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VOL. XIII, NO. 4 DECEMBER 1975 COPYRIGHT 1975 PRINTED IN U.S.A.

OUR NEW MONETARY STANDARD: THE MEASUREMENT AND EFFECTS OF PRICE UNCERTAINTY, 1880-1973*

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U.S. annual inflation rates over the last century are analyzed in an attempt to compare price unpredictability in the recent period with that during the 1880-1915 gold standard period. The movement from negative price change autocorrelations in the earlier period to strongly positive price change autocorrelations in the recent period, is shown to imply an upward shift in the amount of long-term relative to short-term price uncertainty. Empirical evidence on the relationship between the demand for money and actual price change, on the adjustment of interest rates to price changes and on the change in the composition of new corporate debt issues is presented. Evidence suggests that only over the last decade has the public generally recognized the fundamental change from a commodity to a fiduciary standard that has occurred in the underlying monetary framework.

This paper examines the movement of prices and changes in the implied underlying monetary framework in the United States over the last century. I look at annual inflation rates over this period in an attempt to make some historical comparisons and general observations regarding crucial differences in the behavior of prices over the last fifteen years compared to the previous seventy-five. The particular narrow questions I focus upon are: How predictable are price changes now compared to earlier periods? and, What have been the economic effects of changes over time in price uncertainty?

Although I think I have a reasonable story to tell, I have no doubt that other individuals might look at these same inflation rate observations (listed in Table 1) and come up with a very different summary of what is now occurring. For example, Gordon (1971) and Tobin and Ross (1971) have argued that price changes during the recent period have been relatively steady and therefore that price changes are now relatively

*This paper is an extension of my earlier study (1976). I am especially indebted to Armen Alchian, and also to Philip Cagan, Stephen Ferris, Milton Friedman, Levis Kochin, Roger Kormendi, Anna Schwartz, and Paul Wachtel for rewarding discussions. Useful comments were also supplied at various stages of this work by participants at seminars at the VPI Center for Study of Public Choice, UCLA, the University of Chicago, the Federal Reserve Bank of San Francisco, the Board of Governors of the Federal Reserve System and the University of Miami. Able research assistance was provided by Stephen Ferris, Laura La Haye and Dicran Marcarian. Scott Harris drew the charts. I am grateful to the Foundation for Research in Economics and Education for research support. Of course, I remain solely responsible for the opinions expressed and for any errors.

TABLE I

Annual Rate of Change of Implicit National Product Price Deflator, 1870-1973

Date	(ΔlogP)	Date	(ΔlogP)	Date	(ΔlogP)	Date	(ΔlogP)
1870	−5.66	1897	0.45	1924	−1.30	1951	6.49
1871	1.59	1898	2.87	1925	1.99	1952	2.20
1872	−5.14	1899	2.58	1926	0.49	1953	0.90
1873	−1.21	1900	5.17	1927	−2.68	1954	1.42
1874	−1.07	1901	−0.61	1928	0.70	1955	1.46
1875	−2.34	1902	3.39	1929	−0.10	1956	3.37
1876	−4.69	1903	0.98	1930	−4.60	1957	3.69
1877	−3.71	1904	1.54	1931	−12.83	1958	2.51
1878	−7.68	1905	2.08	1932	−12.27	1959	1.62
1879	−3.59	1906	2.04	1933	−1.36	1960	1.60
1880	9.88	1907	4.13	1934	6.34	1961	1.27
1881	−1.93	1908	−0.18	1935	−1.29	1962	1.05
1882	3.15	1909	3.47	1936	4.07	1963	1.29
1883	−1.21	1910	2.52	1937	0.87	1964	1.61
1884	−5.37	1911	−0.83	1938	−0.50	1965	1.87
1885	−6.85	1912	4.26	1939	−0.75	1966	2.72
1886	−1.39	1913	0.48	1940	1.12	1967	3.19
1887	0.99	1914	1.43	1941	7.61	1968	3.92
1888	1.76	1915	3.10	1942	12.27	1969	4.68
1889	0.58	1916	12.20	1943	12.37	1970	5.41
1890	−1.95	1917	21.12	1944	7.17	1971	4.54
1891	−0.99	1918	13.97	1945	4.32	1972	3.01
1892	−4.06	1919	1.51	1946	0.87	1973	5.28
1893	2.45	1920	13.15	1947	11.21		
1894	−6.47	1921	−16.01	1948	6.50		
1895	−1.52	1922	−5.04	1949	−0.66		
1896	−2.89	1923	2.31	1950	1.39		

Sources: 1870-1909, Gallman's annual NNP estimates; 1910-46, Kuznets' annual NNP estimates, adjusted in wartime; 1947-72, annual average of the Commerce Department's quarterly GNP estimates.

predictable.[1] An implication of this observation, they claim, is that public policy should not be concerned with reducing the current inflation rate. I argue here that, on the contrary, the price uncertainty associated with the recent inflation is much greater than previously believed. Once the recent inflationary experience is put into historical perspective and more completely analyzed, it becomes unclear whether price changes are

1. This statement would seem to hold only up to 1973. The rate of price change observation for 1973-74 is 10.14. But this, I think, reflects unique factors (price decontrol, precautionary price increases because of fear of new controls and the oil cartel action) and does not represent a permanent increase in either the level or variability of annual inflation rates.

more predictable now than they were, for example, at the turn of the century, when annual price changes were, in fact, much more variable.

I present evidence, some of it weak but all of it consistent, that clearly suggests that we have only very recently moved to a fiduciary monetary standard where the long-term trend in prices is no longer presumed to be zero and where large price changes in one direction are not expected to be reversible. When all this evidence is taken together a persuasive case can be made that under the new standard the variance of estimates of the price level expected in the future (e.g., six years from now) may be relatively high. Therefore, although variability in the annual rate of price change is now relatively low, *long-term* price unpredictability is significant and the price uncertainty associated with the current inflation no longer seems to be small. Empirical implications of this recent rise in long-term relative to short-term price uncertainty are then examined.

I. THE MEASUREMENT OF SHORT-TERM PRICE UNPREDICTABILITY

It is important at the outset to note explicitly how "unpredictability" of price change is used in this paper. Most discussions of inflation implicitly assume a degenerate prior probability price change distribution. Individuals are assumed to estimate an "expected" rate of price change (which can be thought of as the mean of the prior probability distribution), but the confidence interval on this estimate (the variance of the prior probability distribution) is ignored and implicitly assumed to equal zero. It is useful, however, to distinguish between two separate questions: (a) does the current actual rate of price change, in fact, equal the mean of the expected or predicted price change distribution, i.e., assuming that contracts were adjusted to this mean, does the inflation produce any wealth redistribution effects, and (b) how much uncertainty now exists regarding future price changes, i.e., what is the variance of the expected price change distribution? I am here concerned with the latter question and therefore with the variance of the underlying prior probability price change distribution individuals believe they face. The actual rate of price change may equal the mean expected rate of price change at a particular point in time (and we can therefore call this price change "fully anticipated") yet there may exist a great deal of price change uncertainty. Zero information costs would imply not just that, ex post, the actual rate of price change equals the mean predicted rate of price change but also that the prior variance of predicted rate of price change equals zero, i.e., *perfect accuracy* and *perfect certainty*. The actual rate of price change may not equal the mean predicted rate of price change and therefore be "unanticipated" yet may be "expected" (if, say, the actual is within one standard deviation of the mean). The variance of the prior probability distribution can therefore be thought of as a measure of how much "unanticipated" price change is "expected."

To get some idea of the historical movement of the unpredictability of price change, we use the data in Table 1 to derive a measure of the variability of the annual rate of price change over the period 1880-1973. This is plotted in Chart 1, where variability is measured by the six-term moving standard deivation of the annual rate of change of prices.[2] If price anticipations are assumed not to be formed regarding the acceleration of price change (or of any higher derivatives), this series may be regarded as an operational measure of the amount of unanticipated annual price change over the past six years and the amount of unanticipated price change (or price uncertainty) expected for the immediate future.[3] We therefore consider this series to be a measure of short-term price unpredictability, σ_S. This measure indicates that the unpredictability of short-term price change has been extremely low over the past fifteen years. Although there is a positive relationship between the mean rate of price change and the variability of the annual rate of price change in some countries at some times, it seems *not* to be the case now for the United States. As we can see from Chart 2, which plots a six-term moving average of the annual rate of change of prices, the mean rate of price change over the last two decades has been high by historical U.S. peacetime standards, while the variability in the annual rate of price change has been extremely low over this same period. The only other time interval of similar length that compares with the most recent period in terms of a continuous upward trend in prices is the pre-World War I gold inflation of 1897-1914, when prices rose at an average annual rate of nearly two percent. But the post-1955 inflation has, by comparison,

2. This is similar to the concept used by Friedman and Schwartz (1963) as a measure of the variability of money and income. I first computed logarithmic first differences of a price index series centered in mid-year (table 1) and then computed moving standard deviations from these year-to-year percentage rates of price change for six terms and dated the result as of the final year. The vertical scale on the chart is logarithmic to minimize the heteroscedasticity problem (cf. Friedman and Schwartz, p. 202).

3. This is a crude measure of price unpredictability. A more complete analysis might contain an explicit model of the formation of price expectations based on the stochastic properties of the series and a measure of price change unpredictability based on the deviations of actual from expected price changes over time. But merely fitting a Box-Jenkins ARMA model (or an adaptive regression model) to past rate of price change to make price forecasts at every point in time will yield misleading results. A major point of this paper is that the public considers other information when forming price expectations, such as the nature of the underlying monetary institutions. And the problem is one of explicitly considering shifts in these other factors without relying at any point in time on price information not yet experienced. I did experiment with measures over time of ex post or realized unpredictability based upon the difference between current market interest rates and future rates of price change. But without any independent measure of real rates (e.g., assuming real rate changes were zero), these derived variables were nonsensical. (The 1940's were the most obvious aberration, when interest rates were low while inflation rates were high; interest rates were also very high in 1869-74 while a significant deflation was occurring in the 1870's.) Use of phase average data did not yield more meaningful results.

Variability is, however, a good measure of unpredictability if the underlying stochastic structure is assumed to be one of a constant mean plus some random disturbance. Evidence presented below (table 2) suggests that the assumption of a constant (zero) mean works reasonably well until 1955 and therefore substantiates my implicit model of the formation of expectations at least up to that point.

CHART 1

Short-term Price Unpredictability (σ_S), 1880-1973

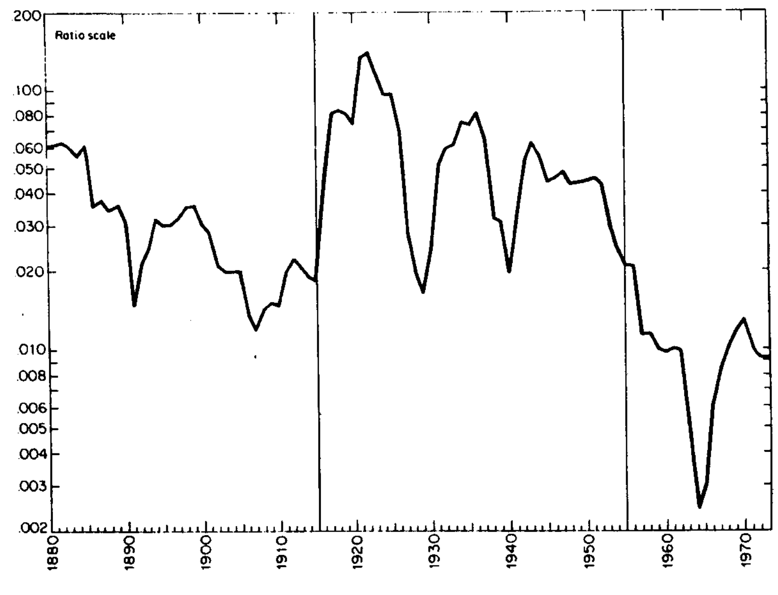
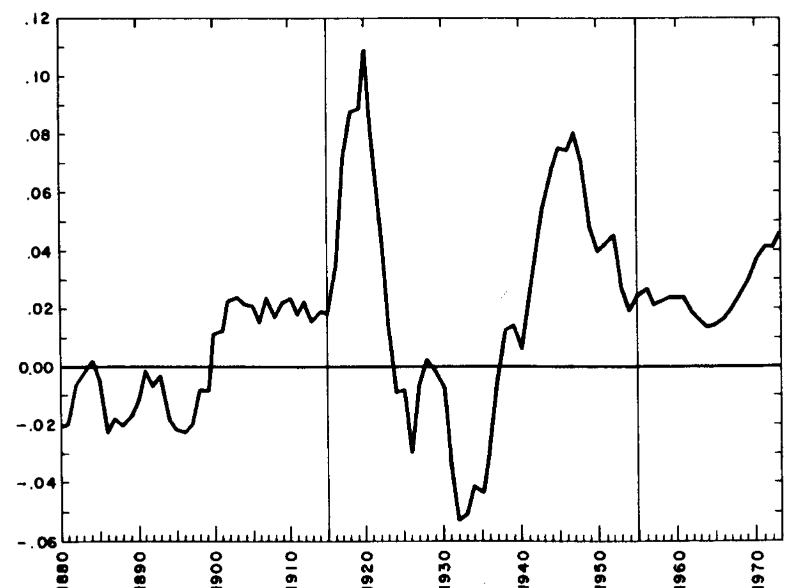


CHART 2

Moving Average Rate of Price Change $E_6(\Delta \log P)$, 1880-1973



been higher and much less variable. The earlier 18 year period follows a long period of deflation and includes three years when prices actually declined. The last twenty years is, in fact, the only such period in our recorded history without a single year in which prices fell. This is reflected in the moving standard deviation of prices, which is significantly lower during the last fifteen years than in any other period, reaching an historically unprecedented low level of .0024 (i.e., .24 percentage points) in 1964. We appear now to be experiencing, for the first time in our recorded history, a significant inflation that is relatively steady and therefore, may lead us to assume, highly predictable.[4] However, under the more complete analysis that follows, this conclusion will be shown to be incorrect.

II. A NEW MONETARY STANDARD

It is convenient for analysis to divide somewhat arbitrarily the total period covered in charts 1 and 2 into three subperiods: (a) the "gold standard" period from 1880 to 1915,[5] (b) the "transitional" period from 1916 to 1955 and (c) the "new standard" period from 1956 to 1973. The corresponding average level of the moving standard deviation variable over each of these subperiods is: (a) .0310, (b) .0569, (c) .0095. The transitional period has the largest average standard deviation. Since this period contains the Great Depression, the two World Wars and the Korean War, comparisons with the other two periods are not entirely relevant. The comparison between the latest period and the gold standard period, however, is striking. The average standard deviation was more than three times as great during the gold standard period than during the recent period. This merely confirms the argument of the previous section regarding the historically unique character of the extremely low level of price unpredictability which now seems to exist.

But comparison of the recent period with the earlier "gold standard" period in terms of a moving standard deviation as a measure of the predictability of prices is misleading. The latest period contains only positive price changes while the earlier time period contains positive and negative price changes. And although annual price changes were previously unsteady, the long-term trend in prices was quite stable with

4. The level of the moving standard deviation was very low by historical standards even at the 1970 peak (.0130) and in 1972-73 was less than one percent (.0091).

5. "Gold standard" is merely a label for this particular time period and is not used here in any descriptive sense. Actually, as I show later, individuals generally believed we were on some type of "gold standard," i.e., price reversion standard, certainly as late as the 1950's and probably into the 1960's.

large price changes in one direction generally expected to be reversed within, say, six years.[6]

This gold standard phenomenon can perhaps be seen most clearly by examining the sample autocorrelations of the annual rates of price change presented in Table 2. Each of the first two subperiods has been divided into two equal periods. There are thus five periods of similar length over which autocorrelations have been calculated. The first two gold standard periods are distinctly different from the final new standard period. The autocorrelations during the gold standard periods are generally negative or close to zero while the autocorrelations during the most recent period are positive — in fact, strongly positive for the one and two year lag terms.[7] The gold standard can be considered to have

TABLE 2

Sample Autocorrelations of Annual Rates of Price Change
1880-1973

(Correlation of $(\Delta \log P)_t$ and $(\Delta \log P)_{t-j}$

j	1880-97	1898-1915	1916-35	1936-55	1956-73
1	−.132	−.595**	.418*	.467**	.751**
2	−.085	.058	.204	.013	.561**
3	−.363	−.009	.076	−.072	.407*
4	−.416*	−.455*	−.153	.024	.227
5	−.273	.100	−.088	.078	.080

** Indicates autocorrelation significantly different from zero at the .95 confidence level, * at the .90 level. (The asymptotic standard error of each sample autocorrelation is $1/\sqrt{n}$, where n is the number of observations in each time period under the null hypothesis that the true autocorrelations are zero, cf. Box and Jenkins [1970, ch. 2].) The indicated dates refer to the $(\Delta \log P)_t$ observation, implying that all autocorrelations within each time period have the same number of observations (although more data are used for the longer lags).

6. In Klein (1976) it is shown that although during the 1880-1915 period annual price changes were highly variable, the variance of the *absolute* rate of change of prices was low. Price changes of similar magnitude but of opposite sign occurred temporally close to one another. If, for example, an eight percent inflation rate occurred in a particular year, an inflation rate of approximately minus eight percent would likely occur a short time later (within six years).

7. Because the rate of price change data in the most recent period are annual averages of quarterly observations, there may be an aggregation bias in the first-order serial correlation (cf. Working (1960)). If the serial correlation of the quarterly data is zero, there is a positive bias of .227. Since we have positive serial correlation in our quarterly data, the bias is lower than .227. If, for example, we use the second quarter price level observation in each year to calculate the annual rate of price change, the sample autocorrelations for 1956-73 are essentially unchanged at .730, .535, .391, .176, .034. Similarly, the sample autocorrelations for 1936-55 using second quarter observations for the post 1946 period are .453, .006, −.084, .013, .071 which are nearly identical to the autocorrelations using annual average observations.

been a period of *mean reversion* in the rate of price change while the current period is one of persistence or long-term *mean revision* in the rate of price change.[8] Hence, the current rate of price change is now a good indication of what the rate of price change will be in the immediate future while under the gold standard the relationship between the current rate and future rates was negative and weaker.[9]

Further evidence for the presence of this gold standard presumption that periods of inflation were expected to be followed by periods of deflation is provided by the effect of the actual rate of change prices in secular (phase average) demand for money regressions.[10] Although the current rate of price change enters negatively over the 1916-1970 period (equation (1), 26 cycle phase observations), which includes both the

8. Including the 1974 rate of price change observation and what is likely to be the 1975 observation in these calculations may lower the autocorrelations for the most recent periods substantially. But, although recent rates of price change are likely to exhibit negative autocorrelation, this is merely a statistical aberration and certainly not evidence of a return to a gold-type (mean reversion) monetary standard. The lower rate of price change likely in 1975 will in large measure be the bursting of an artificial measured inflationary "bubble" created by exceptional circumstances in 1974 (see footnote 1). Although recent Federal Reserve monetary policy will surely contribute to this deceleration, I find it hard to believe that the Fed has permanently adopted a new long-term policy of mean reversion around a given secular inflation rate.

9. The new standard period can be considered to be a martingale in the rate of price change since the sample autocorrelations of the acceleration of price change are not significantly different from zero. Instead of positive serial correlations that one might expect, the autocorrelations of the accelerations of price change in this recent period are close to zero but generally negative. This is similar to the pattern of acceleration autocorrelations in the earlier periods; although in the gold standard periods the negative autocorrelations are sometimes significantly different from zero.

Sample Autocorrelations of Annual Rates of Price Acceleration

Lag	1880-97	1898-1915	1916-35	1936-55	1956-73
1	−.488*	−.647**	−.313	−.140	.038
2	.127	.216	−.088	−.213	−.320
3	−.097	.214	.073	−.021	−.227
4	−.131	−.473*	−.267	.037	−.365

**Indicates autocorrelation significantly different from zero at the .95 confidence level, * at the .90 level.

10. The basic unit of observation is the average value over annually dated cycle phases, where the initial and terminal turning point observations are weighted by one-half and the intervening observations by unity. The regression is then run using these phase averages weighted by $2n^2/(2n-1)$ where n is the duration of the phase. (Assuming each annual observation entering the phase average is statistically independent and has the same disturbance variance, this weight is inversely proportional to the variance of the phase average.) M is broadly defined money balances (currency plus all commercial bank deposits), Y is net national product, P is the national product deflator, N is population and r_L is the long-term (to 30 year) yeild on high-grade corporate bonds. All logs stand for natural logarithms and the absolute values of the t-statistics are given in parentheses beneath the coefficient estimates. The years noted refer to mid-phase dates, i.e., 1880-1916, for example, refers to the period from the 1879-82 expansion to the 1914-18 expansion. The 1916-70 period includes the 1966-67 mini-recession as a contraction phase, although not officially considered such by the NBER. For the entire time period the average length of an expansion phase observation is 2.6 years and for a contraction phase observation is 1.4 years. I am indebted to Anna Schwartz for the data underlying these series.

(1)
$$\log(M/PN) = \underset{(0.38)}{-.069} + \underset{(72.03)}{.989}\log(Y/PN) - \underset{(4.26)}{.101}r_L - \underset{(2.39)}{.012}(\Delta \log P) \qquad R^2 = .999 \quad DW = 0.81$$

new standard and transitional periods, the current rate of price change enters positively over the 1880-1916 gold standard period (equation (2), 21 cycle phase observations).

(2)
$$\log(M/PN) = \underset{(1.89)}{.766} + \underset{(16.24)}{1.086}\log(Y/PN) - \underset{(5.78)}{.484}r_L + \underset{(4.40)}{.047}(\Delta \log P) \qquad R^2 = .992 \quad DW = 0.85$$

This suggests that actual price change may have been negatively correlated with anticipated short-term price change during the pre-World War I period and may explain why "expected" price change variables, measured as a positive function of a weighted average of past actual price changes (with the weighting scheme assumed constant over the entire time period), do not show up significantly in reported long-run U.S. demand for money studies.

III. THE MEASUREMENT OF LONG-TERM PRICE UNPREDICTABILITY

Under a commodity standard, an average of past price changes has no direct *positive* relationship with long-term price anticipations, and so the standard deviation of the annual rate of price change variable cannot be regarded as a complete measure of the unpredictability of prices in such an economy. Although *annual* rates of price change may have been highly variable, the price level expected in five or ten years may have been more predictable during much of our early history than now.

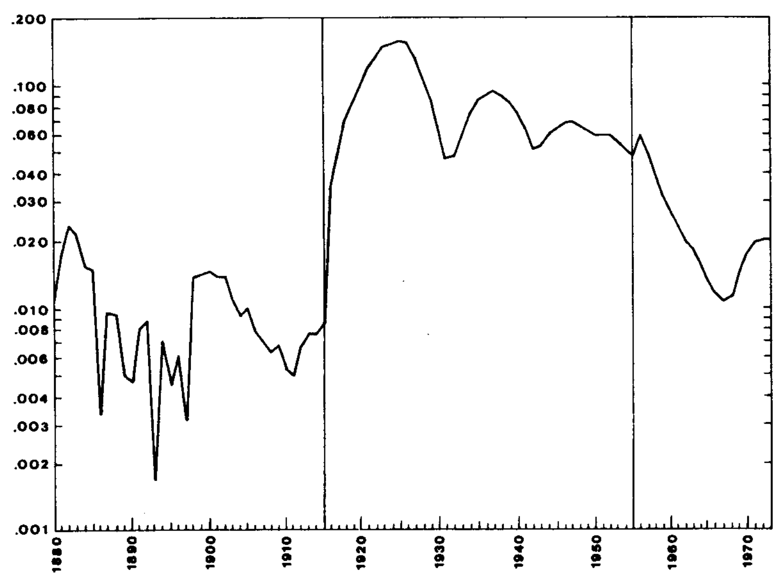
A measure of long-term price unpredictability (longer than that plotted in Chart 1) may be conveniently defined if stability is assumed in the underlying process generating the annual rates of price change in each of the five time periods isolated in Table 2 and these sample autocorrelations are considered as the best point estimates of the true autocorrelations of the underlying statistical processes. The six-term moving standard deviation of the rate of price change variable, σ_S, is considered to be a measure of short-term price unpredictability or uncertainty in next year's rate of price change. To derive a measure of price uncertainty over a longer time period, consider the annual rate of price change expected for each future year as a random variable and merely use the formula for the variance of the sum of n random variables:

(3)
$$Var\left(\sum_{i=1}^{n} x_i\right) = \sum_{i=1}^{n} Var(x_i) + \sum_i \sum_j Cov(x_i, x_j) .$$

Uncertainty of the rate of price change over the next six years, for example, may be measured by the sum of our σ_S^2 variable over the current and previous five years plus a term to measure twice the expected co-variance of the annual rate of price change over these six years, $\sum_i \sum_j \sigma_S(i)\sigma_S(j)r_{i,j}$, where the value of $r_{i,j}$ is taken from Table 2 for the year for which long-term price unpredictability is defined. This variable is divided by six and the square root taken to get a measure of *uncertainty regarding the average annual rate of change of prices over the next six years*, denoted σ_L and plotted in Chart 3. This variable can then be compared to σ_S in Chart 1.

CHART 3

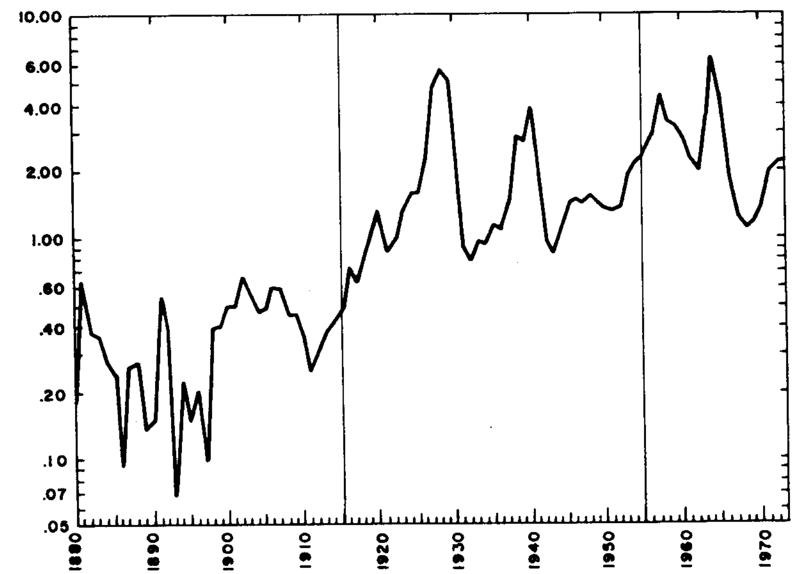
Long-term Price Unpredictability (σ_L), 1880-1973



The average level of this longer-term price unpredictability variable over each of the three subperiods is (a) .0096, (b) .0801, (c) .0232. The transitional period, once again, has the highest average level. This period has by far the greatest degree of price uncertainty with both short-term and long-term price unpredictability, σ_S and σ_L, extremely high. But what has changed in comparison to the relative levels of our σ_S series is that the degree of price uncertainty experienced during the recent period is no longer only one-third what was experienced during the gold standard period but rather now nearly two and a half times as great. The current value of σ_L of slightly more than two percent, is a level we remained below for the entire 1884-1915 period. Clearly, unlike the analysis with regard to σ_S, it cannot be concluded that over the last fifteen years *long-term* price unpredictability has been at an historically unprecedented low level. *What has occurred over time has been an upward shift in the amount of long-term relative to short-term price unpredictability.* This secular movement can be seen by looking at the ratio of σ_L to σ_S over time, which is plotted in Chart 4. The average ratio of σ_L to σ_S over the three subperiods is: (a) 0.31, (b) 1.41, (c) 2.44. This phenomenon

CHART 4

Long-term Relative to Short-term Price Unpredictability (σ_L/σ_S), 1880-1973



can be attributed to the general increase over time in the autocorrelations of the annual rate of change of prices. The σ_S variable indicates that we are less likely now than under the gold standard to experience next year a rate of price change that is more than, for example, two percentage points away from the mean estimate. But the high autocorrelations imply that if in fact we do experience such an unanticipated price change, it is more likely now to continue for a few years while under the gold standard it was likely to reverse or "correct" itself, i.e., "average out" over time.

IV. PUBLIC RECOGNITION OF THE NEW MONETARY STANDARD

Realization that we were on this new monetary standard, where rapid inflation would not likely later be followed by deflation, must have occurred very gradually over the last twenty-five years. There is evidence that suggests that although the U.S. went off the gold standard *de jure* in 1933, gold standard expectations (where large or unanticipated price changes in one direction are expected to be reversible) persisted *de facto* in the 1960's. Although the 1916-55 period was "transitional" in terms of actual price change behavior (the movement from negative to strongly positive price change autocorrelations), it does not appear to be a transitional period in terms of a change in the public's adjustment of price expectations to past price behavior. In the immediate post-World War II period a deflation was generally expected. The Livingston survey data on price anticipations[11] indicates a forecasted rate of change of the CPI for the following year which, except for the Korean War period during 1951 and early 1952, was consistently negative over the 1946-54 period. The reported "expected" annual rate of price decline immediately following World War II in 1946-47 was greater than eight percent. Individuals expected a postwar price reaction to wartime inflation very similar to our experience after earlier wars. Only after the post-World War II deflation did not materialize and then prices also failed to fall following the Korean War and during the recessions of the 1950's and early 1960's did the public gradually recognize that we were operating under new monetary rules.

A major determinant of the fundamental policy shift to the new monetary standard was the gradual *de facto* adoption of the international dollar standard which reduced the force of the balance of payments as a constraint on U.S. monetary policy. But even as late as 1964 firm expectations must have been held that a long-term monetary policy necessary to maintain foreign convertibility of the dollar at $35/oz. would be followed. As Table 3 shows, the index of the official commodity value of gold (the ratio of the official dollar value of gold to the wholesale price index) was only slightly lower in 1964 than in 1922 (after the sharp post World War I deflation). Using this as a benchmark, as late as the mid-1960's the official price of gold was not more than ten percent too low in terms of real purchasing power. The inflation of the 1940's, the 1950's and the early 1960's merely readjusted the level of prices for the deflation and devaluation of the 1930's. It is, therefore, easy to understand why much of the public, although looking at the accumulating annual price change evidence over this period, did not clearly see the fundamental change in the monetary framework that was taking place.

11. Joseph A. Livingston conducts a semi-annual survey of price predictions of economists which has been reported in the Philadelphia Bulletin since 1946.

Since 1964, however, in spite of the recent U.S. devaluations, the purchasing power of official gold has fallen (by late 1973) an additional twenty percent. Within this context the twenty percent increase in the official dollar price of gold that has occurred since 1971 has clearly been of insufficient magnitude. But a major deflation is certainly not now generally anticipated.

TABLE 3

Index of Official Commodity Value of Gold, 1921-73
(1926 = 100)

Year	Index	Year	Index	Year	Index
1921	102	1939	220	1957	93
1922	103	1940	215	1958	92
1923	99	1941	194	1959	92
1924	102	1942	171	1960	92
1925	97	1943	164	1961	93
1926	100	1944	163	1962	92
1927	105	1945	160	1963	92
1928	103	1946	140	1964	92
1929	105	1947	114	1965	90
1930	116	1948	105	1966	87
1931	137	1949	111	1967	87
1932	154	1950	107	1968	85
1933	194	1951	96	1969	81
1934	225	1952	99	1970	79
1935	212	1953	100	1971	76
1936	210	1954	100	1972	79
1937	196	1955	99	1973	77
1938	215	1956	96		

Source: 1921-55 from Cagan [2], table F7, extended 1956-73 using Bureau of Labor Statistics WPI and official U.S. price of gold. Observations are on June 30 of the indicated year.

It is also instructive to note in this context that until very recently the ratio of the total stock of high-powered money to the official dollar value of the total U.S. gold stock has been historically rather stable.[12] The ratio of high-powered money to gold was 2.5 as late as 1960, which was very close to the average level of 2.3 during the 1880-90 period after the return to convertibility. In fact, the ratio averaged 2.2 over the entire 1880-1915 gold standard period. The ratio reached an all-time low of 1.0 in 1941 after the massive gold inflows of the 1930's and a pre-1961 all-time high value of 2.9 in 1893 when the Treasury experienced signifi-

12. See Cagan [1965, p. 56, Chart 4, appendix table F7 and also pp. 49-67].

cant gold drains. In spite of the large increases in the official dollar value of gold, the post-1960 rise in the (H/gold) ratio has been dramatic and is currently close to 10.0. This indicates how unique the last decade has been in terms of the break of the tie between our money stock and gold and the *de facto* movement off the gold standard.

Finally, the substantially shorter lag of adjustment of interest rates to price level changes found by Yohe and Karnosky (1969) than that found in many earlier studies is behavioral evidence that individuals began to realize during the late 1950's and 1960's that a new pure fiduciary standard was replacing any remainig semblance of a gold commodity standard. If the Yohe and Karnosky regressions are extended backward in time from the 1952-69 period used in their study, the total effect of price level changes on long-term interest rates is much smaller and slower. The initial price change coefficients are often negative and the sum of the coefficients is often close to zero. These are results one would expect under a commodity standard with long-term expectations of a stable price level. For example, Table 4 presents regression results over three time periods of the monthly annual rate of CPI change on the long-term interest rate, using a 48 month sixth degree polynomial lag structure.[13] Both the six month and 48 month sum of price change coefficients on the long-term interest rate has risen dramatically in the 1952-72 period compared to the two earlier periods.[14]

Table 5 shows more precisely when the change in the short-run impact on the level of interest rates of a change in the rate of price change took place. This table presents decade by decade results of the sum of the first six months coefficients for similar regressions using a 36 month sixth degree Almon lag of the annual rate of monthly price change in the CPI against both long and short interest rates. These results indicate that a significant positive short-run impact of price change on the level of interest rates is present only in the last decade.

13. The time period noted for these and all other distributed lag regressions refers to the dependent variable. In this case there is therefore another previous four years of rate of price change data entering each estimate. These regressions implicitly assume that the level of the real rate of interest is statistically independent of current and past rates of price change, making it possible to treat it as a constant plus a residual term. Sargent (1973) has demonstrated that this procedure is most appropriate when the interest elasticity of demand for money is zero, a condition that makes some theoretical sense when competitive interest payments are made on money (cf. Klein (1974)). But, in any event, I am merely comparing the effects of current and past price change on interest rates over different time periods and need only assume that whatever short-run changes in the real rate do occur have not changed over time.

14. These results are to be expected from the sample autocorrelations of Table 2 and the efficient markets hypothesis. The autocorrelations imply that the current rate of price change contains information about future rates of price change and the results indicate that the capital market adjusts to this information. It is important to recognize that the efficient market hypothesis implies adjustment of *relative* prices of storable assets. Therefore bond prices (the price of money today relative to tomorrow) will adjust to the future price change information embodied in the current rate of price change, but other current nominal prices (e.g., in the GNP deflator) will not adjust to this information. The current price of a house, for example, will not increase with an increase in the anticipated rate of change of prices since future housing rental prices and the interest rate will both rise, leaving the asset price in current dollars unchanged. The existence of significant positive autocorrelation in the rate of price change variable is therefore not inconsistent with the efficient markets hypothesis. Although we may now have information that general prices will be higher next period, it will not pay to carry those goods in the GNP basket which are storable over to the next period because the *real* value of goods is not anticipated to rise. The efficient markets hypothesis implies zero serial correlation *around trend*, which in this case is the now higher interest rate. Significant positive serial correlation in the rate of price change merely indicates the presence of positive autocorrelation in monetary policy.

TABLE 4

Almon Lag Regressions of Monthly Rate of Change of CPI on Long-Term Interest Rate

TIME PERIOD	$\sum_{i=0}^{48} \beta_i$	$\sum_{i=0}^{6} \beta_i$	MEAN LAG
1917-33	.057	−.005	28.61
1933-52	−.112	−.022	22.41
1952-72	1.068	.577	14.86

The long-term interest rate, r_L, is the basic yield on high grade (Aaa) corporate bonds to 30 year maturity. The β_i coefficients are estimated using a sixth degree Almon lag on the current and past monthly rates of annual change in the CPI, $(\Delta \log P)$, with the far term constrained to zero:

$$(r_L)_t = \alpha_0 + \sum_{i=0}^{48} \beta_i (\Delta \log P)_{t-i} + \epsilon_t.$$

TABLE 5

Six Month Impact of One Percentage Point Change in Rate of Change of CPI on Level of Interest Rates

TIME PERIOD	r_L	r_S
1920-30	.0048	.0029
1930-40	−.0641	−.1021
1940-50	−.0048	.0057
1950-60	−.0318	−.0068
1960-70	.2083	.7246

The long-term interest rate, r_L, is the basic yield on high grade (Aaa) corporate bonds to 30 year maturity. The short-term interest rate, r_S, is the yield on 4-6 month NYC commercial paper. The elements in the table are $\sum_{i=0}^{6} \beta_i$ from the regression: $r_t = \alpha_0 + \sum_{i=0}^{36} \beta_i (\Delta \log P)_{t-i} + \epsilon_t$, where the β_i are estimated using a sixth degree Almon lag with the far term constrained to zero.

Although it is not possible to extend these results back to the pre-1920 decades due to the absence of monthly CPI data, I did run unconstrained regressions of the annual rate of change in the national product deflator against the level of the same short- and long-term interest rates.[15] The results of the annual impact of the current rate of price change (i.e., price change over the last year) on current interest rates are presented in Table 6. Once again a similar pattern emerges of a much larger short-run impact in the 1960's than in previous decades, where the short-run impact is often negative and is always close to zero.[16] It appears, therefore, that changes in the actual rate of price change have only very recently had a large positive impact on changes in the future anticipated rate of price change. In fact, the short-run Fisherian price anticipations

TABLE 6

Annual Impact of One Percentage Point Change in National Product Deflator on Level of Interest Rates

TIME PERIOD	r_L	r_S
1870-80	−.0393	−.0098
1880-90	−.0143	.0341
1890-1900	−.0436	.0633
1900-10	.0144	.0720
1910-20	.0189	.0337
1920-30	.0035	.0635
1930-40	−.0066	−.0929
1940-50	−.0039	−.1250
1950-60	−.0218	.0894
1960-70	.7557	1.0649

The elements in the tables are the α_2 coefficients from the regression:

$$r_t = \alpha_0 + \alpha_1 \log (y/y_P)_t + \alpha_2 (\Delta \log P)_t + \varepsilon_t ,$$

where (y/y_P) is the ratio of real per capita measured to permanent income and $(\Delta \log P)$ is the annual rate of change in the national product deflator.

15. Regressions using the current rate of price change plus lags of past price changes ranging from one to three years were also estimated. However, lagged price changes were almost never statistically significant and the regressions using only the current rate of price change had the lowest standard error of estimate in ten out of twenty cases.

In addition, since the real rate moves procyclically, an attempt to adjust the level of interest rate for changes in the real rate is made by including the ratio of measured to permanent real per capital income. But unfortunately this variable is statistically insignificant in 14 of the 20 regressions and enters significantly in the expected positive direction in only three of the remaining regressions.

16. It is not, however, significantly negative in the early decades as would be expected under a gold (mean reversion) standard.

effects emphasized by Yohe and Karnosky *only* make sense under the pure fiduciary standard of the late 1960's with its substantially greater short-run adjustment in price anticipations to rising prices.[17]

An alternative way of describing these results is to claim not that in the 1960's price expectations adjusted faster to past actual price changes but rather that changes in price expectations merely had a larger and more rapid impact on interest rates during the 1960's. Gibson (1972), using the Livingston price expectations data discussed above, finds a much greater effect of this particular expected rate of price change variable on the level of interest rates after 1959 than before.[18] Gibson "explains" the fact that price predictions were more inaccurate before 1959 (and therefore given less weight by rational market participants) by asserting that "information costs made predicting inflation less rewarding for the market before 1959" (p. 863). This tautology is then fleshed out with two possible hypotheses: (a) since the actual inflation rate was lower before 1959, the benefits from accurately predicting it would also be lower, and (b) it became cheaper to predict prices after 1959. Unfortunately, hypothesis (a) ignores the fact that price uncertainty and the gains from increased accuracy are related to the variance and not the mean of expected price change. And Gibson suggests no reasons why hypothesis (b) may be correct, i.e., why the production function regarding future price level information shifted up in the 1960's. The analysis of this paper suggests that the 1950's were part of the transitional phase of final adjustment to the new monetary standard. Since market participants were not yet fully aware of the fact that the gold standard, in the sense of relative stability in the long-term trend of prices and short-term reversibility of large price changes, was nearing its demise, less accurate price predictions should be expected. It is not the case that expectations formation during the 1950's was "irrational," but that individuals considered information other than the immediately preceding price change behavior to be relevant. The three wars and Great Depression that occurred over the previous twenty-five years clouded the significance of the underlying institutional change that was taking place.

17. This explains why the St. Louis macroeconomic model has a dummy variable for the post-1960 period in their interest rate equations. Yohe and Karnosky note that the larger and more rapid effects of price level changes on interest rates during the 1960's may be due to "institutional changes." But, in a listing of the plausible explanations for a shift in the underlying framework, they never suggest that the complete movement from a commodity to a fiduciary monetary standard may be a major force explaining the shift in behavior.

The fact that comparative historical results such as these have not been emphasized in the literature is likely due to selective reporting by investigators. Without a theoretical understanding of the underlying institutional framework, the pre-1960 results appear meaningless.

18. His regressions begin in 1952. If he took them back to 1946, when the Livingston data begins, the difference of the results between the early and later periods is even much greater.

V. IMPLICATIONS

If the current period is one in which long-term price uncertainty has risen relative to short-term price uncertainty, we would expect the increase in the short-run impact of prices on interest rates to be greater for short-term than for long-term interest rates. If, for example, the σ_S and σ_L variables are measures of the variance of the underlying distribution of short-run and long-run price change individuals believe they face at each point in time, an increase in (σ_L/σ_S) will imply an increase in the weight placed on the observed sample information (e.g., six montly observations on the annual rate of price change) for short-term *relative* to long-term interest rates. This is because as the variability of the underlying generating process decreases, the informational content of the given sample becomes more reliable. As shown in Tables 5 and 6, the differential short-run impact of price change on short-term compared to long-term interest rates does increase as we would expect.[19]

A major implication of an increase in the amount of long-term price unpredictability relative to short-term price unpredictability concerns a change in the composition of debt.[20] We should expect a decrease in the demand for and therefore the quantity of long-term debt relative to short-term debt. On a cursory level, it seems to be obviously true that corporate bond issues have become shorter over time. One hundred year railroad bonds were, for example, issued around the turn of the century, while it is now quite uncommon to find a maturity of a new corporate issue that is greater than 30 years. What I have done in attempting to systematically verify this secular movement towards shorter term corporate debt issues is extend the Hickman NBER (1960) estimates of the maturity distribution of U.S. corporate bond issues. Financial directories were used to compile and classify by term to maturity all listed new issues of single maturity U.S. corporate bond obligations for the period 1944-72. The yearly weighted average of these debt issues and for the earlier Hickman figures is presented in Table 7.[21]

Although the movement since the turn of the century is far from monotonic, a decrease in the term of new single maturity debt offerings

19. The increase in the short-run adjustment of both short-term and long-term interest rates to price changes that occurred in the 1960's does not imply, however, that the variance around the estimates of the mean rate of short-term and long-term price change (or short-term and long-term "price uncertainty") has decreased. (For example, individuals may have held the gold standard presumption of a zero mean rate of long-term price change with great conviction, i.e., with a small variance around the prior probability estimate, and therefore placed little weight on a given sample of price observations.) All the 1960's movement implies is that individuals now more easily reject the hypothesis that their mean estimate of price change is correct. This is because of the high autocorrelation of price change under our new standard.

20. The following discussion and corporate debt results are based upon Klein (1975).

21. As a check I also computed the average maturity of new corporate debt for 1943 using my compilation technique. The figure of 22.2 that I get is close enough to the reported NBER estimate of 22.0 to give me some confidence that I am extending Hickman's work in a consistent manner.

TABLE 7

Weighted Average Maturity of New Corporate Debt, 1900-72

1900	40.0	1937	19.0
1901	32.1	1938	19.1
1902	33.5	1939	24.1
1903	40.7	1940	23.0
1904	39.4	1941	23.4
1905	28.5	1942	21.8
1906	26.4	1943	22.0
1907	23.8	1944	23.4
1908	27.8	1945	30.5
1909	31.0	1946	24.1
1910	24.7	1947	23.2
1911	24.9	1948	21.8
1912	21.4	1949	20.2
1913	24.5	1950	21.7
1914	24.9	1951	20.8
1915	24.3	1952	21.8
1916	26.7	1953	20.0
1917	19.9	1954	22.9
1918	10.6	1955	21.9
1919	11.3	1956	22.5
1920	10.4	1957	22.8
1921	15.5	1958	21.6
1922	25.7	1959	22.0
1923	23.1	1960	22.2
1924	25.0	1961	20.7
1925	21.4	1962	22.1
1926	22.8	1963	21.0
1927	25.1	1964	19.9
1928	25.6	1965	19.5
1929	21.0	1966	21.1
1930	26.6	1967	20.4
1931	29.1	1968	19.3
1932	22.2	1969	21.2
1933	20.6	1970	19.6
1934	14.1	1971	20.9
1935	21.7	1972	19.1
1936	23.5		

Sources: 1900-43 from Hickman (1960, table 94), weighting the yearly dollar volume in each maturity classification by the median maturity of the class; 1944-72 NBER table 94 was extended by categorizing the par values of all single maturity obligations offered yearly in the same maturity classifications and then obtaining a similar weighted average. The yearly debt offers were compiled from *Issuer Summaries* (1949, 1951) for 1943-49 and *Investment Dealers Digest* (1961 issue for 1950-60, 1964 issue for 1961-63 and 1964-73 semiannual issues for 1964-73). Issues floated outside the U.S. and all issues of foreign corporations were excluded.

over time can be seen on a crude level. The average maturity of debt issued during the relatively high (σ_L/σ_S) 1956-72 period (20.9 years) is clearly lower than that issued during the relatively low (σ_L/σ_S) 1900-15 period (29.2 years) and slightly lower than that issued during 1916-55 (21.7 years), when (σ_L/σ_S) is also relatively high.[22] However, this movement over time appears to be erratic, with the years in which the maturity of new corporate debt issues were lowest occuring before the most recent period—in particular, in 1918-21 and in 1934.

Equation (4) reports OLS regression results of the ratio of long-term to short-term price unpredictability variable on the average maturity of new corporate debt figures of Table 7 for the period 1900-72. In addition to the relative price unpredictability variable, I have included the moving average rate of price change variable plotted in chart 2 and a dummy variable for 1934 in the regression.[23] (Absolute values of the *t*-statistics are reported under the estimated coefficients.)

(4)
$$MAT = \underset{(33.83)}{25.326} - \underset{(3.60)}{2.678} \log(\sigma_L/\sigma_S) - \underset{(3.10)}{56.556} E_6(\Delta \log P) - \underset{(2.76)}{13.659} D \qquad R^2 = .260, \quad DW = 0.65$$

The relative price unpredictability term enters in the theoretically expected negative direction, although there is a great deal of positive serial correlation in the residuals and the unexplained variance is very high. The other two independent variables also enter negatively, but these results are more difficult to justify theoretically. The regression estimates indicate that (1) a one percent increase in the ratio of my measure of long-term to short-term price uncertainty will decrease the average maturity of new corporate debt issues by more than two and a half years and that (2) an increase in the moving average inflation rate of one percentage point will decrease the average maturity of new corporate debt issues by more than a half a year. The first effect is certainly understandable while the second observed effect is not.[24] A

22. This movement over time appears more obvious if we convert the average maturity figures into average duration figures. The average duration (or length of time from the present at which the bond generates the average present value dollar) of debt issued during 1900-15 is 15.7 years, during 1916-55 it is 13.9 years, while during 1956-72 it is 12.8 years. The average economic life or duration of a bond will decrease, for a given maturity and coupon, as market rates increase and therefore the average duration of new debt issues during 1968-72 is only 10.3 years. (This movement occurs in spite of the fact that during this period the Treasury has also reduced the average maturity of its outstanding debt held by the public from 8.64 years in 1946 to 3.70 years in 1972; cf. Klein (1975), Table 7.)

23. If these two additional variables are not included in the regression, the results are:

(4)′
$$MAT = \underset{(37.42)}{23.751} - \underset{(2.99)}{2.384} \log(\sigma_L/\sigma_S) \qquad R^2 = .11, \quad DW = 0.56$$

24. It would, in fact, make more theoretical sense for this variable to enter the relation positively. An increase in the long-term inflation rate produces an increase in nominal interest rates and thereby an implicit shortening of the economic term (or duration) of debt. Hence we should expect issuers of debt to move to longer maturities to offset this effect.

likely explanation is that my measures of long-term and short-term price unpredictability are imprecise and that the moving average rate of price change variable is positively correlated with the unmeasured element of the true price uncertainty ratio. For example, the large decrease in average maturity during 1918-20 can, I think, be explained by a large increase in long-term price uncertainty not captured by our σ_L variable. The very rapid inflation during 1916-18 must have been somewhat expected by the public as the usual wartime increase in prices. But when prices did not start to decline after the war, and in fact continued to increase rapidly, especially during 1920, large doubts must have entered the public's mind concerning continued U.S. adherence to the gold standard or long-term price reversion. A large increase in long-term relative to short-term price uncertainty is very likely to have occurred at that point in time. Long-term gold standard price expectations were restored and the maturity of new corporate debt issues increased only after the very large deflation in 1921-22.

Another major fall in the maturity of new corporate debt occurs in 1934, while (σ_L/σ_S) remains unchanged. This discrepancy can also be explained by the use of an improper measure of long-term price uncertainty. 1934 was, of course, immediately after the failure of the Bank of the United States and the banking panic of 1933 which certainly must have increased long-term uncertainty associated with the survival of the financial system. This is picked up not in σ_L but in the dummy variable D.[25]

Finally, if long-term price uncertainty has increased during the recent inflationary period we would expect increased use of price escalator clauses in long-term contracts. As we would also expect, use of such clauses over time seems to be more highly correlated with measures of price unpredictability than with measures of the expected mean rate of price change. Over the 1957-71 period the correlation of the percent of the labor force covered by escalators with the measure of short-term price unpredictability, σ_S, is .53, the correlation with the measure of long-term price unpredictability, σ_L, is .84, while the correlation with the moving average of the past six years rate of price change is only .19.[26] (Since an increase in future price unpredictability should not only increase the

25. Another major residual occurs in 1945 when (σ_L/σ_S) increases while the average maturity of new corporate debt rises dramatically. This movement I have not been able to rationalize.

26. The percentage of the labor force covered by escalators peaks in 1958 and declines until 1966 after which it again rises, but is now still below the 1958-60 level.

The number of workers covered by escalator clauses for this period is reported in Larson and Bolton (1973). This figure is then deflated by a moving average of the labor force where the current year's labor force was weighted one-half and the previous and future year's labor force weighted one-quarter each. The moving average was taken to reduce the statistical noise produced by the procyclical growth of the labor force which is to a large extent a movement of transitory workers not covered by long-term contracts. But the correlations using the current year's labor force as the deflator are nearly identical.

use of escalators in long-term contracts but also decrease the fraction of workers operating under long-term contracts the correlation with σ_L is remarkably high.) If σ_L continues to rise in the future we would therefore expect the use of escalator arrangements to continue to expand.

VI. SUMMARY AND CONCLUSION

The variability of the annual price change series plotted in Chart 1 suggests that price unpredictability is now low by historical standards. If social policy were solely concerned with the price uncertainty associated with the recent inflation, this variable would seem to imply that no attempt should be made to reduce the current rate of price rise. Such an attempt would entail transitional unemployment costs while a major deceleration of inflation would, in fact, *increase* the unpredictability of prices, as measured by this variable. Minimization of price uncertainty would seem to imply a policy of maintaining the inflation rate at about five percent.

But a closer historical examination of annual rates of price change indicates that the recent inflationary episode is much more uncommon than is generally believed and that the moving standard deviation of the annual rate of price change variable does not measure the unpredictability of prices properly. The measure of uncertainty in the annual rate of change of prices expected over the next six years derived in this study showed a markedly different historical pattern than the measure of short-term price uncertainty. This measure of long-term price uncertainty is higher now than at the turn of the century. Under the gold standard annual price changes were relatively unpredictable, but the price level expected in six years was relatively more predictable, and if enough information were available to obtain a measure of price uncertainty with regard to the very far future (e.g., 10-20 years), these effects would probably be increased.

In addition to a survey of price movements over the last century, the behavioral evidence presented on the relationship between the demand for money and actual price change, on the adjustment of interest rates to price level changes, and on the change in the composition of new corporate debts suggests that over the last decade the public has recognized that a major institutional monetary change has occurred and that perceived long-term price uncertainty has increased relative to short-term uncertainty. The long-term movement of the monetary framework away from a gold exchange commodity standard accelerated over the postwar period and has finally culminated in an irredeemable pure fiduciary standard. Compared to the gold standard, the current standard entails the economic benefits of greater short-run price predictability but also the generally unrecognized costs of greater long-term price unpredictability. The net gain or loss crucially depends upon the

importance of long-term contracts, both explicit and implicit.

The current crucial policy question with respect to price predictability is the credibility of the government regarding the long-term trend of price change. A commodity standard (with a low probability of change in the official price of the commodity) severely limits the possible extent of changes in the price level expected over the long-term and can be thought of as a public investment in long-term monetary trust. The behavior of prices since 1955 has destroyed a large part of this capital. Although the annual inflation rate over the recent past may have been steady and near, for example, five percent, there is now little public confidence that the government will maintain this rate over the next decade. While gold convertibility implied an expected long-term price trend within relatively narrow bounds, there is nothing "natural" or sacrosanct about a five or six or seven percent inflation rate. In order to reduce the variance around estimates of long-term price change, what is required is a new faith to replace the now defunct gold standard myth. Unfortunately resources and information are scarce and public confidence that the Fed will now maintain over the long-term any particular rate of price change cannot be created costlessly.

This analysis does not necessarily imply that we should move back to a gold or other commodity standard since the variance of unemployment was certainly much higher during the period 1880-1915 than it has been over the last fifteen years. But what we can say is that the monetary authorities should begin to take explicit account of the influence of policy on long-term price uncertainty. If keeping unemployment low remains a primary objective of economic policy, it will be extremely difficult for the authorities to adopt a secular monetary policy of mean reversion around a given long-term trend, i.e., a policy designed to create a great deal of long-term price predictability. However, public policy will certainly be improved if we only come to recognize the important economic trade-offs that must be made in this area.

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