A Current Appraisal of the Influence of Price Expectations on Interest Rates

Michael Lee Walsh

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A CURRENT APPRAISAL OF THE INFLUENCE OF PRICE EXPECTATIONS ON INTEREST RATES

BY

MICHAEL LEE WALSH

A thesis submitted in partial fulfillment of the requirements for the degree Master of Science, Major in Economics, South Dakota State University

1975

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A CURRENT APPRAISAL OF THE INFLUENCE
OF PRICE EXPECTATIONS ON
INTEREST RATES

This thesis is approved as a creditable and independent investigation by a candidate for the degree, Master of Science, and is acceptable as meeting the thesis requirements for this degree. Acceptance of this thesis does not imply that the conclusions reached by the candidate are necessarily the conclusions of the major department.

Thesis Advisor / Date

mead, economics department / Date

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Chapter 1

INTRODUCTION

In 1930, Irving Fisher published *The Theory of Interest*, in which he advocated that price expectations have an effect on interest rates. In subsequent studies this relationship has been found to hold, but the relationship between past changes in the price level and changes in the interest rate appears to occur with long lag periods. The theoretical basis of the hypothesis, however, has continued to be widely accepted. If, for example, lenders expect prices to continue to rise, they will demand a rate of return that will not only compensate them for foregoing the use of the funds, but will also prevent realization of the expected capital loss which occurs as a result of rising prices. Borrowers, expecting rising prices to occur, will be willing to pay higher rates of interest because of the gain they expect to realize on the debt owed as a result of rising prices. Therefore, if a rising price level is expected by both borrowers and lenders, the nominal rate of interest will rise. One crucial element of this argument is the length of time over which price expectations are formed.

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Price expectations are generally considered to be a "weighted average of current and past changes in prices". Being unable to foresee the future, the individual is forced to rely upon past experience to predict future occurrences. Numerous attempts have been made to estimate the length of time it takes for changes in the level of prices to affect price expectations, and, thereby, change the interest rate. Previous to Yohe and Karnosky's study, the lags of the estimated relationship were very long, indicating that current and recent changes in the price level have little effect on interest rates. Yohe and Karnosky, however, arrived at considerably shorter lags (most of the effect being felt within two years) by using the Almon or polynomial distributed lag estimation procedure, as opposed to previous studies which used lag structures that impose geometric or exponential rates of decay (Koyck lags, for example). Further, the study by Yohe and Karnosky covered a more recent time period in contrast to previous studies which covered data going as far back as 1857. Intuitively, the length of the lag would decrease as the financial market becomes more sophisticated, allowing easier, faster accumulation of data by both borrowers and lenders. In short, it seems obvious that parametric


\(^3\)Ibid., p. 21.
shifts would be to shorten lags due to advances in information. Yohe and Karnosky found that, indeed, there were significant changes in the price expectations forming mechanism in the relatively short period of 1952 - 1969.

The length of lag becomes critical when interest rates are used as target variables or indicators in determining the direction of monetary policy. If the length of lag is long, then little adjustment need be made to determine the immediate impact of present monetary policy. Further, a long lag implies that the full effects of policy actions will not occur for many time periods. A relatively short lag, however, indicates that if interest rates are to be used as indicators, they should be adjusted to account for changes in price expectations. It also implies that price expectations effects of changes in the money supply would occur over a shorter period of time, giving monetary policy a more immediate impact upon the economy.

The purpose of this study is to briefly review the difference between two of the more prominent earlier studies and Yohe and Karnosky's study. Further, this study will apply the estimation technique used by Yohe and Karnosky to more recent data to determine if present lags are longer or shorter and if the results obtained in their expanded model still hold.

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Chapter 2

PREVIOUS STUDIES

Two studies relating prices to interest rates are exemplary of most of the studies and papers done on price expectations effects on interest rates prior to Yohe and Karnosky's. The first study, and that which formally raised the controversy, was published by Irving N. Fisher in 1930, *The Theory of Interest.* The second article discussed, "Commodity Price Expectations and the Interest Rate", was written by Thomas Sargent. The article applied the effect of price expectations on interest rates in an expanded loanable funds model.

Fisher's book, *The Theory of Interest*, develops an entire theory of interest rate determination using data concerning several national economies. This paper will extract those portions of the work which are relevant to the effects of price expectations on the interest rate in the United States. The basic theoretical relationship postulated in the first chapter of this study is very similar to that posited by Fisher. His relationship was put forward in terms of gold redeemable bonds and currency redeemable bonds.

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Fisher maintained that, as the price level, in terms of currency, increased, the rate of interest on currency redeemable bonds also increased, and vice versa.

Fisher began his empirical proof of this relationship by relating money or nominal interest rates to corresponding price levels. Using a price index to indicate price levels, he compared movements in the price level to movements in the nominal interest rate over the period 1824 - 1927. The results thus obtained were not good. The relationship was unstable and the predictions were faulty. In an effort to specify a more accurate relationship he attempted to relate rates in corresponding periods. Again the results were inconclusive. Finally, Fisher lagged the rates of change in the price level using a distributed lag with an arbitrary, arithmetically declining weight structure. This relationship was lagged twenty years, producing an $R^2$ of .857, distributing the influence of prices over a weighted average of 7.3 years. From these studies of price level movements and rates of change in the price level, Fisher draws four conclusions: (1) the rate of interest is high during a rising price level and low during a falling price level, (2) the rate of interest lags behind changes in the price level so that the relationship is obscured when making direct comparisons, (3) the interest rate correlates markedly with a weighted average of past price level changes, and (4) interest rates are high with a high price level and low with a low price level. He
further stated that, even though the relationship does exist, changes in the price level are extremely slow to act on the interest rate.

Thomas J. Sargent undertook a study of the "Fisher effect", as postulated above, in "Commodity Price Expectations and the Interest Rate". In this study he employed a loanable funds model to determine the interest rate. The model employs three interest rate concepts: (1) the nominal rate of interest \( r_n(t) \), (2) the market rate of interest \( r_m(t) \), and (3) the full stock equilibrium rate of interest \( r_e(t) \).

The market rate of interest is the nominal rate of interest adjusted for price expectations effects and represents the internal rate of return on bonds in real terms. It equates the demand for and supply of bonds in a single period. The full stock equilibrium rate of interest is the real rate of interest that equates ex-ante savings and investment. Sargent presents the following identity and proposes as his purpose, to explain the three right hand terms:

\[
r_n(t) = r_e(t) + (r_m(t)-r_e(t))+(r_n(t)-r_m(t))
\]

To explain the first term, Sargent postulates a savings and investment function where investment is a function of the market rate of interest and the change in aggregate output at time \( t \). He further assumes investment to be negatively related to the market rate of interest and positively
related to the change in aggregate output. Savings is a function of the market rate of interest and the level of aggregate output, and is positively related to both. The investment function is of the accelerator type which Sargent modified to allow for the effects of interest rates. The savings function is a "simple" Keynesian Function:

\[ I(t) = I(r_m(t), \Delta X(t)) \quad \frac{\partial I}{\partial r_m} < 0, \quad \frac{\partial I}{\partial \Delta X} > 0 \]

\[ S(t) = S(r_m(t), X(t)) \quad \frac{\partial S}{\partial r_m} > 0, \quad \frac{\partial S}{\partial X} > 0 \]

Both of the above equations assume the absence of the money illusion as implied by the use of the market rate of interest. In equilibrium (no excess demand for loanable funds) the equilibrium rate of interest is a function of only the level of aggregate output, and the change in this level, or

\[ r_e = f(\Delta X(t), X(t)) \quad \frac{\partial f}{\partial \Delta X} > 0, \quad \frac{\partial f}{\partial X} < 0 \]

In this model, an increase in the rate of increase in aggregate output will drive up the equilibrium rate of interest through an increase in the demand for loanable funds, while a "once and for all" increase in the level of aggregate output will generate increased savings and a downward pressure on the equilibrium rate of interest.

The second term on the right side of the equation is the difference between the market rate of interest and the
full stock equilibrium rate of interest. Sargent assumes this gap to be due to supplies and demands for funds generated by the banking system, which is not accounted for in the savings or investment functions. He postulates that the gap between \( r_m(t) \) and \( r_e(t) \) are due to relative changes in the real money stock brought about by the operation of the banking system:

\[
r_m(t) - r_e(t) = g(M^*(t) - M^*(t-1)/M^*(t-1)) g' < 0
\]

where \( M^*(t) \) is the real money supply in period \( t \). This specifies that as the real money supply rises, the market rate falls with respect to the equilibrium rate. Sargent also points out that rising commodity prices drive up the market rate by reducing the real money balances.

The third term on the right side of the equation (the term with which this study is primarily concerned) is the difference between nominal rates and real market rates of interest. Sargent hypothesizes that this difference "arises as a result of anticipated commodity price inflation", or is a price expectations effect on the nominal interest rate. He gives the following formula as an explanation of this effect:

\[
r_n(t)-r_m(t) = (\log p^e(t+j)-\log p(t))/j
\]

where \( j \) is the term to maturity of the loan and \( p^e(t+j) \) is the expected price level \( j \) periods hence. Sargent further
assumes that "the expected average proportionate rate of price inflation over the term of the loan is a distributed lag function of actual current and past rates of inflation", which is an assumption of adaptive expectations. This is described as follows:

\[ r_n(t) - r_m(t) = w(i)(p(t-i) - p(t-i-1)/p(t-i-1)) w(i) \geq 0 \]

Sargent then tested his model. In the price expectations effect term he used a geometrically decaying lag structure where \( w(0) \) was set equal to zero and subsequent decay was as follows:

\[ w(i) = d^i-1 \]

The relationship was estimated using data for the period 1902 - 1940. Sargent, using this technique, like Fisher, found that price expectations do have an important effect on nominal interest rates and that the lag in forming price expectations is very long. Sargent also found that rising prices have two effects: (1) They generate expectations of continued increases (an extrapolative effect), and (2) a regressive effect which is a shorter term expectation of a fall in prices. The regressive effect was found not to affect long term interest rates. Concerning the price expectations effect, Sargent and Fisher reached the same general conclusions. First, there is a relationship between price expectations and the nominal interest rate, and second,
the formation of price expectations, within an adaptive expectations framework, occurs over a very long lag.
Chapter 3

YOHE AND KARNOsky's study

William P. Yohe and Denis S. Karnosky, in "Interest Rates and Price Level Changes, 1952 - 69", examine two of the conclusions reached by Fisher: (1) Interest rates lag behind price level changes which obscures the relationship between them, and (2) there is a correlation between interest rates and a weighted average of past price level changes.¹

The article begins by assuming an adaptive expectations hypothesis under which price expectations are assumed to be formed by past experience with regard to price level changes. Then Yohe and Karnosky summarize the differences between their study and previous studies. First, they use monthly instead of quarterly data in more flexible lag structures. Second, they confine their data to the period following the Treasury-Federal Reserve Accord of 1951 "in order to avoid having to contend with the constraint on interest rate movements imposed by the Federal Reserve's 'par pegging' of government securi-
ties prices". Finally, they incorporated Sargent's loanable funds model to include "real" variables that might affect the interest rates through the real rate of interest.

Yohe and Karnosky use securities issued in the private sector in order to avoid the effects of debt management and monetary policy actions as much as possible. The short term interest rate (rns) is approximated by the yield on four-to-six month commercial paper. The long term interest rate is approximated by the yield on Aaa-rated corporate bonds. Price expectations are measured by the rate of change in the consumer price index for all items. The equations estimated are as follows:

\[ rns = a_0 + a_1 Pe(t) + a_2 Pe(t-1) + \ldots + a_n Pe(t-n-1) \]

\[ rn1 = a_0 + a_1 Pe(t) + a_2 Pe(t-1) + \ldots + a_n Pe(t-n-1) \]

Using ordinary least squares, they found that "price movements account for about 50 percent of the variance in interest rates between 1952 and late 1969" (data series ends September, 1969). The coefficients generally decline as the lag increases and, therefore, are consistent with the adaptive expectations hypothesis, and are not statistically significant after \( t-24 \) months. (They acknowledge that the T-test was suspect due to the presence of multicollinearity.) The results of this estimation, using an unconstrained distributed lag, are markedly different from those obtained in previous studies in that the greater portion of information used in the formation of price expectations comes from current and recent past experience (within the last two years).
In order to deal with multicollinearity, Yohe and Karnosky used the Almon lag technique which produces a smoother distribution, more consistent with the adaptive expectations hypothesis. Short term interest rates were affected by movements in prices over only the previous year (using a sixth degree polynomial). The time formation of price expectations on the long term rates was found to be somewhat longer and the price expectations effect less pronounced. This finding is consistent with Fisher's hypothesis that the time horizon in forming price expectations is related to the term to maturity of the instrument.

In an effort to determine why their results were different from those of previous studies, Yohe and Karnosky examined three possible sources of difference. First, was the disaggregation of data significant, second, was the form of the lag significant, and thirdly, have institutional changes occurred, over time, to change the impact of price level changes on the formation of price expectations. Through aggregation of their data, highly similar results were obtained, therefore, this source of difference was not considered to be significant. To determine the significance of the estimation technique, they estimated the effect of prices on interest rates using a Koyck transformation:

\[ r_n(t) = a_0 + \sum_{i=1}^{\infty} \lambda^i P(t-1) \]
All of the regressions produced decay coefficients greater than one, which, "taken at face value suggests that the lagged terms do not decay". Decay coefficients that are greater than one are not consistent with the adaptive expectations hypothesis because they do not allow expectations to be adjusted according to recent experience. Though several adjustments were made to the estimation procedure and to the data, decay coefficients were found to remain above or slightly less than one. These various experiments with Koyck-type lags suggest that they are not ideal in estimation of price expectations effects. In all cases, they produced longer lags than the more flexible unconstrained or Almon lags.

A test of the significance of institutional changes involved dividing the data into two segments: 1952-60, and 1961-69. Significant differences arose between the two periods. The total price expectations effect was greater in the latter period. For short term rates, price level changes produced about ninety percent of the total change in interest rates, while for long term rates, they produced about eighty percent. In the earlier period, 1952-60, the effect was approximately twenty-five percent. The $R^2$ for long term rates changes even more drastically, from around 16 percent to 97 percent. These differences between the results obtained from the two subperiods indicate that institutional changes are, indeed, significant in determining the source of possible differences between this and earlier
studies. Yohe and Karnsoky posited four sources or possible institutional changes that may account for the differences in the formation of price expectations. Prices becoming more flexible in the upward direction in the 1950's and 1960's, than over previous periods, combined with more readily available information could "convey greater awareness of recent price level behavior", and, thereby, change the price expectations forming mechanism. Nominal rates may also be affected more by price level fluctuations due to a decrease in the money illusion or a decrease in real wealth effects of an increase in the price level. If, in fact savings are negatively related to real wealth, an increase in the price level would decrease real wealth, and as a result, savings would increase. This would produce more pronounced shifts in the level of savings due to price level changes. This effect on the supply of funds could only be significant in explaining institutional changes if real wealth was affected less than it was before by changes in the price level (i.e., a shift toward assets not fixed in nominal terms). Another possible factor is that interest rates may be more flexible than in the past, simplifying the reflection of price expectations in interest rates. The final possible source of institutional changes presented is a change in the frame of reference for forming expectations. This is attributed to the absence of cyclical changes in prices in the 1960's. This eliminates "reference points from which to extrapolate into
the future and forces individuals to the use of heavier weights on the more recent past".

William E. Gibson posited some further explanation of possible institutional changes that may have occurred over time.² He maintains that during the period of time just after the Treasury-Federal Reserve Accord, people were still accustomed to pegged interest rates and did not adjust interest rates due to this fact. He also examines the factors affecting the costs of forming expectations as compared to the expected benefits of adjusting interest rates to account for expectations. First, he points out that, not only has the rate of inflation increased, but the costs of gathering data with which to form expectations has decreased since 1960. This decrease in costs of data collection is due, in part, to "better press coverage of economic news, greater theoretical expertise of market participants, better efforts of the government to assemble and disseminate economic measures, and the like".

Yohe and Karnosky applied the Almon lag and more recent data to Sargent's model. The following equation was estimated:

\[
\text{rn}(t) = a_0 + \sum_{i=0}^{n} a_i \cdot \Delta P(t-i) + B_1 Y^*(t) + B_2 \Delta Y^*(t) + B_3 M^*(t)
\]

where \( P(t-i) \) is the annual rate of change in the GNP price deflator (or the monthly proxy of the rate of change in the CPI for all items), \( Y^* \) and \( \Delta Y^* \) are the level and rate of change in real GNP (or the monthly proxy of personal income deflated by the CPI), and \( M^* \) is the rate of change in the real money stock (nominal money stock deflated by the GNP price deflator or its monthly proxy). Nominal short and long term interest rates are the same as before.

The explanatory capabilities of price expectations was changed little through the use of this expanded model. The signs of the coefficients derived from the variables introduced were as expected, and the findings support Sargent's specification of variables. The Almon lag structure produces better statistical results than the geometric decay structure used by Sargent over the same data. The conclusions concerning the short lag and institutional changes also were found to hold under the expanded model.

Yohe and Karnosky conclude their study by a comparison of movement of the real rate of interest and the nominal rate of interest. They found that movements in the rate of interest were due to price expectations effects almost entirely.

The results obtained in their study led Yohe and Karnosky to conclude that price level changes since 1952 have a "prompt and substantial effect on price expectations and nominal interest rates". Further, the effect of price
expectations and the speed of their effect has increased since 1960. Lastly, changes in the price level account for nearly all the variation in the interest rate.
Chapter 4

EMPIRICAL RESULTS USING MORE RECENT DATA

To determine if the conclusions reached by Yohe and Karnosky still hold, an Almon or polynomial distributed lag was run on data from the beginning of 1957 to the end of 1974. This time period was chosen in order to maintain approximately the same sample size as Yohe and Karnosky, and to limit the study to a period of time wherein adjustments had been made to the post accord movements in interest rates, and wherein the expanded use of computer technology in data analysis was employed.

The short and long term interest rates are the same as those used by Yohe and Karnosky. The short term interest rate (rns) used is the money rate on prime commercial paper (four-to-six months), not seasonally adjusted. The long term interest rate (rnl) is the yield on Moody's Aaa corporate bonds, not seasonally adjusted. The rate of change in the price level is the rate of change in the CPI all items (Pe).

A sixth degree polynomial was used in order to assure conformation to the previous study. The results of the regression run on the short term rate of interest by the rate

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1Data Resources Incorporated, Computer data banks and programs were used for computational purposes.
of change in the price level are presented in Figure 1. As the length of the lag was increased from twenty-four to thirty-six, and, finally, to forty-eight periods, the mean lag of the regression rose in magnitude, as well. This is consistent with the results obtained by Yohe and Karnosky. This increase in the mean lag as the number of lag periods is increased is consistent with the adaptive expectations hypothesis that assumes that price expectations are a continuous function of current and past price level changes. The coefficient of correlation increases significantly as the number of lag periods is increased from twenty-four to thirty-six periods. Increasing the length of the lag from thirty-six to forty-eight periods does not, however, make a significant contribution to $R^2$ or to the length of the mean lag. Generally, this extension merely smooths the distribution of coefficients.

The results of regressing the rate of change in the price level on long term interest rates did not conform to Yohe and Karnosky's results as well as those of the short term rates. The results are presented in Figure 2. The results achieved with lags of twenty-four, thirty-six, and forty-eight months appeared to be inadequate in length, so the number of periods lagged was extended to sixty months with only slightly improved results. Once again, as the number of periods lagged was extended, the mean lag of the regression increased to a high of 22.8 months in the lag of
sixty months. The $R^2$ values also increased as the lag was extended. The majority of the lag effects are still realized within two years, as concluded by Yohe and Karnosky. It is interesting to note that there are no negative coefficients present in the long term case as there were in Yohe and Karnosky's estimation. This is consistent with Sargent's finding that regressive effects were not significant when dealing with long term interest rates (see Chapter 2 of this study). The $R^2$ term of the regression is improved somewhat, indicating the explained variance between the time periods has improved in the later series. The sum of regression coefficients has also improved in the later relationship. These two improvements indicate that even more of the movement in interest rates is explained by the rate of change in the price level over the more recent time period than over the 1952-69 time period. This indicates that as time passes there are continuing institutional changes in the bond market. Most important, the majority of the effects of changes in the price level are still felt within two years as compared to twenty or more years obtained in studies prior to Yohe and Karnosky's.

The length of the lag in forming price expectations for short term rates is markedly shorter than the length of the lag for long term interest rates. This, again is consistent with Fisher's hypothesis that the length of the lag is
correlated to the term to maturity of the instrument under consideration.

The polynomial distributed lag was applied to Thomas Sargent's model (see Chapter 2) in order to determine whether or not movements in factors affecting the real rate of interest add significantly to the explanatory power of the regression.

Rns, rnl, and Pe use the same data. For a level of aggregate production real personal income was used (same procedure as used by Yohe and Karnosky). The rate of change in the money supply was also done the same way as Yohe and Karnosky's estimation. The following equation was estimated:

\[ \text{rns}(t) = a_0 + a_{1+(t-i)} + B_1Y + B_2Y + B_3M^* \]

where the variables are named the same as by Yohe and Karnosky.

Best statistical results were realized using a fifth degree polynomial lagged thirty-six periods. The results of the regression are presented in Figure 3. The signs of the variables were not constrained, but did appear as specified by Sargent. The results do indicate that Sargent properly specified the variables even though their explanatory contribution is small. The explanatory power of the expanded regression is only slightly improved in the expanded model. The coefficient of correlation \((R^2)\) increased from .8069 to .8082 while the sum of lag coefficients declined by .0887.
The mean lag of the regression was not significantly different from the mean lag without the additional variables as specified by Sargent. The decline in mean lag of the expanded regression is from 7.83645 months (simple regression) to 7.16133 months (expanded regression). As was the case with the simple form the mean lag of the expanded regression increased as the number of periods lagged was increased. The expanded model also supports the conclusion that institutional changes have occurred since Yohe and Karnosky's data base.

The results of the expanded model, when applied to the 1957-74 time period, are consistent with the results obtained by Yohe and Karnosky over the 1961-69 period. The importance of price level changes in explaining movements in nominal interest rates is diminished only slightly, if any, by the inclusion of variables specified in the expanded model. The polynomial distributed lag yields much better statistical results than the geometrically decaying lag used by Sargent over earlier as well as the same data period. Finally, the real market rate of interest implied by the regression does not move drastically, suggesting that the changes in the price level account for nearly all of the movement in nominal interest rates.
Chapter 4

CONCLUSIONS

The findings of this study support the conclusions drawn by Yohe and Karnosky. The "Fisher effect" has continued to be the most significant variable in determination of nominal interest rates, or, in other words, changes in the price level have continued to have a "prompt and substantial effect on price expectations and nominal interest rates". This becomes important when one considers that, due to this more immediate effect of price level changes on the nominal interest rate, most of the movement in nominal interest rates is caused by changes in the price level. Further, the inclusion of variables to account for movements in the real rate of interest does not significantly change the outcome of the regression. Changes in the price level maintain their position as the primary determinant of the nominal interest rate.

The impact of these findings upon the use of interest rates as target variables or as indicators of monetary policy continues to be significant. The use of nominal interest rates without adjustment for changes in the price level may lead to incorrect conclusions concerning the direction of monetary policy.
SUM  CONSTANT  $R^2$

24 LAGS  .7179  2.6910  .7910
36 LAGS  .7915  2.5433  .8069
48 LAGS  .8004  2.5332  .8074

Figure 1

Distributed Lag Patterns: Short Term Interest Rates 1957-1974
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**Figure 2**

Distributed Lag Patterns: Long Term Interest Rates 1957-1974
**Figure 3**

Distributed Lag Pattern of the Expanded Model

- **SUM**: 0.7027
- **CONSTANT**: 2.4458
- **$R^2$**: 0.8082
BIBLIOGRAPHY


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