sharp increase in energy prices in 1979 and 1980 reduced both potential output and productivity, and temporarily increased the inflation rate in the same way, and to the same extent, as in 1974-75. In addition, the absence of perfect price flexibility can give rise to a transition to short-run equilibrium during which total spending, actual output and the unemployment rate are affected. These effects are strongly supported by the empirical estimates for the period ending in the third quarter of 1978 or in the third quarter of 1980. The results support the claim that these effects are transitory.

The equation estimates indicate that a rise in the relative price of energy reduces potential output immediately but that the price level effect of this reduction occurs more slowly (over the subsequent year). Initially, total spending is dominated by reduced output with little change in prices; subsequently, prices are increased. There are strong positive output and GNP effects associated with these price increases toward the end of a six-quarter adjustment period. The output reduction due to an energy price increase initially is smaller than the decline in potential output, then overshoots it, before returning to the size of the permanent decline. The pattern of unemployment rate developments matches this outcome: Initially, the unemployment rate declines, then rises to higher levels before falling sufficiently so that, after six-quarters, an energy price increase has no effect on the unemployment rate.

The magnitude of the transitional effects on GNP prices, output and the unemployment rate have been estimated for the two sharp increases in the relative price of energy in 1973-74 and 1979-80. In 1973-74 and early 1975 there were relatively large reductions followed by relatively large increases in spending growth associated with a rise in the relative price of energy. On average, GNP growth was lowered 0.6 percentage points in 1973, 1.5 percentage points in 1974 and raised 1.5 percentage points in 1975. Due to the 1979-80 episode, GNP growth is estimated to have been 0.8 percentage points lower in 1979 and 2.0 percentage points lower in 1980. These effects are estimated to be offset by faster GNP growth in 1981. The extent of temporary inflation rate effects is estimated to be largest in 1974 and 1980 when energy price developments temporarily added 2.1 percentage points to measured inflation rates.

The temporary effects on real output growth are reflected in unemployment rate developments. The estimates show that energy price developments reduced the unemployment rate by 0.5 percentage points during the first three quarters of 1974, then raised it over the next three quarters, so that at the peak of the unemployment rate in II/1975, 1.2 percentage points were associated with energy price increases. This transitional increase was eliminated quickly. In 1979-80, the peak positive impact of energy price increases is about 0.5 percentage points late in 1980 and early 1981; this impact is estimated to be eliminated by the end of 1981.

The empirical investigation is conducted so that the energy price effects are estimated using data from the period prior to the recent episode of price increases. Aside from providing a stronger test of the hypotheses using the 1979-80 increases, the approach provides an opportunity to examine the impact of the increased emphasis on money growth reductions announced in November 1978 and reinforced by the announcement of procedural changes in October 1979. The simulations for GNP, inflation and unemployment conducted from IV/1978 to III/1980 indicate no change in the basic reduced-form relationships and no independent impact of these announcements or any actions intended to implement the slowing of money growth. Instead, the reduced-form relationships appear to explain spending, price, output and unemployment rate developments as well as they did previously.

Appendix 1

The GNP Results Using an Almon Lag for Energy Price Changes

The purpose of this appendix is to provide comparable estimates to equation 5 using an Almon polynomial distributed lag rather than an ordinary distributed lag. When equation 5 is estimated for the period I/1955-III/1978 using both third and fourth degree polynomials, with and without end-point constraints, for up to 16 lagged terms for the growth in the relative price of energy, the "best" equation is found using the third degree polynomial with six lagged terms without end-point constraints. The specification for the other variables is the same as in equation 5 in the text. The estimated equation for the period I/1955-III/1978 is:

$$(1.1)\quad \dot{GNP}_t = \underset{(3.25)}{2.681} + \underset{(7.59)}{1.124} \sum_{i=0}^{4} w^o_{t-i} \dot{M}_{t-i} - \underset{(-0.04)}{0.003} \sum_{j=0}^{4} w^1_{t-j} \dot{E}_{t-j}$$

$$- \underset{(-3.83)}{0.475}\, S_t + \underset{(0.44)}{0.024} \sum_{k=0}^{6} w^2_{t-k}\, \dot{p}^e_{t-k}$$

$\bar{R}^2 = 0.53$ S.E. $= 2.93$ D.W. $= 1.96$

where the actual coefficients on $\dot{p}^e_{t-k}$ are:

current	–0.028(–0.96)		
t–1	–0.010(–0.65)	t–4	–0.041(–2.34)
t–2	–0.001(–0.07)	t–5	–0.004(–0.22)
t–3	–0.029(–2.18)	t–6	0.116(4.01)

This estimate is similar to equation 5 in the text. The sum of the money growth coefficients is not significantly different from one, and the sums of the expenditure growth variables and energy price change variables are each not significantly different from zero. The pattern of energy price effects and magnitude are the same as in equation 5. The fit of the equation is essentially the same as for equation 5. An F-test of the three additional coefficients estimated in equation 5 indicates they do not add significantly to the explanatory power of equation 1.1. The F-statistic for the addition of the energy price variables to equation 4 in the text is $F_{4,83} = 4.43$, which is significant at the 1 percent level. When equation 1.1 is used to simulate GNP in the eight-quarter post-sample period, the results are essentially the same as the results in table 1 in the text.

When equation 1.1 is estimated over the sample period ending in III/1980, the optimal lag length and polynomial degree remain the same, as do the other properties described above. The F-statistic for the addition of the energy price variables is $F_{4,91} = 5.14$, which is significant at the 1 percent level. The coefficients on the changes in the relative price of energy (from current to t–6) with t-statistics are: –0.041(–1.56), 0.008(0.56), 0.003(0.17), –0.023(–1.96), –0.036(–2.14), 0.003(0.15) and 0.118 (4.17). The sum of the energy price coefficients is 0.024 (0.44). The adjusted R^2 of the equation is 0.54 and the standard error is 2.93 percent. The Durbin-Watson statistic is 2.00.

Unreal Estimates of the Real Rate of Interest

W. W. BROWN and G. J. SANTONI

IN the nearly five decades since the publication of Irving Fisher's *The Theory of Interest,*[1] economists have engaged in numerous attempts to measure the *ex ante* real rate of interest. The effort devoted to obtaining these estimates reflects the fact that the ex ante real interest rate conveys information about some fundamental economic relationships. The ex ante real interest rate is the *expected* net rate of increase in wealth arising from additional investment. Alternatively, it can be viewed as the value of present consumption in terms of future income and, consequently, is implicit in the relative price of present consumption in terms of capital goods. Each of these is reconciled with the others by the profit-seeking market activity of individuals.[2]

Like other relative prices, the ex ante real interest rate enters the optimizing calculus of individuals and ultimately affects resource allocation. Each decision an individual makes, to save or invest or to change current consumption relative to either of these, is a choice which, implicitly at least, involves consideration of the ex ante real interest rate.

Changes in the ex ante real interest rate transmit information about changes in the relative values of resources employed in alternative uses and eventually result in a reallocation of resources to higher valued uses. Changes in this interest rate reflect changes in the net demand for present consumption goods relative to future consumption goods. The allocation of present resources to the production of these goods will be redirected in response to the change in their relative values.

Since all goods are more or less durable (i.e., they yield consumption streams which persist over varying lengths of time), the reallocation of present resources resulting from a change in the ex ante real interest rate will pervade all markets. In the absence of information about the movement of the ex ante real interest rate, it is difficult to distinguish "disturbances" (resource reallocation) induced by shifts in the demand for present consumption goods *relative* to future consumption goods from those caused by shifts in *aggregate* demand for both present and future goods. From the point of view of the policymaker, the distinction is crucial. If the disturbance is the result of a shift in relative demands, resources will be reallocated to higher-valued uses and community net wealth will rise. If the disturbance is the result of a shift in aggregate demand, any *temporary* reallocation of resources occurring during the disturbance must be to lower-valued uses causing community net wealth to fall. Policymakers might wish to eliminate the latter result but should not attempt to retard the former.

While information about changes in the ex ante real interest rate is valuable to the policymaker, it is difficult to obtain. The ex ante real interest rate reflects the *expectations* of individuals regarding *future* events. As such it can not be directly observed. It is, of course, possible (and inexpensive) to observe the

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[1]Irving Fisher, *The Theory of Interest and Capital* (New York: Augustus M. Kelley, 1965).

[2]For a more complete discussion see Armen Alchian and William Allen, *Exchange and Production: Competition, Coordination and Control* (Belmont, California: Wadsworth, 1977), pp. 435-36.

consequences of decisions that are made on the basis of these expectations. The wealth consequences associated with any economic decision can always be calculated after the fact. However, this ex post real rate of return does not bear on economic decisions since it is only known after these decisions have been made. Unlike the ex ante real rate of interest, the ex post real rate of return is irrelevant to the process of resource allocation.

Since the ex ante real interest rate can not be observed directly, individuals interested in estimating its magnitude have been led to employ the simple Fisherian relationship that the nominal (market) rate of interest is equal to the sum of the ex ante real rate of interest and the anticipated rate of inflation in the *general level* of prices. The relationship implies that empirical estimates of the ex ante real interest rate can be obtained by subtracting some measure of the anticipated rate of inflation in the general level of prices from the nominal rate of interest. As a result, previous estimates of the ex ante real interest rate have turned on the complicated problem of measuring the anticipated rate of inflation.

Virtually all previous studies have dealt with this problem by modeling the anticipated rate of inflation in the general level of prices as some function of past changes in the consumer price index (CPI) or GNP deflator.[3] If the real rate of interest is not changing, this method may produce "reasonably" accurate estimates of the anticipated rate of inflation in the general level of prices. Unfortunately, if the real rate of interest is itself changing, these commonly used price indices will produce biased estimates of actual changes in the general level of prices. Consequently, use of these indices to proxy *expected future* price level changes in Fisher's equation will prejudice *measurement* of both the level and direction of movement of the real rate of interest.[4]

This particular problem arises in a number of recent articles dealing with the inflationary period since the late 1960s which have reported sharply declining and negative *ex ante* real rates in 1974 and 1975.[5] The theoretical possibility of a negative ex ante real rate of interest is not at issue here.[6] Casual observation suggests that the preconditions for a negative *ex ante* real interest rate do not now exist, nor did they exist in 1974 and 1975.[7] More importantly, however, sharply declining ex ante real rates imply specific kinds of economic adjustments which were contrary to those that actually occurred during this period.

The purpose of this article is to demonstrate that the *estimates* of the ex ante real rate obtained by these previous studies are spurious. Following Alchian and Klein,[8] it is first demonstrated that, when real rates of interest are rising, commonly used price indices will overstate changes in the general level of prices. This introduces a downward bias into estimates of the real rate of interest when the estimates depend on measured changes in these price indices. Secondly, evidence is presented which indicates that the ex ante real rate of interest increased during

[3]Recent examples include Albert E. Burger, "An Explanation of Movements in Short-Term Interest Rates," this *Review* (July 1976), pp. 10-22; John A. Carlson, "Short-Term Interest Rates as Predictors of Inflation: Comment," *American Economic Review* (June 1977), pp. 469-75; Michael Echols and Jan Walter Elliot, "Rational Expectations in a Disequilibrium Model of the Term Structure," *American Economic Review* (March 1976), pp. 28-44; Jan Walter Elliot, "Measuring the Expected Real Rate of Interest: An Exploration of Macroeconomic Alternatives," *American Economic Review* (June 1977), pp. 429-44; Eugene F. Fama, "Short-Term Interest Rates as Predictors of Inflation," *American Economic Review* (June 1975), pp. 269-82; Eugene F. Fama, "Inflation Uncertainty and Expected Returns on Treasury Bills," *Journal of Political Economy* (June 1976), pp. 427-48; Martin Feldstein and Otto Eckstein, "The Fundamental Determinants of the Interest Rate," *The Review of Economics and Statistics* (November 1970), pp. 363-75; P. J. Hess and J. L. Bicksler, "Capital Asset Prices Versus Time Series Models as Predictors of Inflation," *Journal of Financial Economics* (December 1975), pp. 341-60; William P. Yohe and Denis S. Karnosky, "Interest Rates and Price Level Changes, 1952-1969," this *Review* (December 1969), pp. 18-38.

[4]This bias exists apart from the tax and uncertainty effects noted by others. See, for example, James E. Pesando and L. Smith, "Tax Effects, Price Expectations and the Nominal Rate of Interest," *Economic Inquiry* (June 1976), pp. 259-69; Michael Darby, "The Financial and Tax Effects of Monetary Policy on Interest Rates," *Economic Inquiry* (June 1975), pp. 226-76; Y. Amihud and A. Barnea, "A Note on Fisher Hypothesis and Price Level Uncertainty," *Journal of Financial and Quantitative Analysis* (September 1977), pp. 525-29.

[5]See for example Elliot, "Measuring the Expected Real Rate of Interest: An Exploration of Macroeconomic Alternatives;" Fama, "Interest Rates as Predictors of Inflation;" Hess and Bicksler, "Capital Asset Prices Versus Time Series Models as Predictors of Inflation;" Pesando, "On the Efficiency of the Bond Market: Some Canadian Evidence," *Journal of Political Economy* (December 1978), pp. 1057-76.

[6]Like Fisher, who discusses negative rates in the context of shipwrecked sailors whose store of figs is deteriorating, we think that "The fact we seldom see an example of zero or negative interest rates is because of the accident that we happen to live in an environment so entirely different . . ." (Fisher, *The Theory of Interest and Capital*, p. 192).

[7]Such preconditions would imply ". . . a world in which the only provisioning for the future consisted in carrying over initial stocks of perishable food, clothing and so forth and if every unit so carried over into the future were predestined to melt away . . ." (Fisher, *The Theory of Interest and Capital*, p. 91).

[8]Armen Alchian and Benjamin Klein, "On a Correct Measure of Inflation," *Journal of Money, Credit and Banking* (February 1973), pp. 173-91.

1974-1975. These results suggest that the previously reported falling and/or negative estimates of the ex ante real rate are statistical artifacts. To put it directly, they are nothing more than the predictably spurious consequences of the method used to generate them.

MEASUREMENT OF THE REAL RATE

The methodology commonly used in measuring the real rate of interest is represented by the following three equations:

(1) $r = i - P_e$

(2) $\hat{P}_e = f(C),\ f' > 0$

(3) $\hat{r} = i - \hat{P}_e$.

Equation 1 states the familiar theoretical relationship developed by Fisher between the *ex ante* real rate of interest (r), the observed nominal rate of interest (i) and the anticipated future rate of inflation (P_e), assuming continuous compounding. Equation 2 characterizes the methodology commonly employed in estimating the anticipated rate of inflation. It indicates that estimates of the *anticipated* future rate of inflation ($\hat{P}_e$) are obtained from observation of past changes in some price index (C).[9]

Finally, equation 3 states that estimates of the ex ante real rate ($\hat{r}$) are derived by subtracting $\hat{P}_e$ from the observed nominal rate of interest.

Since neither r nor P_e is directly observable, the validity of this process for accurately estimating the ex ante real rate depends crucially on whether $\hat{P}_e$ is a reliable proxy for P_e. Typically, $\hat{P}_e$ is regarded as "good" or "bad" depending on how well it predicts the *actual* contemporaneous rate of change in the particular price index being used. The implicit assumption is, of course, that contemporaneous changes in the index reflect true changes in the general level of prices.

Fama's justification of his use of the CPI is fairly typical. He comments:

> The Bureau of Labor Statistics Consumer Price Index (CPI) is used to estimate ΔP, the rate of change in the purchasing power of money from the end of month t–1 to the end of month t. The use of any index to measure the level of prices of consumption goods can be questioned. There is, however, no need to speculate about the effects of shortcomings of the data on the tests. If the results of the tests seem meaningful, the data are probably adequate.[10]

Several authors have questioned whether functions of past rates of change in the CPI, or GNP deflator, serve as reliable predictors of expectations regarding future price level change.[11] Others have commented on how measurement errors in the indices must be taken into account when estimating real interest rates.[12] None, however, have tried to confirm the validity of the estimates by observing economic relationships known to depend on the real rate of interest.

Alchian and Klein have noted a significant difficulty in using changes in common price indices as measures of changes in the general level of prices, or "purchasing power of money." In particular, they argue that changes in the purchasing power of money are determined by changes in the prices of both present consumption goods and long-lived assets, not just changes in the prices of present consumption goods alone. They comment:

> The analysis . . . bases a price index on the Fisherian tradition of a proper definition of intertemporal consumption and *leads to the conclusion that a price*

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[9]The index most frequently used is the CPI. See Burger, "An Explanation of Movements in Short-Term Interest Rates;" Elliot, "Measuring the Expected Real Rate of Interest: An Exploration of Macroeconomic Alternatives;" Fama, "Inflation Uncertainty and Expected Returns on Treasury Bills;" Hess and Bicksler, "Capital Asset Price Versus Time Series Models as Predictors of Inflation;" Yohe and Karnosky, "Interest Rates and Price Level Changes, 1952-1969." The GNP deflator has been used less frequently. See Feldstein and Eckstein, "The Fundamental Determinants of the Interest Rate." The procedure used to estimate expected inflation for period t from the observation of past levels of some price index is, roughly, the following: An estimate of the period t price level is made in period t–1. This estimate is a weighted average of past price levels. That is,

$$_{t-1}\hat{C}_t = \sum_{i=t-1}^{t-n} W_i C_i;$$

where the left-hand term is the estimate and the W are the weights assigned to past price levels. The estimated change in the price level is obtained by subtracting the price level in period t–1 from the estimate for period t as follows

$$\Delta\hat{C}_t = {}_{t-1}\hat{C}_t - C_{t-1}.$$

Last, the estimated change in the price level is defined to be the estimate of expected inflation for period t,

$$\Delta\hat{C}_t \equiv \hat{P}_{e_t}.$$

[10]Fama, "Short-Term Interest Rates as Predictors of Inflation," p. 247.

[11]See Carlson, "Short-Term Interest Rates as Predictors of Inflation," Edward J. Kane and Burton G. Malkiel, "Autoregressive and Nonautoregressive Elements in Cross-Section Forecasts of Inflation," *Econometrica* (January 1976), pp. 1-16.

[12]See Fama, "Inflation Uncertainty and Expected Returns on Treasury Bills;" Feldstein and Eckstein, "The Fundamental Determinants of the Interest Rate;" Kane and Malkiel, "Autoregressive and Nonautoregressive Elements in Cross-Section Forecasts of Inflation;" C. Nelson and G. Schwart, "Short-Term Interest Rates as Predictors of Inflation: On Testing the Hypothesis that the Real Rate of Interest is Constant," *American Economic Review* (June 1977), pp. 478-86.

index used to measure inflation must include asset prices (italics added). A correct measure of changes in the nominal money cost of a given utility level is a price index for wealth. If monetary impulses are transmitted to the real sector of the economy by producing transient changes in the relative prices of service flows and assets, (i.e., by producing short-run changes in 'the' real rate of interest), then the commonly used, incomplete, current flow price indices provide biased short-run measures of changes in the 'purchasing power of money.'[13]

The CPI and GNP deflator largely exclude the prices of long-lived goods and existing capital assets.[14] Consequently, changes in these price indices will depend on changes in the real rate of interest because of the well-known difference in the interest elasticities of the market prices of short- and long-lived goods.

THE MEASUREMENT PROBLEM

Our criticism of the methodology currently used to measure the ex ante real rate of interest rests on two interrelated points. First, the quantity weights used in calculating the CPI and GNP deflators do not accurately reflect the mix of goods actually available to individuals. As a result, changes in these commonly used price indices produce biased estimates of actual changes in the general level of prices when the real interest rate is changing. Second, given that it is the *expectation* of market participants concerning the future rate of inflation in the general level of prices that is relevant in Fisher's theory of the nominal rate of interest, *estimates* of the real interest rate that employ past changes in a commonly used price index as a proxy for expected inflation will be biased when the real rate is changing. Each of these points is demonstrated below.

Point 1: Changes in the General Level of Prices versus Changes in Commonly Used Price Indices

Assume initially that an increase in the real rate of interest occurs and that both the quantity of money and its velocity are unchanged.[15] If the quantity of output is also unchanged, there will be no change in the general level of money prices or the level reflected in a Fisherian price index (i.e., one which includes asset prices). However, since the prices of short-lived goods *rise* relative to the prices of long-lived goods when the real interest rate rises, the money prices of short-lived goods (long-lived goods) will rise (fall) relative to the general level of money prices. Thus, when the real interest rate is rising, commonly used price indices, in which the prices of short-lived goods receive a relatively heavy weight, will rise introducing a systematic upward bias into the estimation of changes in the general level of prices. The reverse holds when the real interest rate falls.

If an increase in the real interest rate produces an increase in the general level of money prices through a once-and-for-all rise in velocity, the resulting increase in commonly used price indices will contain two components: 1) an increase due to the *rise* in the general level of prices and 2) an increase due to the bias introduced by capturing only part of the price changes that have occurred. However, wealth-maximizing market participants will ignore both of these components in forming their expectation regarding the *future* rate of inflation in the general level of prices. They will ignore the first component because it represents a once-and-for-all change which leaves the future rate of inflation unaffected. They will ignore the second component because its effect is to overstate the true change in the general price level. On the other hand, *estimates* of price expectations that employ the common methodology (the ability to reproduce actual changes in the CPI) will include both.

This argument can be presented more formally. Assume there are two kinds of goods — short-lived, Q^S, and long-lived, Q^L — and money. Suppose, in the base period, the real rate of interest is r_0. Then,

$$(4) \quad M_0 \cdot V_0 = P_0^S \cdot Q_0^S + P_0^L \cdot Q_0^L$$

where M_0 is the money supply, V_0 is velocity, and P_0^S and P_0^L are the prices of short- and long-lived goods, respectively.

If the interest rate increases to r_1, velocity will rise as relative prices change.[16] Let

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13Alchian and Klein, "On a Correct Measure of Inflation," p. 173.

14Durable goods have a weight of 18.75 percent in the CPI. Nondurable goods and services have weights of 47.19 and 34.03 percent, respectively. See Bureau of Labor Statistics, *Handbook of Methods*, Bulletin 1910, 1976. The GNP deflator includes the prices of currently produced capital goods but it excludes the prices of existing capital assets.

15Economic theory suggests that velocity will rise with an increase in r. This is discussed below.

16Quantities will eventually adjust as well but that is ignored here. In any case, the quantity adjustment which takes place makes no difference for the measurement of the change in a fixed weight index.

$$(5) \quad F_1 = \frac{P_1^S \cdot Q_0^S + P_1^L \cdot Q_0^L}{P_0^S \cdot Q_0^S + P_0^L \cdot Q_0^L}$$

represent the level of a Fisherian price index in the current period. If the change in the interest rate was the only change that affected the index between the base and current period, the change in the Fisherian price index is

$$(6) \quad \Delta F = F_1 - 1.$$

Let

$$(7) \quad C_1 = \frac{P_1^S \cdot Q_0^S}{P_0^S \cdot Q_0^S}$$

represent the level of a commonly used price index in the current period. It differs from the Fisherian index in that it excludes prices of long-lived goods. The change in this price index, due to the change in r occurring between the base period and the current period, is

$$(8) \quad \Delta C = C_1 - 1.$$

It is a simple matter to show that an increase in the real rate of interest will have a greater effect on the commonly used price index than on the Fisherian price index. We know that

$$(9) \quad P_1^S/P_1^L > P_0^S/P_0^L$$

because a rise in the real rate of interest increases the price of short-lived goods relative to long-lived goods. Now consider the Fisherian index which can be written as

$$F_1 = \frac{P_1^S}{P_0^S} \times [\frac{Q_0^S + (P_1^L/P_1^S)Q_0^L}{Q_0^S + (P_0^L/P_0^S)Q_0^L}].$$

That is,

$$F_1 = C_1 \times [\frac{Q_0^S + (P_1^L/P_1^S)Q_0^L}{Q_0^S + (P_0^L/P_0^S)Q_0^L}].$$

The term in the brackets is less than one since, from (9),

$$P_1^L/P_1^S < P_0^L/P_0^S$$

and thus

$$Q_0^S + (P_1^L/P_1^S)Q_0^L < Q_0^S + (P_0^L/P_0^S)Q_0^L.$$

It follows that $F_1 < C_1$ and $\Delta F < \Delta C$.

In general, when the real interest rate is increasing, use of price indices that are based primarily on short-lived goods will introduce a systematic upward bias into estimation of changes in the general level of prices (in the Fisherian sense). The reverse is true during periods of decline in the real interest rate.[17]

Point 2: Biased Estimates of the Real Interest Rate

If r remains unchanged, changes in commonly used price indices accurately reflect changes in a Fisherian index of prices. Consequently, the methodology summarized in equations 1-3 will yield accurate estimates of r for such periods. However, during periods in which r is changing, bias in the common price indices introduces, through equations 2 and 3, bias into any estimate of the real interest rate that employs these indices.

To demonstrate this second point, ignore other factors that affect common price indices (e.g., a change in the monetary growth rate) and express C as a function of the real rate of interest. That is,

$$(10) \quad C = \phi(r), \phi' > 0.$$

The error generated in estimating the real interest rate by the method employed in the studies referenced earlier is given by

$$(11) \quad \hat{r} - r = P_e - f(\phi(r)).$$

The error in estimated changes in the real rate is obtained by differentiating equation 11 with respect to r. In doing so, note that the price expectations (P_e) of market participants are based upon the anticipated future rate of change in the general level of prices in the sense of Fisher's theory and not upon once-and-for-all changes produced by changes in r. Hence, price expectations will be unaffected by changes in r while the *estimate* of price expectations will vary positively with such changes. That is,

$$(12) \quad \frac{d\hat{r}}{dr} = 1 - \frac{\partial f}{\partial \phi}\frac{\partial \phi}{\partial r}.$$

The term $\frac{\partial f}{\partial \phi} \cdot \frac{\partial \phi}{\partial r}$ is always positive. Estimates of changes in the ex ante real rate of interest will *always understate* any actual change that occurs.

Even worse, the procedure employed in previous work can err in assessing *the direction of change* in the real rate. If the effect of a change in the interest rate on the commonly used price index described in

[17]Interestingly, Alchian and Klein commented on this source of inherent measurement error in the CPI and GNP deflator, but did not pursue its implications for estimating the real rate of interest. They remark: "It should be noted that although our discussion emphasizes that movements in asset and service prices differ largely because of differing rates of adjustment to cyclical monetary disturbances there may also be a significant secular bias due to changing equilibrium real asset yields. (The apparent increase in real rates of interest over the years is ignored in our discussion.)" Alchian and Klein, "On a Correct Measure of Inflation," p. 180.

Table 1
Selected Estimates of the Real Rate of Interest[1]

Year	Elliot short-term	Carlson T-bill rate	St. Louis Fed yield on high grade corp. bonds	Ex post short-term yield
1970	0.57%	2.38%	2.86%	2.58%
1971	1.59	1.05	2.18	2.02
1972	2.13	1.28	2.72	2.52
1973	1.07	2.35	2.84	2.10
1974	–0.41	0.40	1.78	0.28
1975	—	0.07	0.05	–2.25

[1]The interest rate we report is the annual average of the various subperiods. In the case of Elliot, we report his neo-Keynesian monetary estimate which he accepts as most accurate. The Federal Reserve Bank of St. Louis discontinued publishing estimates prior to the end of 1975. The estimate we attribute to them for 1975 is one that we calculate using their method of estimation.

equation 12 is sufficiently large, $\frac{d\hat{r}}{dr}$ will be negative. Hence, even though the change in the real rate is positive, the estimated change could be negative. This may explain the declining estimated real rates reported for the mid-1970s.

EVIDENCE ON CHANGES IN THE REAL RATE

Table 1 presents some previously reported estimates of the ex ante real rate of interest from 1970 to 1975. Additionally, it presents the difference between current short-term market rates and contemporaneous rates of change in the CPI. The latter would represent the "true" ex post yield if changes in the CPI measured changes in the general level of prices without error.

All of these estimates show dramatic declines in 1974 and 1975, years in which substantial increases were recorded in the CPI. Elliot's reaction to his results is perhaps typical. He asserts:

> . . . some relationship appears to exist between the temporal pattern of the real rate and the current rate of inflation. . . . The negative and statistically significant nature of this relationship suggest that expected real rates are systematically lowered when the most current realized rate of inflation is increasing.[18]

However, before concluding that changes in the CPI affect the real rate of interest, it seems appropriate to determine whether other evidence is consistent with this hypothesis. Changes in the ex ante real rate of interest imply specific behavior in the prices of long-lived assets relative to the prices of short-lived assets. Falling real rates of interest in 1974 and 1975 should have been accompanied by a rise in the present prices of long-lived assets (which produce future consumption services) relative to the prices of short-lived goods. Evidence indicates, however, that the relative price of long-lived assets *fell* during 1974 and 1975. This evidence is inconsistent with the contention that the ex ante real rate of interest declined precipitously during this period.

SOME EVIDENCE FROM INDIVIDUAL MARKETS

The movement of relative prices in various markets is examined below. As noted earlier, a change in the ex ante real rate of interest shows up as a change in the relative price of less durable (present) goods in terms of more durable (capital) goods. An increase in the ex ante real rate of interest reflects an increase in the demand for present goods relative to capital goods. Consequently, the price of present goods in terms of capital goods will rise. This adjustment in relative prices mirrors the change in the ex ante real interest rate.

[18]Elliot, "Measuring the Expected Real Rate of Interest: An Exploration of Macroeconomic Alternatives," p. 442. For similar statements see Carlson, "Short-Term Interest Rates as Predictors of Inflation: Comment," p. 472; Feldstein and Eckstein, "The Fundamental Determinants of the Interest Rate," p. 366; Yohe and Karnosky, "Interest Rates and Price Level Changes, 1952-1969," p. 24 and p. 26.

By its nature, this type of evidence requires examination of price movements in individual markets. This procedure of examining relative price movements is always open to the charge that any observed relative price change in an *individual market* may be due to circumstances unrelated to a change in the ex ante real interest rate. As was noted previously, however, a change in the ex ante real interest rate pervades all markets. If an examination of a number of markets reveals that the price of the less durable good has consistently moved in the same direction relative to the price of the more durable good, the contention that the observed change in relative price is due to the impact of special circumstances in each of these markets loses much of its force.

Since the ex ante real interest rate can not be directly observed, any evidence about its magnitude or direction of change will always be circumstantial. The evidence presented below is no exception. However, as Thoreau has noted, "(s)ome circumstantial evidence is very strong, as when you find a trout in the milk."

The evidence presented below is reasonably consistent across the various markets for the 1968-1975 period. Moreover, changes in the price ratios examined correspond perfectly across markets for the 1972-1975 period. However, the direction of change in the ex ante real interest rate implied by these price ratio changes occurring during the later period contradicts that reported in previous studies. This contradiction is perhaps not surprising. We have shown that past increases in the real rate will introduce a downward bias into *estimates* of the *present* change in the ex ante real interest rate. Examination of changes in the price ratios occurring in all four markets indicates an increase in the ex ante real interest rate in the two years immediately preceding 1974. Three of the four markets indicate an increase in the real rate in the three years immediately preceding 1974. The above contradiction is the "trout" whose presence is verified by this evidence.

1. ***The Commodity Markets:*** Changes in the real rate of interest will be reflected in changes in spot relative to futures prices. The spot price of a good is today's price for delivery today while the futures price is today's price for delivery in the future. A decrease in the real rate must be reflected in a decrease in the value of present (spot) goods *relative* to future goods. Spot prices will fall *relative* to futures prices when the ex ante real rate of interest falls.

Between 1960 and 1972 the average annual ratio of the Dow Jones index of spot prices to the Dow Jones index of futures prices was 1.019, with a standard deviation of .018 (see table 2). Between 1973 and 1975 this ratio averaged 1.057. In 1974, when previous studies report a precipitous decline in the real rate (see table 1), the ratio reached its *highest* level (1.076) in the entire 16-year period. Relative price behavior in the commodities markets is inconsistent with a falling ex ante real rate of interest in 1974 and 1975.

Table 2

Spot and Futures Prices
1924-1926 = 100

Year	Index of spot prices	Index of futures prices	Ratio of spot prices to futures prices
1960	141.80	141.22	1.004
1961	149.85	148.44	1.009
1962	149.85	143.90	1.041
1963	159.83	154.49	1.034
1964	142.99	136.82	1.045
1965	142.47	139.31	1.022
1966	139.44	136.71	1.019
1967	142.88	141.79	1.007
1968	144.45	143.26	1.008
1969	144.90	139.10	1.041
1970	145.07	144.81	1.001
1971	144.35	146.30	.986
1972	189.49	184.58	1.026
1973	340.51	320.50	1.062
1974	384.53	357.26	1.076
1975	296.33	287.88	1.029

SOURCE: The Dow Jones Commodities Handbook, Dow Jones Company, New York 1977, pp. 178-179.

2. ***Durable and Nondurable Goods:*** Durable goods, by definition, embody a longer-lived stream of future services than do nondurable goods. Therefore, falling real rates of interest imply a decrease in the price of nondurable goods relative to the price of durable goods.

From 1960 to 1972 the average ratio of the U.S. Bureau of Labor Statistics' index of nondurable goods prices to its index of durable goods prices was .976 (table 3), with a standard deviation of .040. Between 1973 and 1975 it averaged 1.122. In 1974 it was 1.156. Again, this relative price behavior is inconsistent with

Table 3
Nondurable and Durable Goods Prices

Year	Index of nondurable goods prices	Index of durable goods prices	Ratio of nondurable goods prices to durable goods prices
1960	89.4	96.7	.924
1961	90.2	96.6	.933
1962	90.9	97.6	.924
1963	92.0	97.9	.939
1964	93.0	98.8	.941
1965	94.6	98.4	.961
1966	98.1	98.5	.995
1967	100.0	100.0	1.000
1968	103.9	103.1	1.007
1969	108.9	107.0	1.017
1970	114.0	111.8	1.019
1971	117.7	116.5	1.010
1972	121.7	118.9	1.023
1973	132.8	121.9	1.089
1974	151.0	130.6	1.156
1975	163.2	145.5	1.121
1976	169.2	154.3	1.097
1977	178.9	163.2	1.096
1978	192.0	173.9	1.105

SOURCE: Department of Labor, Bureau of Labor Statistics, Consumer Price Index, Special Indexes.

Table 4
Ratios of Earnings/Stock Prices and Price of Nondurable Goods/Stock Prices

Year	Standard and Poor's Stock Price Index[1]	Earnings/Price ratio X 100	Ratio of nondurable goods prices to stock prices
1960	55.8	5.90	1.61
1961	66.2	4.62	1.36
1962	62.4	5.82	1.45
1963	69.9	5.50	1.31
1964	81.4	5.32	1.14
1965	88.2	5.59	1.07
1966	85.3	6.63	1.15
1967	92.0	5.73	1.08
1968	98.7	5.67	1.05
1969	97.8	6.08	1.11
1970	83.2	6.46	1.37
1971	98.3	5.41	1.19
1972	109.2	5.50	1.11
1973	107.4	7.12	1.23
1974	82.8	11.60	1.82
1975	86.2	9.12	1.89
1976	102.0	8.90	1.66
1977	98.2	10.80	1.82
1978	96.0	12.05	2.00

[1]Standard and Poor's Statistical Service, Security Price Index Record, Standard and Poor's Corporation, New York, N.Y.

the dramatic decline in the real rate suggested by the estimates in table 1.

Furthermore, the estimates in table 1 do not appear to be appropriately related to relative prices over extended periods. If estimates generated by the standard method track the real rate, they should be positively correlated with the relative price ratios. This is not the case, however, between 1960 and 1975. The correlation between Elliot's estimates and the ratio of nondurable prices to durable prices is –.625. Between his estimates and the ratio of spot and futures prices, the correlation is –.484. The corresponding coefficients for Carlson's estimates are –.459 and –.073. Those for the St. Louis Fed are –.692 (significant at the 5 percent level) and –.121.

None of these estimates of the ex ante real rate of interest generated by the standard method moved in the direction implied by movements in these relative prices during the 1969-1975 period. The correlations suggest that the effect $\frac{\partial f}{\partial \phi} \cdot \frac{\partial \phi}{\partial r}$ described in equation 12 may be sufficiently large to make $\frac{d\hat{r}}{dr}$ negative.

3. ***The Stock Market:*** The stock market provides further evidence on this issue. Because stock prices represent the present value of expected future earnings, a decrease in the ex ante real rate of interest will be reflected by a rise in the price of shares relative to *current* earnings and a fall in the earnings to price ratio. During the period 1960-1972, earnings to price ratios averaged 5.709 (table 4) with a standard deviation of .511. In 1974 and 1975, earnings to price ratios reached levels of 11.60 and 9.12, respectively.

In addition, a decrease in the rate of interest will be reflected by a fall in the price of nondurable present consumption goods relative to stock prices. Between 1960 and 1972 the ratio of the Index of Nondurable Good Prices to the Standard and Poor's Stock Price Index averaged 1.234, with a standard deviation of .177. In 1974 and 1975 it rose to 1.82 and 1.89, respectively. Again, this relative price behavior is clearly inconsistent with the contention that the ex ante real rate of interest fell in 1974 and 1975.

CONCLUSIONS

The method currently used to estimate the ex ante real rate of interest can lead to serious error. The error arises because this method requires the investigator to measure the *expectations* of market participants regarding the *future* rate of inflation. Unfortunately, since these expectations are never directly observed, the accuracy of the measurement is questionable.

Price expectations have typically been approximated by observing *past* rates of change in either the CPI or the GNP deflator. This method of approximation assumes, first, that expectations about the future rate of inflation depend largely on the past rate of inflation and, second, that the past rate of inflation is accurately reflected by the past rate of change in these price indices. This article has put aside the first issue and argues that past rates of change in the CPI and the GNP deflator may not accurately reflect the past rate of inflation.

We have shown that real interest rate changes themselves affect these indices. This occurs not only because these price indices give substantial weight to the prices of current consumption goods, as opposed to the prices of assets productive of future consumption (capital goods), but also because they reflect the impact of once-and-for-all changes in prices produced by changes in the real interest rate. Therefore, it is impossible when using this estimation procedure to separate changes in the real interest rate from changes in the rate of inflation. As a result, the method produces biased estimates of changes in the ex ante real rate of interest.

Furthermore, the direction of this error is predictable. In particular, when the real rate of interest rises, as in 1974 and 1975, the current method of estimation will understate the change in the real rate. Evidence from the mid-1970s suggests that estimates of the real rate based on the CPI failed to detect the direction of change in the real rate.

Because estimates of the real rate employing measures of anticipated inflation based on common price indices are suspect unless real rates are unchanging, their value is severely limited for use in formulating economic policy. Estimates of the ex ante real rate of interest are important to policymakers if they aid in distinguishing shifts in relative demands from shifts in aggregate demand (i.e., are able to actually detect changes in the real interest rate). However, the widely employed method of estimation breaks down precisely during periods in which the ex ante real interest rate changes. Consequently, estimated changes in the ex ante real rate of interest should be checked against the behavior of the relative prices known to depend upon the real rate prior to employing these estimates for economic policy purposes.

Outlook for Food and Agriculture in 1981

NEIL A. STEVENS

PRODUCTION of a number of major food products in the United States is predicted to decline slightly from 1980 levels. Continued increases in demand for food, and thus faster increases in food prices, are in prospect. Also, a sizable increase in net farm income is expected. These were among the conclusions presented by U.S. Department of Agriculture (USDA) analysts at the 1981 Food and Agricultural Outlook Conference in Washington, D.C., last November and are summarized in this article.

Factors Underlying the 1981 Forecasts

Food price developments result from the interaction of demand and supply forces. The major factors affecting the demand for food include per capita real income, population growth and the general rate of inflation. In 1980 economic growth slowed or stopped in most countries. At the outlook conference, USDA analysts expected only slight economic growth in the United States during the first half of this year, with somewhat more rapid growth in the second half. More recent developments, however, suggest that economic growth in the first half of the year may be more sluggish than USDA analysts expected. Although real income growth will not be a major factor increasing the demand for food, world population growth will continue to increase and will contribute to an increase in export demand for U.S.-grown foodstuffs.

Supply factors dominated the outlook for food prices and farm income in 1981. The bulk of food output in the first half of 1981 will be derived largely from livestock production already under way and 1980 crop production.

World production of grains, which includes wheat, rice, and feed grains, in 1980 was roughly equal to that in 1979. However, world stocks at the beginning of the year were lower so that available supplies in the 1980/81 marketing year are down about 2 percent. Among grains, however, supplies of food grains (wheat and rice) have increased relative to feed grains (corn, sorghum, oats and barley). World food grain production in 1980/81 rose 3.5 percent over 1979/80; feed grain production fell about 3 percent, largely as a result of a severe U.S. drought.

Reduced feed grain supplies will affect U.S. retail food prices primarily through lower livestock production and higher prices of livestock products. Total meat output in 1981, including beef, veal, mutton and poultry, is expected to decline 1 to 3 percent below the record levels in 1980. In contrast, total meat output rose about 3 percent last year.

Most of the decline in meat output will reflect reduced pork production. USDA analysts expected hog producers to reduce the June-November pig crop by about 10 percent as a result of feeding losses in the spring and summer of 1980. Consequently, pork production in the first half of 1981 was expected to drop about 11 percent from a year earlier. Recent information, however, indicates that the June-November pig crop is down only 5 percent from the year before; as a result, pork supplies may decline only 6 percent in the first half of 1981. Production in the second half is more uncertain, but pork supplies are anticipated to be 5 to 10 percent below levels of a year earlier.

In contrast, production of beef, broilers and turkeys is expected to increase somewhat. Beef supplies will be relatively large in the first quarter of 1981 due to increased placements in feedlots during last summer's drought. However, production in the second quarter is expected to fall below that of a year earlier. Broiler output in the first half of 1981 is projected to be up slightly from 1980. Expansion in the second half of the year may increase output by 3 percent above the 1980 level. Turkey production, given relatively high prices, may increase about 6 percent. Egg output in 1981 is expected to be about 1 percent less than in 1980. Most of this decline is anticipated in the first quarter; production in the rest of the year will be about the same as last year. Milk output, on the other hand, is expected to rise 1 to 3 percent.

Crop-related food supplies, as a whole, are expected to expand slightly in 1981. The supply of cereal crops provides a substantial base for the production of cereal and bakery goods. However, the prices of some ingredients — in particular, oils and sugar — are predicted to rise. Reduced production of

Table 1
Retail Food Price Changes (from previous year)

Food category	1978	1979	1980	1981[1]
All food	10.0%	10.9%	8.7%	12.2%
Food away from home	9.0	11.2	10.0	10.4
Food at home	10.5	10.8	8.1	13.0
Meats	18.7	17.0	3.5	17.9
Beef and veal	22.9	27.3	6.4	13.5
Pork	12.9	1.5	–2.6	27.6
Other meats	17.8	14.7	4.1	17.5
Poultry	10.3	5.0	4.1	18.0
Fish and seafood	9.5	9.8	9.2	9.6
Eggs	–5.5	9.5	–3.1	16.9
Dairy products	6.7	11.6	10.2	10.7
Fats and oils	9.5	8.0	6.7	11.0
Fruits and vegetables	11.1	8.0	7.0	8.0
Sugar and sweets	12.2	7.8	22.4	21.5
Cereals and bakery products	8.9	10.1	11.9	10.9
Nonalcoholic beverages	5.7	5.0	10.8	12.0
Other prepared foods	8.0	10.1	10.9	10.3

[1]USDA forecast

SOURCE: Paul C. Westcott, "1981 Food Price Outlook" (Presented at the 1981 Agriculture Outlook Conference, Washington, D.C., November 19, 1980), p. 10.

oilseeds will cause the prices of fats and oils to rise by 11 percent. World sugar production in 1980/81 is slightly above the reduced 1979/80 crop, but beginning stocks are estimated to be down for the second consecutive year. Raw sugar prices in late 1980 were up 67 percent from the 1979 average. At the retail level, the price of sugar and other sweeteners advanced 22 percent in 1980; a similar advance is expected in 1981. A significant development in the sweetener market is the sharp increase in the use of corn-derived sweeteners. These have grown from about 16 percent of the market in 1970 to about 33 percent in 1980 and may reach nearly 50 percent of the market for nutritive sweeteners by 1985.

Supplies of fruits, including fresh apples and most canned and frozen fruits, are greater than a year ago. Until the January freeze in Florida, a record citrus crop was expected. That crop has now been reduced significantly by the freeze. Florida orange production, which accounts for about 75 percent of the total orange crop, is expected to be down about 20 percent. Large stocks of frozen orange juice, however, will tend to moderate the price impact of the freeze.

Supplies of processed vegetables, both canned and frozen, are down about 6 percent in 1980/81, reflecting a planned cutback in production. The fall 1980 potato crop is down about 12 percent, and the fresh winter vegetable crop was reduced by the recent freeze in Florida. Hence, supplies of some fresh vegetables will be reduced until replanted crops come to market.

1981 Food Price Increases — Higher than General Inflation

Given these demand and supply developments, food prices on a yearly average basis are projected to rise about 12.5 percent from 1980 to 1981. This increase is expected to be somewhat greater than the anticipated rate of inflation as measured by the consumer price index (CPI). In contrast, food prices in 1980 rose 8.7 percent, while the CPI increased 13 percent.

Developments in the first half of 1980, however, were quite different compared to the second half of the year. In the first six months, farm prices were below the previous year, reflecting large grain supplies from the 1979 harvest and record meat output. Farm prices began to rise sharply in the second half of 1980 as increases in livestock production slowed and as the effects of the summer drought on crop production led to higher grain prices. As a result, retail food prices rose substantially in the second half of the year.

The projected year-to-year price changes for various food groups in 1981 are shown in table 1. Meats, poultry, eggs and sugar are the main food groups with the greatest projected price increases in 1981. Large increases for these groups reflected the expected decline in overall meat output. This decline and, hence, the upward pressure on the prices of animal protein foods may not be as great as USDA analysts expected, since indications are that pork production will not decline as much as anticipated. On the other hand, the increase in fruit and vegetable prices is now likely to be greater than projected due to the freeze damage in Florida.

Farm Income to Recover Much of Last Year's Decline

Price increases of meats and other livestock products are expected to lead to a recovery of farm income

Table 2
Farm Income (billions of dollars)

	1978	1979	1980[1]	1981[1]
Cash receipts	$112.5	$131.5	$140	$158
Crop	53.5	62.8	71	77
Livestock	59.0	68.6	69	81
Other income	14.0	14.0	16	17
Total farm income	126.5	145.5	156	175
Production expenses	100.8	118.6	131	147
Net cash income	33.8	35.8	34	—
Net farm income (before inventory adjustment)	25.7	26.9	25	28
Net farm income (after inventory adjustment)	26.1	31.0	24 (23-25)	29.5 (27-32)

[1]USDA forecast

SOURCE: George H. Hoffman, "Farm Income Situation and Outlook" (Presented at the 1981 Agriculture Outlook Conference, Washington, D.C., November 19, 1980), pp. 6-10.

from the relatively low 1980 level. Overall, net farm income of farm operators is forecast at about $30 billion, up 20 percent from 1980, and only slightly below the 1979 level (table 2).

For the year 1980 as a whole, prices received by farmers were only 2 percent above 1979, and total cash receipts were up 6.5 percent. Total farm income including cash receipts, other cash income, government payments and imputed income on such items as family dwellings, was up about 7 percent. Production expenses, reflecting general inflation trends in the economy, rose over 11 percent in 1980. Increases in input prices were led by a 39 percent increase in fuel and energy, a 23 percent rise in fertilizer and a 20 percent gain in short-term interest rates.

As a result of the faster rise in farm input prices over farm commodity prices, 1980 net farm income after inventory adjustment was about $24 billion, down $7 billion from 1979. Cash flow, a measure of the farmer's ability to meet short-run obligations which excludes imputed income and expenses, did not decline so sharply. This measure totaled around $34 billion, down 5 percent from 1979. Much of the difference between net farm income and cash flow was due to a reduction in inventories.

In general, crop producers in 1980 fared better than livestock producers. Crop receipts went up 13 percent, while livestock cash receipts remained unchanged. However, there were considerable income differences among crop farmers. In some areas, drought reduced crop yields significantly and incomes were down sharply. Good yields and significantly higher prices resulted in improved incomes in the upper Midwest and eastern Corn Belt. Among livestock producers, hog operators fared relatively poorly. Dairy farmers, reflecting increased government price supports, had generally profitable operations.

The projected increase in farm income in 1981 is based largely on a 16 to 20 percent increase in livestock receipts. Crop receipts are expected to increase by 6 to 10 percent.

Production expenses are expected to increase by 11.5 percent, about the same rate as in 1980. Farm origin input costs, unlike last year, are expected to rise sharply. Total feed expenses will rise by 15 percent or more to ration the reduced supply among competing uses. Expenses for purchased livestock are expected to rise about 10 percent. Petroleum-based inputs such as fuel, fertilizer and chemicals may register significant gains. With a slower rate of overall inflation expected, a moderation of price increases for manufactured inputs is anticipated. Total interest expense is not anticipated to rise significantly, even though farm debt will be larger. Short-term interest rates are expected to fall from 1980 levels.

OUTLOOK FOR MAJOR FARM PRODUCTS

Feed Grains

U.S. production of feed grains in 1980 was about 198.3 million tons, 17 percent below the record harvest in 1979. Planted acreage was 2.4 percent above 1979, but a severe drought in some major producing areas reduced yields to 1.95 metric tons per acre, down 16 percent from 1979's record yields. With the relatively large feed grain carryover from 1979/80, overall U.S. supplies (production plus stocks) for the 1980/81 marketing year totaled 250.5 million tons, 12 percent below 1979/80. Production of corn, the major feed grain, was 6.6 million bushels in 1980/81 compared with 7.9 million bushels in 1979/80. Supplies (production plus carryover) totaled 8.2 million bushels, down from 9.2 million bushels in 1979/80.

With the quantity of feed grains essentially fixed by the 1980 harvest plus 1979/80 carryover stocks, price changes in the next few months will result primarily from changes in demand. Demand is expected to remain strong, reflecting increased demand for exports and domestic food. Domestic livestock feeding, primarily hog feeding, however, will decline somewhat from the previous year as average feed grain prices are expected to be significantly above those for last year. Corn and sorghum prices are expected to average about $3.40 and $3.30 per bushel, respectively, compared with $2.50 and $2.35 per bushel, respectively, last year.

Total feed grain use may be only slightly below that of the 1979/80 season, and carryover stocks will be substantially reduced. U.S. stocks are expected to fall from 52 million metric tons at the end of the 1979/80 marketing year to 21 million tons at the end of the current year. The ratio of stocks to utilization is expected to decline to 9.2 percent, the lowest since 1975.

While feed grain prices are expected to be higher this year than last year, their impact on incentives to increase production will be partially offset by a sizable increase in prices paid by farmers for production items. Nevertheless, higher feed grain prices, and hence higher profits, will provide incentive for farmers to increase feed grain acreage and production inputs per acre. According to USDA projections, given normal weather conditions this year, corn yields are likely to rise to about 103 bushels per planted acre, up 14 percent from last year but still below the record 109 bushels per acre in 1979.

Food Grains

The supply of food grains, wheat and rice, is relatively more abundant than feed grains, reflecting the relatively large harvest in 1980. U.S. wheat production in 1980 was a record 2.37 billion bushels, up 11 percent from a year earlier, and 1980/81 supplies totaled a record 3.3 billion bushels. On a worldwide basis, however, wheat production was smaller than anticipated, which, coupled with reduced feed grain crops, led to wheat price advances in the late summer and fall. With projected use of U.S. wheat near the production level, stocks at the end of the 1980/81 marketing year are expected to remain near last year's level of 900 million bushels. Wheat prices are expected to follow a normal pattern of seasonal strength through the remainder of 1980/81 and may average $4.05 per bushel for the year, about 25 cents per bushel above last year's price. Fall plantings of winter wheat are estimated to be up 11 percent from 1980 and, with normal yields, another large U.S. wheat crop is in prospect for 1981.

U.S. rice production in 1980 was estimated at 145 million hundredweight (cwt.), 10 percent above the year before. Yields were down from recent years, but producers planted 16 percent more acres, reflecting the relatively high profits expected from rice production. While beginning stocks were down, total U.S. rice supplies are up 4.4 percent and world rice supplies are up about 3 percent. U.S. farm prices for rice in the 1980/81 season are expected to average about $11.50 per cwt., up about 10 percent from the 1979/80 average. Production costs are expected to rise substantially, however, and a reduction in rice acreage is likely in 1981.

Soybeans

Production of soybeans, which constitutes about 88 percent of U.S. oilseed production, declined 20 percent in 1980. The impact of this unexpected shortfall on prices and consumption, however, was blunted by a large inventory and an increase in oilseed production elsewhere in the world. World oilseed supplies are down only about 3 percent. World consumption is expected to continue expanding, and ending stocks will be down substantially from the 1979/80 level. The year-end world stock-to-use ratio is expected to be around 9.4 percent, still above most recent years. U.S. soybean supplies, however, are relatively low, and prices in the 1980/81 season may average $7.90 per bushel, up from $6.25 a bushel in the previous season.

While soybean prices are likely to be substantially higher than last year, the soybean/corn price ratio does not provide farmers with the incentive to shift from corn to soybean production. Thus, acreage is not expected to change much from last year's level. However, a return to normal soybean yields in 1981 would result in a sharp recovery in U.S. soybean production.

Cotton

U.S. cotton production of 11.1 million bales in 1980 was down 24 percent from the relatively large 1979/80 crop. World production was also down, largely a result of the decline in the U.S. crop. With demand for cotton relatively strong, prices in late 1980 averaged 34 percent above the previous October.

Despite relatively low supplies and high prices, cotton acreage may decline by a half million acres or more in 1981. Prices of soybeans and grain sorghum have increased relative to cotton, providing an incentive to shift acres from cotton to these crops. In addition, the costs of producing cotton, in absolute terms, have increased more than some competing crops. Assuming normal yields of about 1 bale per acre, supplies of cotton are expected to remain tight throughout 1981 and into 1982.

Tobacco

U.S. tobacco production in 1980 recovered from the relatively small crop in 1979, but because of the hot and dry growing conditions, the quality of some tobacco is low. Tobacco production rose 17 percent from the very small 1979 crop as a result of a 12 percent increase in acreage and a 4 percent rise in yields. With much lower carryover stocks, however, total supplies for the 1980/81 marketing year are down about 2 percent. Tobacco production is heavily influenced by government price supports and marketing quotas, and the current law mandates a 12 percent rise in price supports for eligible tobacco.

Beef Cattle

The liquidation phase of the cattle cycle ended in 1980. The number of cattle and calves on farms as of July 1, 1980, indicated a rapid rebuilding, with cattle numbers up 4 percent from 1979. The 1980 calf crop of 45.5 million head was up 6 percent from 1979. Several factors, however, may increase costs of production, thereby limiting future beef herd expansion. These include a substantial increase in land converted from pasture into cropland, and higher energy costs, which limit fertilization of pastures.

Higher cattle prices are in prospect for 1981, particularly in the second quarter, as total meat supplies are expected to fall below levels of a year ago. Cattle feedlot operators increased placements during the summer as drought led to larger marketings of feeder cattle. These cattle will come onto the slaughter market in the first quarter and will moderate increases in prices. Choice steer prices are expected to average around $73 per cwt. in the first quarter.

Although cattle marketings for slaughter will rise somewhat in the second quarter, the slaughter of nonfed beef should fall below the 1980 level if grazing conditions return to normal. As a result, overall beef production will likely fall and the price of choice steers will rise. Despite increased feeding costs, profit margins are expected to increase in the second quarter. However, cattle prices are not expected to increase much further in the second half of the year, and feeding margins may be reduced or even become negative. The profitability of feeding operations in the second half will depend on feed costs and therefore on the outlook for 1981 grain crops.

Hogs

Hog producers experienced large losses in the first half of 1980 as large meat supplies led to prices below $30 per cwt. in April and May. Producers reacted by slaughtering more breeding stock and cutting back on breeding inventory. At the outlook conference, the June-November pig crop was anticipated to decline about 10 percent; more recent information, however, indicates about a 5 percent decline.

Lower production in the first half of 1981 will result in higher hog prices and upward price pressure on all animal products. With a 10 percent decline in pork production, hog prices had been expected to average around $50 per cwt. in the first half of 1981, nearly $16 above the depressed levels of 1980. But with pork production likely to fall only about 6 percent in the first half, prices are not likely to reach profitable levels. This would indicate more cutbacks in pork production in the second half of 1981.

Poultry and Eggs

After suffering losses in the first half of 1980, broiler producers planned to reduce production in the second half of 1980. This, coupled with an unusually hot summer that caused a substantial unplanned reduction, resulted in higher prices.

Reduced breeding flocks, the result of last summer's hot weather, and higher production costs are expected to limit production increases to around 3 percent above 1980. As meat supplies decline, broiler prices are expected to rise in 1981. Wholesale prices may average around 52 cents per pound in the first quarter, increasing to around 55 cents in the second quarter and 56 cents in the second half.

Since turkey production has generally been profitable since 1977, producers have sharply increased output. Increasing year-round consumption of turkeys has meant a substantial increase in demand. Despite higher feed costs, producers have increased the number of poults hatched for slaughter purposes in recent months, and output may increase around 7 percent to 8 percent in the first half of 1981. Prices may average 67 cents to 70 cents per pound in the first half of 1981, compared with 57 cents in the first half of last year.

Egg production was not profitable in 1980. During the first half of the year, prices were low due to a weak economy and large supplies of competing protein foods. In the second half, rising costs largely offset price increases. As a result, producers have cut back egg production and output is expected to be down about 1 percent from 1980. Most of the reduction will occur in the first quarter, which should cause egg prices to rise in the first half of the year.

Milk

Milk production has expanded since 1979 as favorable prices to producers have prevailed, largely due to government price supports. Production last year was about 3 percent larger than in 1979. Milk prices are expected to rise this year, but higher feed prices will reduce producers' profits to levels below those of the past couple of years. While larger dairy herds should result in higher milk production, higher feed costs will slow total output per cow, so that production will likely rise by about 2 percent.

The government support price of manufacturing milk for the marketing year beginning October 1 was set at the minimum required level of 80 percent of parity — $12.80 per cwt. This will be adjusted again on April 1 to reflect changes in the index of prices paid by all farmers. In price support operations, government purchases of milk in the first nine months of 1980 totaled 7.35 billion pounds, almost 8 percent of all milk marketed, compared with 1.31 billion pounds in 1979. Commercial use of milk and dairy products was down 1.6 percent in 1980, but an increase may occur in 1981. Despite this increase, USDA purchases of dairy products in price support operations are expected to continue if the gains in milk production occur.

CONCLUSION

Retail food prices in 1981 are expected to increase 12.5 percent (range from 10 to 15 percent). General inflation underlies much of the increase, though food prices may rise somewhat faster than overall prices. This reflects such adverse supply factors as reduced feed grain supplies resulting from last summer's drought, reactions of hog producers to unfavorable profit opportunities and reduced sugar supplies. As a result, substantially higher livestock and sugar prices will contribute to higher retail food prices and substantially higher net profits of farm operators.