

# The Adjustment of Stock Prices to Information About Inflation

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## ABSTRACT

This paper analyzes the reaction of stock prices to the new information about inflation. Based on daily returns to the Standard and Poor's composite portfolio from 1953-78, it seems that the stock market reacts negatively to the announcement of unexpected inflation in the Consumer Price Index (C.P.I.), although the magnitude of the reaction is small. It is interesting to note that the stock market seems to react at the time of announcement of the C.P.I., approximately one month after the price data are collected by the Bureau of Labor Statistics.

## I. Introduction

THE RELATIONSHIP BETWEEN INFLATION and common stock returns has been studied extensively. In particular, Nelson [17], Bodie [3], Jaffe and Mandelker [14], and Fama and Schwert [10] all present evidence that monthly returns to a broad group of New York Stock Exchange (N.Y.S.E.) common stocks are negatively related to both the expected and unexpected components of the Consumer Price Index (C.P.I.) inflation rate since 1953.

This paper extends the existing evidence by analyzing the reaction of daily stock returns to the announcement of the C.P.I. inflation rate. If unexpected inflation is bad news for the stock market, and if the announcement of the C.P.I. contains new information about inflation, then unexpected inflation (deflation) should be associated with a decrease (increase) in stock prices at the time of the announcement. There is a lag of more than a month between the time that the Bureau of Labor Statistics (B.L.S.) collects the price data and the time when the C.P.I. is announced. By using daily common stock returns, it is possible to test whether the stock market reacts at the time that the price data are collected, or at the time when the C.P.I. is announced, if it reacts at all.

## II. Stock Returns and Unexpected Inflation

There are numerous hypotheses about the distributive effects of unanticipated inflation on stock returns. Kessel and Alchian [15] note that unexpected inflation benefits net debtors at the expense of net creditors when contracts are written in nominal terms; hence, the stock returns of net creditors should be negatively

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related to the current unexpected inflation rate. Similarly, there are distributive tax effects as a result of unanticipated inflation. Since depreciation and inventory expense are based on historical costs, rather than current replacement costs, unexpected inflation which affects all prices simultaneously increases revenues without an offsetting increase in depreciation and inventory expense, thus increasing the real tax burden of the firm.<sup>1</sup>

Perhaps a more important reason to expect a relationship between stock returns and unexpected inflation is that unexpected inflation contains new information about future levels of expected inflation. Fama [7, 8] argues that movements in the term structure of interest rates seem to be dominated by inflationary expectations. If expectations of future inflation are higher, current nominal interest rates will increase so that expected real interest rates are not affected by the level of expected inflation. *Ceteris paribus*, an unexpected increase in expected inflation has a larger impact on value the longer the time to maturity of the debt, and this results in a wealth transfer from bondholders to stockholders. Similar effects occur for the value of other long-term fixed price contracts.

Despite the simplicity of the debtor/creditor hypothesis, in practice it is difficult to predict the distributive effects of unexpected inflation on stock returns. First, firms engage in a variety of long-term contracts which specify prices in terms of dollars, such as labor contracts, raw materials contracts, debt contracts, and pension commitments. To the extent that these contracts are not frequently renegotiated and they do not have perfect cost-of-living adjustment clauses, unexpected inflation can have a variety of effects on the value of the firm. It would be necessary to examine the entire structure of fixed price contracts, not just the debt contracts or tax obligations, in order to determine the effect of unexpected inflation on a particular firm.

Second, an unexpected increase in expected inflation could cause government policy-makers to react by changing monetary or fiscal policy in order to counteract higher inflation. Such policy reactions, which can affect investment and equilibrium real returns to assets, are probably the basis of the hypothesis that inflation is "bad for business."<sup>12</sup> One example would be the imposition of price controls. If price controls distort optimal production-investment plans, the controls would have a negative effect on the value of firms. If unexpected inflation increases the probability of price controls, then stock prices should fall in response to this new information.

Even though it is not possible to separate the information and distributive effects of unexpected inflation without knowledge of the contractual obligations of firms, it is interesting to estimate the net impact of the C.P.I. inflation rate on aggregate common stock values.

<sup>1</sup> Fama [9] argues that changes in tax rates and regulations have effectively allowed for inflation in the United States over the last 25 years through the deductibility of interest expense, liberalized depreciation methods, and investment tax credits, among other things. Nevertheless, even though these changes in the tax law lowered average tax rates during periods of high inflation, there were probably distributive effects of unexpected inflation because marginal tax rates were not adjusted to offset inflation for all firms.

<sup>2</sup> Fama [9] coined this phrase and discusses other possible scenarios.

### III. Measuring Unexpected Inflation

Alchian and Kessel [1], De Alessi [5], Bach and Stephenson [2], and Hong [13], among others, attempt to test the net debtor/creditor hypothesis by separating firms into net debtor or net creditor samples and measuring the returns to these securities in periods of high inflation. Hong [13] also tests for the tax effects of inflation by looking at sets of firms with different amounts of depreciation or inventory expense. Unfortunately, these tests do not distinguish between expected and unexpected inflation. The periods of high inflation examined in most of these papers probably correspond to episodes of high *expected* inflation, since rational expectations imply that unexpected inflation will be serially uncorrelated with a mean of zero. Thus, none of these previous tests actually measure the impact of *unexpected* inflation.

#### A. Models for Expected Inflation

In order to test the effects of unexpected inflation, a model for expected inflation is necessary. Two models for expected inflation have been used to analyze the effects of unexpected inflation on stock returns: (1) Nelson [17] and Bodie [3] use extrapolative time series models to predict inflation; and (2) Jaffe and Mandelker [14] and Fama and Schwert [10] follow Fama [7] in using the short-term interest rate as a predictor of inflation.

Nelson and Schwert [18] estimate a first-order moving average process (MA(1)) for the first differences of the monthly C.P.I. inflation rate,  $\rho_t$ ,

$$\begin{aligned} \rho_t &= \rho_{t-1} + \hat{u}_t - .894\hat{u}_{t-1} + .18 \times 10^{-4} \\ &\quad (.029) \quad (.15 \times 10^{-4}) \\ S(\hat{u}) &= .00201 \end{aligned} \tag{1}$$

where the standard errors of the coefficients are in parentheses,  $\hat{u}_t$  is the estimate of unexpected inflation in month  $t$ , and  $S(\hat{u})$  is the estimate of the standard deviation of unexpected inflation.<sup>3</sup> Based on this time series model, the estimate of the current expected inflation rate,  $\hat{\rho}_t$ , is a random walk with drift,

$$\begin{aligned} \hat{\rho}_t &= \rho_{t-1} - .894\hat{u}_{t-1} + .18 \times 10^{-4} \\ &= \hat{\rho}_{t-1} + .106\hat{u}_{t-1} + .18 \times 10^{-4}, \end{aligned} \tag{2}$$

so the change in the expected inflation rate,  $(\hat{\rho}_t - \hat{\rho}_{t-1})$ , is perfectly correlated with the unexpected inflation rate,  $\hat{u}_t$ . In this model, all of the new information about future inflation rates which becomes available at time  $t$  is contained in the unexpected inflation rate. Nelson [17] uses a similar time series model for the C.P.I. inflation rate to examine the effect of unexpected inflation on the monthly returns to the Standard and Poor's composite portfolio.

Fama [7] argues that the short-term interest rate on treasury bills,  $TB_t$ , is a

<sup>3</sup> Nelson and Schwert use annualized percent monthly inflation rates, so they report the constant and the standard deviation of unexpected inflation as 1200 times the respective numbers in equation (1). Box and Jenkins [4] and Nelson [16] provide detailed descriptions of autoregressive-integrated-moving average (ARIMA) time series models.

proxy for the market's expectation of inflation based on all information available at time  $t - 1$ ,  $\phi_{t-1}$ ,

$$E(\rho_t | \phi_{t-1}) = TB_t - E(r), \quad (3)$$

if the expected real rate of interest,  $E(r)$ , is constant over time. Consistent with this model, Fama estimates the regression of inflation on the interest rate for the January 1953–July 1971 period,

$$\rho_t = -0.0007 + .98 TB_t + \hat{u}_t, \\ (.0003) (.10)$$

$$S(\hat{u}) = .00196 \quad (4)$$

and finds that the coefficient of  $TB_t$  is very close to 1.0. Based on Fama's model (3), unexpected inflation is measured by the actual inflation rate minus the nominal interest rate, which is known at the beginning of the period, plus the expected real rate of interest,

$$\hat{u}_t = \rho_t - TB_t + E(r). \quad (5)$$

In this model, the change in the expected inflation rate is measured by the change in the nominal interest rate,  $(TB_t - TB_{t-1})$ , and this is not necessarily perfectly correlated with the unexpected inflation rate, since investors can use more information than just the current inflation rate to revise their expectations of future inflation.

Previous tests by Nelson [17], Bodie [3], Jaffe and Mandelker [14], and Fama and Schwert [10] all concentrate on the period from 1953 to July, 1971, since President Nixon imposed price controls on August 15, 1971 and they were not completely removed until 1974. Since price controls restricted the inflation of the prices in the C.P.I., but probably not the inflation of the total cost of consumer goods including the cost of queuing, it is likely that measures of unexpected inflation based on the C.P.I. do not measure the "true" unexpected inflation rate during this period. In particular, the surge of food prices when some controls were lifted in August, 1973, probably exaggerated the increase in the total cost of food in that month. Because of this problem, all of the tests below will be replicated with and without the data after August 16, 1971.

Table 1 contains estimates of the means, standard deviations, and the first twelve autocorrelations of the C.P.I. inflation rate and the two measures of unexpected inflation for the January 1953–1971 period and the August 1971–December 1978 period. Table 1 also shows the correlation between the unexpected inflation rate and the corresponding measure of expected inflation. A good prediction model for inflation would have errors with a mean close to 0., a low standard deviation, small autocorrelations, and the correlation between the prediction and the prediction error should be small. From this perspective, both the time series model and Fama's treasury bill model are reasonably good prediction models for inflation. In the 1971–78 period, the treasury bill model is slightly worse than the time series model because of the positive average unexpected inflation rate (with a  $t$ -statistic of 4.1), and the correlation of expected and unexpected inflation (with a  $t$ -statistic of 2.6). Nevertheless, in both time periods

Table 1  
Summary Statistics for Unexpected Inflation Measures<sup>a</sup>

	$\rho_1$	$\rho_2$	$\rho_3$	$\rho_4$	$\rho_5$	$\rho_6$	$\rho_7$	$\rho_8$	$\rho_9$	$\rho_{10}$	$\rho_{11}$	$\rho_{12}$	$S(\rho_1)$	Mean	Std. Dev.	Correlation <sup>b</sup> with Expected Inflation
Jan. 1953-July 1971																
CPI Inflation	.37	.36	.27	.30	.28	.25	.33	.36	.33	.26	.36	.07	.00188	.00233	—	
Treasury Bill Model (5)	.11	.12	-.02	-.01	-.03	-.02	-.07	.05	.10	.10	.03	.19	.07	-.00043	.00195	-.02
Time Series Model (1)	-.02	.02	-.12	-.05	-.06	-.06	-.12	.03	.07	.04	-.04	.13	.07	.00002	.00201	-.14
Aug. 1971-Dec. 1978																
CPI Inflation	.40	.47	.39	.30	.33	.32	.28	.15	.26	.22	.15	.11	.10	.00550	.00321	—
Treasury Bill Model (5)	.10	.24	.13	.00	.08	.04	.07	-.05	.14	.12	.06	.09	.10	.00124	.00264	.30
Time Series Model (1)	.00	.16	.08	-.03	.06	.09	.06	-.11	.14	.12	.05	.04	.10	-.00004	.00274	-.14

where the standard errors of the parameters are in parentheses.  
 " This is the correlation between the unexpected inflation measure and the associated measure of expected inflation, which should be zero for a well-specified model.

the standard deviation of unexpected inflation is lower using the treasury bill model in (5).

For the purpose of this paper, Fama's model will be used to measure unexpected inflation as in (5). To assure that the results are not sensitive to this choice, all of the tests are replicated using a time series model like (1) to estimate unexpected inflation; however, there are no instances where the choice between these models for unexpected inflation has a substantive effect on the results.

### *B. Chronology of the C.P.I.*

Even when it is possible to estimate unexpected inflation, it is not obvious when the stock market should react to this information. Figure 1 illustrates the typical sequence of events which result in the publication of the C.P.I.<sup>4</sup> First, the price data are sampled in the middle of the month, so that the January inflation rate measures price changes which occur between December 15 and January 15. This is referred to as the *measurement month*. Second, previous researchers such as Jaffe and Mandelker [14], Bodie [3], Nelson [17], and Fama and Schwert [10] have used stock returns from the end of one month to the end of the next month, thus measuring the stock market reaction to January's inflation over the *calendar month* from January 1 to January 31. Third, the B.L.S. doesn't announce the C.P.I. until approximately three weeks after the end of the calendar month. Thus, the January inflation rate is announced on about February 21. The period around the announcement date is referred to as the *announcement period*.

If the stock market is efficient, stock prices will react to information about inflation when it first becomes available. If investors can perceive the inflation rate by observing prices of individual commodities at the same time that the B.L.S. collects the prices, the reaction should occur within the measurement month. On the other hand, if the B.L.S. provides incremental information about inflation by collating and assimilating a large sample of prices from different locations, the stock price reaction should occur in the announcement period. The tests below using daily data should indicate when the C.P.I. inflation rate affects stock returns.<sup>5</sup>

## **IV. The Market Reaction to Unexpected Inflation**

### *A. Weekly Response*

The first test of the information content of C.P.I. announcements examines the returns to the Standard and Poor's composite portfolio for the period from 9

<sup>4</sup> An additional complication occurs because some of the components of the C.P.I. are not sampled every month. This means that the current C.P.I. inflation rate contains part of the actual inflation rates for previous months. See the Bureau of Labor Statistics Bulletin No. 1517, "The Consumer Price Index: History and Techniques," for a detailed description of the methods used to construct the C.P.I.

<sup>5</sup> Of course, there is a limit to the magnitude of the stock market reaction to unexpected inflation at the time the C.P.I. is announced. If there was a large stock price reaction several weeks after the B.L.S. collects the price data, there would be an incentive for private organizations to produce a similar inflation measure before the B.L.S. announcement.

Figure 1  
Typical Chronology of the Consumer Price Index

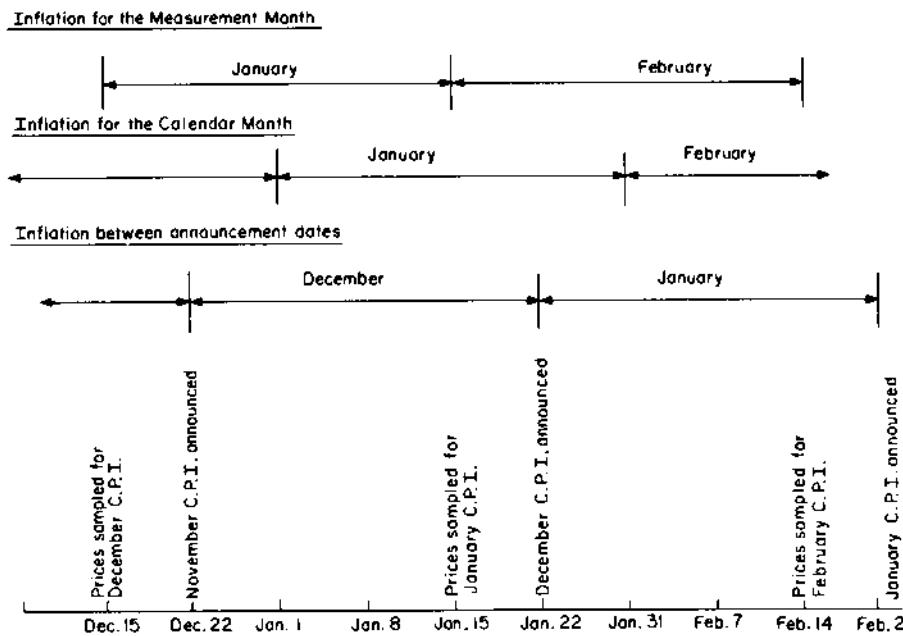


Fig 1.

weeks before to 2 weeks after the C.P.I. announcement.<sup>6</sup> In order to measure the effects of unexpected inflation on daily stock returns, two additional factors which affect daily stock returns will be included in the model. First, the evidence in Fama and Schwert [10] indicates a strong negative relationship between monthly stock returns and the one month treasury bill rate,  $TB_t$ . Second, French [12] finds that the average returns to the Standard and Poor's portfolio are different for different days of the week. In particular, the average return from Friday to Monday is significantly lower than the other daily returns.<sup>7</sup> Thus, Table 2 contains estimates of the regression model,

$$R_t = \alpha_0 + \sum_{i=1}^4 \alpha_i D_{it} + \beta TB_t + \sum_{k=-8}^2 \gamma_k \hat{U}_t(k) + \epsilon_t \quad (6)$$

<sup>6</sup> Professor Eugene Fama provided the Standard and Poor's data for the 1953-62 period. The data for the 1963-78 period were obtained from the Center for Research in Security Prices (CRSP). The returns to the Standard and Poor's portfolio do not include dividends, but it is unlikely that omitting dividends has as important effect on the tests, since firms don't seem to adjust their dividend decisions in response to monthly unexpected inflation or deflation. Nevertheless, as a check the tests reported in this paper were replicated using the returns including dividends to the CRSP value-weighted portfolio for the 1963-78 period, and there were no substantive differences in the results. The data on the C.P.I. announcement dates were obtained from the Bureau of Labor Statistics.

<sup>7</sup> The tests were replicated without either the day-of-the-week dummy variables or the treasury bill rate in the regressions, and there were no substantial changes in the results for the unexpected inflation tests.

Table 2

Effects of Unexpected Inflation on Stock Returns in Different Weeks Relative to the Announcement Date<sup>a</sup>

$$R_t = \alpha_0 + \sum_{i=1}^4 \alpha_i D_{it} + \beta TB_t + \sum_{k=-8}^2 \gamma_k \hat{u}_t(k) + \epsilon_t$$

		(1) 1/2/53- 12/29/78	(2) 1/2/53- 8/13/71	(3) 8/16/71- 12/29/78
Effects of Unexpected Inflation, $\gamma_k$				
Week Relative to Announcement Date, $k$ :				
Announcement Period	[+2 +1 0 -1 -2 -3 -4 -5 -6 -7 -8]			
Measurement Month	[Calendar Month Month]			
		-.058	-.010	-.199
		-.174*	-.129	-.284
		-.168*	-.060	-.339*
		-.107	-.127	-.097
		.051	-.120	.245
		.033	.051	-.017
		-.019	-.009	-.047
		.035	.085	-.055
		.180*	.096	.245
		.002	-.083	.112
		-.161	-.251*	-.041
Standard Error for each $\gamma_k$ , $k = +2, \dots, -8$ <sup>b</sup>		(.084)	(.102)	(.158)
<i>t</i> -tests for sums of $\gamma_k$ :				
Announcement Period, $k = +1, 0, -1$		-3.00	-1.76	-2.50
Calendar Month, $k = 3, -4, -5, -6$		1.33	1.08	0.36
Measurement Month, $k = -5, -6, -7, -8$		0.33	-0.74	0.75
Effect of Expected Inflation, $\beta$		-.205**	-.262**	-.368
Standard Error of $\beta$		(.062)	(.076)	(.186)
Day-of-the-Week Dummies:				
Constant, $\alpha_0$		-.0009**	-.0011**	.0007
Std. Error for $\alpha_0$		(.0003)	(.0003)	(.0009)
Tuesday, $\alpha_1$		.0017**	.0019**	.0010
Wednesday, $\alpha_2$		.0026**	.0030**	.0017*
Thursday, $\alpha_3$		.0020**	.0023**	.0014*
Friday, $\alpha_4$		.0026**	.0030**	.0018*
Std. Error for each $\alpha_i$ , $i = 1, \dots, 4$ <sup>b</sup>		(.0003)	(.0003)	(.0007)
Coefficient of Determination		.022	.031	.017
$S(\epsilon)$		.0074	.0067	.0088
Durbin-Watson		1.61	1.65	1.54
Sample Size		6523	4660	1863

<sup>a</sup>  $R_t$  is the daily continuously compounded price change for the Standard and Poor's composite portfolio;  $D_{it} = 1$  on Tuesdays,  $D_{it} = 1$  on Wednesdays, etc.;  $TB_t$  is the yield on a one month treasury bill, observed at the beginning of the calendar month, for each of the days in the month; the measure of unexpected inflation is from equation (5);  $\hat{u}_t(k)$  is the unexpected inflation rate if the observation  $t$  occurs within week  $k$  relative to the announcement date (e.g. when  $k = 0$ , this variable is equal to the unexpected inflation rate for the 5 trading days prior to and including the C.P.I. announcement), otherwise,  $\hat{u}_t(k) = 0$ .

where  $R_t$  is the daily continuously compounded rate of return on the Standard and Poor's composite portfolio; the day-of-the-week dummy variables are  $D_{1t} = 1$  on Tuesdays,  $D_{2t} = 1$  on Wednesdays, and so forth;  $TB_t$  is the rate observed at the beginning of the calendar month for the treasury bill which matures at the end of the month (this number is the same for each of the days in the calendar month); and  $\hat{u}_t(k)$  is the measure of unexpected inflation from (5) when day  $t$  occurs within week  $k$  relative to the announcement date, and zero otherwise.

In order to understand the results in Table 2 it is important to understand the variables used in (6). From the definition of the day-of-the-week dummy variables, the constant term  $\alpha_0$  represents the intercept which applies to observations on Monday, and the intercepts for Tuesday through Friday can be found by adding  $\alpha_0$  to  $\alpha_1$  through  $\alpha_4$ , respectively. Thus, the dummy variable coefficients measure the differential intercepts for Tuesday through Friday relative to Monday. French's [12] evidence indicates that  $\alpha_1, \dots, \alpha_4$  will all be positive and significant for the 1953-78 period.

Since I only have monthly observations on the treasury bill rate, the same treasury bill rate is used for each of the days in the calendar month. Note, however, that  $TB_t$  has the dimension of a monthly return and  $R_t$  is a daily return, and there are about 21 trading days in a calendar month, so that the coefficient of  $TB_t$  should be about 1/21 as large as the coefficients found by previous researchers who used monthly stock returns in similar regressions. For the January 1953-July 1971 period, Fama and Schwert [10, p. 135] estimate the coefficient of  $TB_t$  to be -5.50 when using monthly stock returns, which implies that the estimate of  $\beta$  in (6) should be about -0.262 for this period.

Similarly, since the C.P.I. inflation rate is only measured once a month, there is only one estimate of unexpected inflation per month. The variables  $\hat{u}_t(k)$  for  $k = -8, \dots, +2$  are used to determine the time periods when daily stock returns respond to this monthly unexpected inflation rate. If the January unexpected inflation rate from (5) is 0.01, then  $\hat{u}_t(k) = 0.01$  if day  $t$  occurs within the  $k$ th week relative to the announcement of the January C.P.I., and zero otherwise. For example,  $\hat{u}_t(0) = 0.01$  for the five trading days prior to and including the announcement day (week  $k = 0$ );  $\hat{u}_t(\pm 1) = 0.01$  for the five trading days following the announcement day (week  $k = \pm 1$ ); and so forth. If investors observe inflation at the same time that the B.L.S. samples prices (the "measurement month"), the coefficients for  $k = -8, \dots, -5$  should be non-zero. If investors learn about inflation during the calendar month, as implicitly assumed by previous researchers who used monthly stock returns, then the coefficients for  $k = -6, \dots, -3$  should be non-zero. Finally, if investors learn about inflation around the time that the B.L.S. announces the C.P.I. (the "announcement period"), the coefficients for  $k = -1, 0$ , or  $+1$  should be non-zero.

As with the  $TB_t$ , unexpected inflation has the dimension of a monthly rate of price change, so it is necessary to sum the coefficients within these periods to

\*\* More than 3 standard errors from zero.

\* More than 2 standard errors from zero.

<sup>b</sup> The standard errors of the estimates of  $\gamma_k$  are equal (to three decimal places) because the different variables  $\hat{u}_t(k)$  are just lagged values of the same measure of unexpected inflation, and none of the lags are highly correlated with the other regressors,  $D_u$  or  $TB_t$ . Similarly, the standard errors of the differential intercepts,  $\alpha_k$ , are equal, so only one is reported.

provide an estimate of the effect of unexpected inflation on monthly stock returns. Table 2 contains *t*-tests for the significance of the sums of unexpected inflation coefficients over three time intervals: (a) the *announcement period*, from 9 trading days before to 5 trading days after the announcement date (weeks -1, 0, and +1); (b) the *calendar month*, from 34 trading days before to 15 trading days before the announcement date (weeks -6, -5, -4, and -3); and (c) the *measurement month*, from 44 trading days before to 25 trading days before the announcement date (weeks -8, -7, -6, and -5). These *t*-tests provide a preliminary answer to the question of when the stock market responds to new information about inflation.<sup>8</sup>

For the entire 1953-78 period, in column (1) of Table 2, the strongest effect of unexpected inflation occurs during the announcement period, where the *t*-statistic for the sum of the unexpected inflation coefficients is -3.0. All of the estimates are negative for the three weeks surrounding the announcement date, and the estimates for weeks 0 and +1 are more than two standard errors below 0. Neither the calendar month, nor the measurement month seem to have significant reactions to unexpected inflation.

Consistent with the earlier studies which used monthly data, the coefficient of the treasury bill rate is negative and more than 3 standard errors below 0. Also, the day-of-the-week dummy variables have coefficients similar to those which are reported by French [12], indicating that the average returns to Monday are significantly below the average returns for the other days of the week.<sup>9</sup>

The results for the pre-price controls period from the beginning of 1953 to August 13, 1971, are reported in column (2) of Table 2. The estimates of the coefficients of unexpected inflation are all negative for the announcement period (weeks -1, 0, and +1), and the *t*-statistic for the sum is -1.76. The results for the calendar month and the measurement month show no substantial response to unexpected inflation.

Interestingly, the coefficient of the treasury bill rate is -0.262 for the pre-price controls period, which is exactly comparable to the results reported by Fama and Schwert [10, p. 135] based on monthly stock returns for this time period. The *t*-statistic of -3.45 for this coefficient indicates that the average daily returns to the Standard and Poor's portfolio were significantly lower in months when the treasury bill rate, which was observed at the beginning of the month, was high.

The results for the period from August 16, 1971 to the end of 1978 are reported in column (3) of Table 2. Again, the strongest effects of unexpected inflation occur during the announcement period. The only coefficient estimate for unexpected inflation which is more than 2 standard errors from 0. occurs in the announcement week, and the *t*-statistic for the sum of coefficients is -2.5 for the announcement period (weeks -1, 0, and +1).

<sup>8</sup> The nominal significance levels for these tests should be interpreted cautiously since they assume that the disturbances in equation (6) are drawn from a stationary normal distribution. Given the well-known evidence showing non-normality, or at least heteroscedasticity, in daily stock returns, the actual significance levels of these tests are probably higher than the nominal significance levels.

<sup>9</sup> It should be noted that the Durbin-Watson statistic indicates significant positive residual autocorrelation at lag 1. This is caused by the non-synchronous trading problem discussed in Fisher [11], Fama [6], and Scholes and Williams [19]. This small autocorrelation does not seriously affect the significance tests for unexpected inflation.

The coefficient of the treasury bill rate in column (3) is more negative ( $-0.368$ , implying a coefficient of  $-7.73$  for monthly stock returns), but it is less significant ( $t$ -statistic  $= -1.98$ ) than for the pre-price controls period. The day-of-the-week dummy variable coefficients are smaller and less significant in the post-1971 period than in the pre-1971 period, which is consistent with the findings of French [12].

Based on the regression results in Table 2, it seems that the stock market reacts negatively to the announcement of unexpected inflation in the C.P.I. Apparently, the data collection process carried out by the Bureau of Labor Statistics provides the market with information which is not available from other sources, and the stock market reacts to that information.

### B. Daily Response

Given the results in Table 2, it is interesting to examine the daily response of stock returns to unexpected inflation in the period from 9 trading days before to 5 trading days after the C.P.I. announcement date (weeks  $-1$ ,  $0$ , and  $+1$ ). Table 3 contains estimates of the regression model

$$R_t = \alpha_0 + \sum_{i=1}^4 \alpha_i D_{it} + \beta TB_t + \sum_{k=-9}^5 \gamma_k \hat{u}_t(k) + \epsilon_t, \quad (7)$$

where all of the variables are defined as in (6), except that  $\hat{u}_t(k)$  is equal to the unexpected inflation rate if observation  $t$  occurs on day  $k$  relative to the announcement date, and zero otherwise. In other words, instead of estimating the effect of unexpected inflation on stock returns for weekly periods as in (6), equation (7) estimates a different coefficient for each day in weeks  $-1$ ,  $0$ , and  $+1$ . Thus,  $\gamma_0$  represents the change in the stock return on the announcement day (e.g., February 21) if the unexpected inflation rate is 1.0 for the previous month (i.e., January).

If the announcement of the C.P.I. contains information about inflation, and if the market efficiently adjusts stock prices to reflect this information, the coefficient on the announcement day ( $k = 0$ ) should be non-zero. If there is a leakage of information prior to the formal announcement, such as government officials discussing the C.P.I. based on preliminary analysis of the price data, then the coefficients prior to the announcement day ( $k = -9, \dots, -1$ ) should be non-zero. If the stock market reacts slowly to the information contained in the C.P.I. announcement, then the coefficients after the announcement day would be non-zero.<sup>10</sup> In order to compare the results in Table 3 with the results in Table 2,  $t$ -statistics are calculated for the sums of the daily coefficients for  $k = (-9, \dots, -5)$ ,  $(-4, \dots, 0)$ , and  $(+1, \dots, +5)$ , which correspond to weeks  $-1$ ,  $0$ , and  $+1$  in Table 2.

The results for the entire 1953-78 period are contained in column (1) of Table 3. Twelve out of the fifteen estimates of the unexpected inflation coefficients,  $\gamma_k$ , are negative. Consistent with the results in Table 2, the  $t$ -statistics for the sums of the unexpected inflation coefficients for days  $-4$  to  $0$  and days  $+1$  to  $+5$  are

<sup>10</sup> It is possible that the stock market reaction could occur on the day after the official release of the C.P.I. if the official announcement occurs after the New York Stock Exchange quits trading, but lags beyond day  $+1$  would seem to indicate inefficiency.

Table 3

Effects of Unexpected Inflation on Stock Returns in Different Days Relative to the Announcement Date<sup>a</sup>.

$$R_t = \alpha_0 + \sum_{i=1}^4 \alpha_i D_{it} + \beta TB_t + \sum_{k=-9}^5 \gamma_k \hat{u}_t(k) + \epsilon_t$$

	(1) 1/2/53- 12/29/78	(2) 1/2/53- 8/13/71	(3) 8/16/71- 12/29/78
Effects of Unexpected Inflation, $\gamma_k$			
Day Relative to Announcement Date $k$ :			
+5	-.318	-.030	-.696*
+4	-.091	-.077	-.175
+3	-.144	.073	-.468
+2	-.416*	-.475*	-.380
+1	.010	-.241	.251
0	-.092	.247	-.524
-1	-.504*	-.167	-.993**
-2	-.301	-.329	-.336
-3	.171	.069	.255
-4	-.240	-.220	-.317
-5	-.119	.041	-.350
-6	-.015	-.277	.241
-7	.098	.062	.085
-8	-.162	-.108	-.266
-9	-.281	-.289	-.311
Standard Error for each $\gamma_k$ , $k = +5, \dots -9^b$	(.184)	(.225)	(.330)
<i>t</i> -tests for sums of $\gamma_k$ :			
+1, ..., +5	-2.32	-1.48	-1.94
-4, ..., 0	-2.34	-0.79	-2.53
-9, ..., -5	-1.16	-1.13	-0.79
Effect of Expected Inflation, $\beta$	-.196**	-.260**	-.307
Standard Error of $\beta$	(.059)	(.076)	(.171)
Day-of-the-Week Dummies:			
Constant, $\alpha_0$	-.0010**	-.0011**	.0005
Std. Error for $\alpha_0$	(.0003)	(.0003)	(.0009)
Tuesday, $\alpha_1$	.0017**	.0019**	.0011
Wednesday, $\alpha_2$	.0026**	.0030**	.0017*
Thursday, $\alpha_3$	.0020**	.0023**	.0014*
Friday, $\alpha_4$	.0026**	.0030**	.0019*
Std. Error for each $\alpha_i$ , $i = 1, \dots 4^b$	(.0003)	(.0003)	(.0007)
Coefficient of Determination	.023	.031	.021
$S(\hat{\epsilon})$	.0074	.0067	.0088
Durbin-Watson	1.60	1.64	1.53
Sample Size	6523	4660	1863

<sup>a</sup>  $R_t$  is the daily continuously compounded price change for the Standard and Poor's composite portfolio;  $D_{it} = 1$  on Tuesdays,  $D_{it} = 1$  on Wednesdays, etc.;  $TB_t$  is the yield on a one month treasury bill, observed at the beginning of the calendar month, for each of the days in the month; the measure of unexpected inflation is from equation (5)  $\hat{u}_t(k)$  is equal to the unexpected inflation rate if the observation  $t$  occurs on day  $k$  relative to the announcement date (e.g. when  $k = 0$ ,  $\hat{u}_t(k)$  is equal to the unexpected inflation rate on the announcement date, and 0 otherwise).

\*\* More than 3 standard errors from zero.

\* More than 2 standard errors from zero.

-2.34 and -2.32, respectively. Thus, unexpected inflation seems to have a significant negative impact on stock market returns for the five trading days on either side of the C.P.I. announcement. The sum of all 15 of the estimates of the unexpected inflation coefficients is -2.38, indicating that a 1.0 percent unexpected inflation rate is associated with a 2.38 percent decrease in stock values within this 15 trading day period around the announcement. It appears, however, that the negative coefficients are not concentrated around the announcement date. The estimates of the day-of-the-week dummy variables and the treasury bill rate coefficients are essentially identical to the results in Table 2.

The results for the pre-price control period from 1953 to August 13, 1971 are contained in column (2) of Table 3. Ten out of the fifteen estimates of the unexpected inflation coefficients are negative, and the sum of the 15 estimates is -1.72.

The results for the period from August 16, 1971 to the end of 1978 are contained in column (3) of Table 3. Eleven out of the fifteen unexpected inflation coefficient estimates are negative, and the sum of the 15 estimates is -3.98. Again, however, it does not seem as though the negative coefficients are concentrated around the announcement date. The *t*-statistic for the sum of the five estimates after the announcement date ( $k = +1, \dots, +5$ ) is -1.94, which is only slightly less than the *t*-statistic of -2.53 for the sum of the five estimates prior to and including the announcement date ( $k = -4, \dots, 0$ ).

In short, while it seems that common stock returns are significantly negatively affected in the 15 trading days surrounding the announcement of unexpected inflation of the C.P.I., it does not appear that this effect occurs primarily on or before the announcement date. This could indicate that there is both leakage of information prior to the formal announcement, and an inefficient, slow response by the stock market subsequent to the announcement.

## V. Summary and Conclusions

This paper has extended the evidence on the relationship between stock returns and inflation by examining the daily returns to the Standard and Poor's composite portfolio around the C.P.I. announcement dates from 1953-78. Perhaps the most interesting finding is that the stock market reacts to unexpected inflation around the time when the C.P.I. is announced, and the stock market does not seem to react to unexpected inflation during the period when the C.P.I. is sampled, several weeks before the announcement date. This suggests that the Bureau of Labor Statistics provides information to the market by collating and assimilating observable prices into a single index number, and the stock market reacts to that information.

Nevertheless, the reaction of aggregate stock returns to unexpected inflation is not strong. Given the large sample sizes, the significance tests do not provide overwhelming evidence that the stock market reacts strongly to unexpected

<sup>b</sup> The standard errors of the estimates of  $\gamma_k$  are equal (to three decimal places) because the different variables  $\dot{u}_t(k)$  are just lagged values of the same measure of unexpected inflation, and none of the lags are highly correlated with the other regressors,  $D_t$  or  $TB_t$ . Similarly, the standard errors of the differential intercepts,  $\alpha_k$ , are equal, so only one is reported.

inflation. Perhaps this explains why the coefficients of unexpected inflation seem to be small and negative for the 15 trading days around the announcement date, instead of having the announcement date coefficient represent the predominant effect. For the days prior to the announcement, leakage of information occurs which foreshadows the subsequent announcement. For the days after the announcement, the market seems to react slowly to the announcement of unexpected inflation, but the magnitude of the reaction is so small that there is probably no opportunity for a profitable trading strategy.

Fama [9] suggests a reason why the stock market reaction to unexpected inflation is weak. He argues that unexpected inflation is contemporaneously correlated with unexpected movements in important "real" variables, such as capital expenditures or real G.N.P., so that the correlation between stock returns and unexpected inflation is spurious.

In any case, it seems that future research in this area should head in one of two directions. First, it seems that future research on the effects of unexpected inflation should concentrate on distributive effects, like the net debtor/creditor hypothesis, rather than looking at an aggregated market portfolio of securities. Second, the most puzzling result of all is still unexplained: why are aggregate stock returns negatively related to the level of expected inflation (or the level of the treasury bill yield)? This anomaly, which implies that the risk premium on N.Y.S.E. common stocks is inversely related to the level of the nominal interest rate, remains a mystery.

#### REFERENCES

1. Armen Alchian and Reuben Kessel. "Redistribution of Wealth Through Inflation," *Science*, 130 (September 1959), pp. 535-539.
2. George Bach and J. B. Stephenson. "Inflation and the Redistribution of Wealth," *Review of Economics and Statistics*, 56 (February 1974), pp. 1-13.
3. Zvi Bodie. "Common Stocks as a Hedge Against Inflation," *Journal of Finance*, 31 (May 1976), pp. 459-470.
4. G. E. P. Box and G. M. Jenkins. *Time Series Analysis, rev. ed.*, (San Francisco: Holden-Day, 1976).
5. Louis DeAlessi. "Do Business Firms Gain From Inflation?", *Journal of Business*, 37 (April 1964), pp. 162-166.
6. Eugene F. Fama. "Tomorrow on the New York Stock Exchange," *Journal of Business*, 38 (July 1965), pp. 285-299.
7. Eugene F. Fama. "Short-term Interest Rates as Predictors of Inflation," *American Economic Review*, 65 (June 1975), pp. 269-282.
8. Eugene F. Fama. "Inflation Uncertainty and Expected Returns on Treasury Bills," *Journal of Political Economy*, 84 (June 1976), pp. 427-448.
9. Eugene F. Fama. "Stock Returns, Real Activity, Inflation, and Money," manuscript, University of Chicago Graduate School of Business, (June 1979).
10. Eugene F. Fama and G. William Schwert. "Asset Returns and Inflation," *Journal of Financial Economics*, 5 (November 1977), pp. 115-146.
11. Lawrence Fisher. "Some New Stock Market Indices," *Journal of Business*, 39 (January 1966), pp. 191-225.
12. Kenneth French. "Stock Returns and the Weekend Effect," *Journal of Financial Economics*, 8 (March 1980), pp. 55-69.
13. Hai Hong. "Inflation and the Market Value of the Firm: Theory and Tests," *Journal of Finance*, 32 (September 1977), pp. 1031-1048.

14. Jeffrey Jaffe and Gershon Mandelker. "The 'Fisher' Effect for Risky Assets: An Empirical Investigation," *Journal of Finance*, 31 (May 1976), pp. 447-458.
15. Reuhen Kessel and Armen Alchian. "Effects of Inflation," *Journal of Political Economy*, 70 (December 1962), pp. 521-537.
16. Charles R. Nelson. *Applied Time Series Analysis*, (San Francisco: Holden-Day, 1973).
17. Charles R. Nelson. "Inflation and Rates of Return on Common Stock," *Journal of Finance*, 31 (May 1976), pp. 471-483.
18. Charles R. Nelson and G. William Schwert. "On Testing the Hypothesis that the Real Rate of Interest is Constant," *American Economic Review*, 67 (June 1977), pp. 478-486.
19. Myron Scholes and Joseph Williams. "Estimating Betas with Nonsynchronous Data," *Journal of Financial Economics*, 5 (December 1977), pp. 309-327.
20. U. S. Department of Labor. "The Consumer Price Index: History and Techniques," Bulletin No. 1517, Washington, D.C.: Government Printing Office, 1966.