Division of Research
School of Business Administration

August 1987

RELATIVE PRICE VARIABLILTY, INFLATION AND THE STOCK MARKET

Working Paper #526

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Abstract: This paper attempts to bring together apparently independent lines of research from the financial-economics and macro-economics literatures by investigating the effects of relative price variability on real activity and stock returns. First, the relations between relative price variability and inflation are examined. Second, the real effects of relative price variability are documented. Finally, the effects of relative price variability on the previously documented relations between stock returns and expected and unexpected inflation are examined.

1. Introduction

A great deal of research in the financial economics literature has focussed on the effects of inflation, both expected and unexpected, on the stock market. A number of papers have attempted to explain the "anomalous" negative relations between stock returns and inflation [see, for example, Kessel (1956), Lintner (1975), Modigliani and Cohn (1979), and Summers (1981)].

One explanation which has held up well in light of empirical evidence is Fama's (1981) proxy hypothesis. Fama postulates that the negative stock return-inflation relations are spurious to the extent that they merely reflect the more fundamental positive relation between stock returns and real activity [see also Geske and Roll (1983) and Kaul (1987)]. In this approach real activity is treated as exogenous.

In this paper, we attempt to analyze the potential real effects of uneven inflation on output and the stock market; in particular, the real adverse effects of relative price variability. A major objective of our analysis is to test whether the negative stock return-inflation relations witnessed in the U.S. are also a reflection of the welfare costs of uneven inflation.

Recent research in the macroeconomic literature has focussed on two issues pertinent to the relations between stock returns and inflation. First, it has been established that various inflation level measures (e.g., the inflation rate, expected inflation and unexpected inflation) could be positively related to inflation variability measures (e.g., the variance of the aggregate inflation rate and relative price variability).[1] Second, it has been shown that relative price variability could have detrimental effects on

[1] See Cukierman (1983), Fischer (1981a) and Taylor (1981) for reviews of the literature.

output and employment [see, for example, Barro (1976) and Cukierman (1982)].[2]

We attempt to bring together the apparently independent lines of research in the financial- and macro-economics literature in order to analyze the real effects of inflation on the stock market. Specifically, we use post-war U.S. data to empirically investigate: (1) the relations between various inflation variables, (2) the real effects of relative price variability on output and real stock returns, and (3) the relative strengths of, on the one hand, the relations between stock returns and expected and unexpected inflation and, on the other, those between stock returns and relative price variability.

Our results indicate that relative price variability is positively related to various inflation measures. Second, relative price variability has a significant negative effect on real output, and this effect predominantly occurs with a lag. The adverse effects of such variability on future output, however, are incorporated in current stock prices: stock returns are strongly negatively related to the contemporaneous relative price variability measure. Finally, and most importantly, the negative relations between stock returns and expected and unexpected inflation are dominated by the negative relation between stock returns and relative price variability in the (more reliable) annual evidence. Thus, inflation does appear to have real effects on the stock market.

Section 2 provides a discussion of the various issues related to the effects of inflation (both the level and variability) on output and stock returns. The empirical evidence is presented in section 3. A brief summary and conclusions are contained in section 4. The appendix provides a simple model demonstrating the real effects of relative price variability.

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[2] There is empirical evidence in support of both the positive relations between various inflation variables and the adverse effects of relative price variability on output. See section 2 for a detailed discussion.

2. The major issues

In this section we briefly discuss three major issues crucial to our hypothesis: (1) the potential adverse effects of relative price variability on output and employment, (2) the positive relations between various inflation level and variability measures, and (3) the real effects of relative price variability on the stock market and whether such effects could explain the negative relations between stock returns and expected and unexpected inflation.

2.1 The adverse effects of relative price variability

In his Nobel lecture Friedman (1977) argues that relative price variability, accompanying variable inflation, could have detrimental effects on output and employment. Friedman's hypothesis is based on the loss of efficiency caused by uneven inflation. Specifically, there are two ways in which relative price variability could reduce efficiency and, consequently, adversely effect real output.

First, Hayek (1945) and Alchian (1970) underline the importance of relative prices (as opposed to the general price level) as the relevant signals in the optimal allocation of resources. An increase in the variance of relative prices diminishes a producer's ability to accurately extract the signal concerning relative prices. Furthermore, an unexpected change in relative prices renders the producers' original production plans suboptimal. Consequently, to the extent a change in real production plans in midstream is costly, relative price variability imposes costs on the producers. In addition, there can be a further reduction in measured output because of the increase in the optimal real resources (including time) devoted to search activities.[3]

Second, even unexpected movements in the general price level can cause misallocation of resources, if absolute price level movements are confused with the relative price changes. Lucas (1973, 1975) shows that with limited information, agents will react to an increase in general level of prices by increasing the short-term supply of their goods and services [also see Barro (1976), Sargent and Wallace (1975), Sargent (1976), and Lucas (1977)]. The short-run output response to inflation diminishes as the variance of general price changes dominates the variance of relative price changes. In the long run, agents become informed about the general price changes and reduce the supply of goods and services. Seyhun (1988) provides evidence from corporate insiders' transactions in their own firms which is consistent with the Lucas-type absolute-relative price confusion models.

The precise manner in which an increase in relative price variability causes a reduction in output and employment has not been formally worked out. However, Barro (1976) and Cukierman (1982) have shown that increased relative price variability does have welfare costs to the extent that it leads to an increase in the dispersion of actual output around the full information output level.[4] In the appendix, we present a simple model of production decisions for a profit maximizing firm and demonstrate the adverse real effects of relative price variability under general conditions.

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[3] Increased inflation variability is also likely to bring about institutional changes (e.g., more frequent contract negotiations for non-indexed arrangements) which require real resources and, hence, reduce productive efficiency.

[4] See also Fischer (1981a) for a simple diagramatic analysis of the welfare effects of increased relative price variability.

The empirical evidence on the relation between inflation uncertainty and output/employment supports the adverse real effects hypothesis [see, for example, Blejer and Leiderman (1980), Levi and Makin (1980) and Mullineaux (1980)]. There are two broad conclusions which can be deduced from the empirical research: (1) inflation uncertainty and/or relative price variability have a detrimental effect on industrial production and employment, and (2) this effect is stronger if lagged values of the volatility measures are used (in addition to the contemporaneous volatility measure).

The evidence, therefore, indicates that the adverse real effects of inflation uncertainty persist over time. To the extent that there are frictions (costs) in the economy which cause desired production changes to take time, such a lagged effect should be expected. Moreover, it is plausible that the signalling mechanism of market prices, and productive efficiency, are reduced by both the current and cumulative relative price variability [Blejer and Leiderman (1980)].

2.2 The relations between inflation rate and inflation variability measures

A number of theories have been proposed to explain the relations between inflation and relative price variability. The most commonly accepted theory is based on the Lucas-type market-clearing framework with rational expectations, in which agents are confused between absolute and relative price movements. In this approach, relative prices as perceived by agents (and based on which agents make their production decisions) depend on unanticipated changes in the general price level which, in turn, depend on monetary policy. Unanticipated changes in the price level and increased variation in relative prices are both caused by unanticipated changes in the money stock. Hence, unexpected inflation and relative price variability are positively related.

[For specific models which examine this relation, see Barro (1976), Cukierman (1979), Hercowitz (1980) and Parks (1978).][5,6]

2.3 The relations between stock returns and inflation variables

Stock returns have been found to be negatively related to both expected and unexpected inflation during the post-war period in the U.S. Fama's (1981) proxy hypothesis uses money demand theory to demonstrate a strong negative relation between inflation and anticipated real activity.[7] Stock returns are, however, positively related to anticipated real activity. Consequently, the negative relations between stock returns and inflation are spurious to the extent that they simply proxy for the positive relations between stock returns and future real variables.

The proxy hypothesis treats real activity as exogenous. However, there are two important aspects of the inflationary process which may be pertinent to an explanation of the stock return-inflation relations. First, inflation uncertainty, in particular relative price variability, may be positively related to both expected and unexpected inflation rates (as discussed in section 2.2). Second, and more importantly, relative price variability may have adverse real effects on the economy (see section 2.3).

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[5] Cukierman (1982) develops a model based on confusion between permanent and transitory (as opposed to absolute and relative) price movements which has identical implications. A contract-based approach [e.g., Taylor (1981)] has also been used to analyze the relations between inflation and relative price variability.

[6] Sheshinski and Weiss (1977) rely on sticky prices to obtain a positive relation between expected inflation and relative price variability [see also Mussa (1977) and Rotemberg (1980)]. Such a positive relation between fully anticipated inflation and relative price variability is also consistent with a world in which prices respond asymmetrically to excess demand and supply [see Cukierman (1983) and Fischer (1981a)].

[7] Geske and Roll (1983) and Kaul (1987) consider money supply responses which could either strengthen or attenuate such negative relations.

A scenario consistent with the results of Fama (1981) and Kaul (1987) is one in which stock returns are fundamentally determined by anticipated real activity but inflation, and relative price variability in particular, may have adverse real effects on output and, consequently, on the stock market. And, to the extent that both expected and unexpected inflation are positively related to relative price variability, the documented negative stock return-inflation relations could merely be a reflection of the welfare costs of uneven inflation. In this paper, we empirically investigate this hypothesis.

3. Empirical evidence

In this section, we analyze post-war U.S. data to investigate: (1) the adverse effects of relative price variability on real output and stock returns, (2) the relations between inflation level variables (namely, the overall inflation rate, expected and unexpected inflation) and inflation variability measures (namely, the variance of the overall inflation rate and relative price variability), and (3) whether the negative stock return-inflation relations witnessed in the post-war period simply reflect the adverse affects of uneven inflation on real output. Specifically, we test whether the negative relations between stock returns and expected and unexpected inflation are statistically dominated by the relation between stock returns and relative price variability.

3.1 Data description

Table 1 shows summary statistics (autocorrelations, means, and standard deviations) for the annual relative price variability, inflation, stock returns, and real activity variables used in this paper for the 1948-1984 period.

3.1.1 The inflation variability measures

The variable VAR_t is the variance of the overall inflation rate calculated using the U.S. Producer Price Index (PPI). We use monthly values of the index to estimate the annual variance of the inflation rate. This method provides us with 12 non-overlapping observations per annual estimate.

The variable $RVAR_t$ is the variance of the inflation rates of the individual components of the PPI. In particular,

$$RVAR_t = \frac{1}{N} \sum_{i=1}^{N} (I_{it} - IP_t)^2 \qquad (1)$$

where I_{it} = inflation rate of the ith component of the index in month t,

IP_t = overall inflation rate for month t,

and N = number of commodities.

This measure of relative price variability is standard [see Blejer and Leiderman (1980), Fischer (1981a), Parks (1978), Taylor (1981) and Vining and Elwertowski (1976)].[8]

The prices used to construct $RVAR_t$ are the price indices of the components of the PPI at the item/product level for each year between 1948 and 1984. The basic data are available on tape from the Bureau of Labor Statistics. The number of commodities included in the index vary between 1,000 and 2,700 from the beginning of our sample period to the end. In order not to introduce a bias due to changes in the sample size and composition, we used 535 products for which an unbroken series of price observations exist between 1948 and 1984.[9]

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[8] Strictly speaking, it is the variance of relative price changes but, for convenience, we will refer to $RVAR_t$ as relative price variability.

[9] The names and codes of these products are available from the authors. Due to missing observations, there is minor year-to-year variation in the actual number of products in our sample.

The use of such disaggregated data is suggested by the absolute-relative price confusion models. Fischer (1981a) points out that if the misallocation of resources caused by unexpected inflation arises from excessive search, "it is possible that search would take place only in response to believed differences in prices of very similar goods."[10] However, the use of disaggregated data forces us to use an unweighted measure of relative price variability because weights for the different products are unfortunately not available. Hopefully, the wide spectrum (and large number) of commodities in the sample approximates the general relative price instability during the post-war period.

Finally, our annual relative price variability measure is obtained by cumulating the estimates over the 12 months within each year. This procedure is adopted for two reasons: (1) the higher the within-the-year relative price variability of a commodity the more difficult it presumably is for an agent to extract the relevant price signal for production purposes, and (2) the precision of the variability measure is improved by using 12 monthly, rather than one annual, observations of the variance of the inflation rates of the individual components of the PPI.

The evidence in table 1 indicates that both the variability measures, VAR_t and $RVAR_t$, exhibit some autocorrelation at the first lag.

3.1.2 The inflation variables

We use three inflation variables in our study. The variable I_t is the inflation rate for year t calculated from the U.S. Consumer Price Index (CPI).

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[10] In fact, under these circumstances, one should use time series of the variance of prices of the same good [Fischer (1981a), p. 391].

The use of the CPI, in lieu of the PPI, is largely to facilitate a direct comparison with the evidence on the stock return-inflation relations reported in the literature.[11]

The annual expected inflation series, EI_{t-1}, was constructed by multiplying EI_{t-1} for the first month of each year (obtained by fitting an ARIMA time series model on monthly data) by twelve. This procedure is valid since shorter-term expected inflation estimates are close to a random walk [see Fama (1981) and Kaul (1987)]. The resulting annual estimates were regressed on realized inflation rates to test their statistical properties as predictors of inflation. The estimated regression was:

$$I_t = \underset{(0.007)}{0.0035} + \underset{(0.131)}{0.921}\, EI_{t-1} + \varepsilon_t \qquad (2)$$

$$\bar{R}^2 = 0.58 \qquad s(\varepsilon) = 0.02251 \qquad \hat{\rho}_1 = 0.09$$

The inflation forecasts exhibit good statistical properties as proxies for expected inflation, namely (1) conditional unbiasedness, i.e., an intercept close to zero and a slope coefficient close to 1.0, (2) serially uncorrelated residuals (the first order autocorrelation, $\hat{\rho}_1$, is 0.09 and all higher order autocorrelations are close to zero), and (3) low residual standard error, $s(\varepsilon)$.

The autocorrelations in table 1 indicate that both I_t and EI_{t-1} are highly autocorrelated series, and the unexpected inflation series ($I_t - EI_{t-1}$) has autocorrelations which are close to zero at all lags.

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[11] The entire analysis was replicated with the inflation rate, and the corresponding expected and unexpected inflation rates, using the PPI. Not surprisingly, the results were very similar since the two inflation rates have an estimated correlation coefficient of 0.86. We did not use the individual components of the CPI to construct $RVAR_t$ because the sample of products is reduced by 80 per cent.

3.1.3 The real variables

The variable RS_t is the real rate of return on common stocks calculated using the NYSE value-weighted index obtained from the Center for Research in Security Prices (CRSP). This variable exhibits low autocorrelations at all lags and has a much higher standard deviation relative to all the other variables used in this study. Finally, $DIIP_t$ is the annual growth rate of the Industrial Production Index (IPI) published in the Survey of Current Business, Business Statistics, 1984. This variable also exhibits low autocorrelations at all lags (see table 1).

3.2 The correlation between various inflation measures

Table 2 presents estimates of the correlations between the inflation level and variability measures. It can be seen that the distributions of the overall rate of inflation, I_t, and that of relative prices, $RVAR_t$, are not independent. A few broad conclusions can be inferred from table 2. First, relative price variability and the variance of the overall rate of inflation are highly positively related. This evidence confirms the findings of Fischer (1981b) and Vining and Elwertowski (1976), and is explained by a model presented by Cukierman (1979) in which relative and aggregate price variability measures are related because both are influenced by the variance of aggregate shocks.

Second, relative price variability is also positively related to all of the inflation level variables (I_t, EI_{t-1}, and UI_t). The relation between $RVAR_t$ and UI_t is much stronger than the relation between $RVAR_t$ and EI_{t-1}, and is in line with the findings of Fischer (1981a), Hercowitz (1981), and Parks (1978). However, there still exists a positive relation between $RVAR_t$ and

EI_{t-1} which lends some support to the costly price adjustment models [Sheskinski and Weiss (1977), Mussa (1977) and Rotemberg (1980)].[12] Hence, both expected and unexpected inflation rates are positively correlated with our measure of relative price variability.

3.3 The adverse effects of relative price variability on the real sector

In this section we analyze the potential detrimental effects of relative price variability on real output and real stock returns. The estimated regressions for the overall period are shown in table 3, panel A.

3.3.1 The relation between output and relative price variability

Regressions (1) - (3) report the contemporaneous and lagged relations between the growth rate in industrial production, $DIIP_t$, and the measure of relative price variability, $RVAR_t$. It is evident that $RVAR_t$ has an adverse effect on output and that the effect predominantly occurs with a lag. The coefficient on the contemporaneous variability measure is negative but insignificant, whereas the lagged measure, $RVAR_{t-1}$, has a highly significant negative coefficient. Moreover, the contemporaneous measure, $RVAR_t$, has no marginal explanatory power when included with $RVAR_{t-1}$ [see regression (3)]. This evidence supports the adverse real effects hypothesis which is consistent with the results reported by Blejer and Leiderman (1980). This evidence indicates that desired changes in both production levels and composition are costly and require time [see also Levi and Makin (1980), Mullineaux (1980), and Makin (1982)].

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[12] Fischer (1981a,b) finds a similar positive relation between relative price variability and expected inflation in the U.S.

An investigation of the residuals of the regressions reported in table 3 reveals significant heteroskedasticity in some cases. In these regressions, the heteroskedasticity test of White (1980) produces chi-square statistics which are greater than conventional significance levels.[13] Accordingly, we compute standard errors based on White's heteroskedasticity-consistent method and report the corresponding t-statistics for regressions in which the p-values of the chi-square statistics are less than 0.05.

3.3.2 The relation between stock returns and relative price variability

We have seen that relative price variability has an adverse effect on output and that this effect is predominantly lagged. On the other hand, changes in stock prices reflect changes in the market's expectation of future real activity. Regression (6) in table 3 shows that future real activity growth, $DIIP_{t+1}$, is significantly positively related to current real stock returns, RS_t, and explains about 60 per cent of the variation in the latter [see Fama (1981) and Kaul (1987) for similar evidence]. Consequently, in an efficient stock market, the adverse lagged effects of relative price variability on output should be reflected in contemporaneous stock price changes.

The results reported in table 3 are consistent with this hypothesis. There is a strong negative relation between stock returns and the contemporaneous variability measure [see regression (4)]. Moreover, the lagged variability measure, $RVAR_{t-1}$, has no marginal explanatory power when included with $RVAR_t$ [see regression (5)].

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[13] The White (1980) test procedure does not require specification of the heteroskedastic structure; however, the efficiency gains in White's estimate appears to be small in small samples. [See Cragg (1982, 1983) for efficiency gains in heteroskedastic regressions and some finite sample properties of White's tests.]

3.3.3 Some sub-period issues

The various regressions were re-estimated over two sub-periods: 1948-1965 (panel B) and 1966-1984 (panel C) in table 3. The negative effects of relative price variability on future output and contemporaneous real stock returns witnessed in the overall period are driven by the second sub-period, 1966-1984. There are no relations between the variability measure and the real variables in the 1948-1965 sub-period, while the relations are significantly negative in the 1966-1984 sub-period [see regressions (1) and (2) in panels B and C, respectively].[14] This is not surprising because the U.S. witnessed very low and steady inflation rates during the fifties and sixties. It is also of interest to note that the adverse real effects of relative price variability are significant only during the sub-period in which the inflation rate is (significantly) negatively related to stock returns (see table 4). This evidence suggests the interpretation that at least the negative stock return-unexpected inflation relations themselves proxy for the underlying adverse real effects of relative price variability.

Table 3 also shows the positive relations between stock returns and future real activity. This positive relation is highly significant in both sub-periods (see regression (3) in panels B and C). A formal test for the equality of the coefficients of $DIIP_{t+1}$ in regression (3) across the two sub-periods could not be rejected at conventional significance levels.

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[14] Inclusion of an interactive dummy variable for relative price variability showed a statistically significant difference in the relations across the two sub-periods.

3.4 Real stock returns, inflation, and relative price variability

In this section, we analyze the relations between stock returns and inflation rate variables and investigate whether these relations are a mere reflection of the adverse effects of relative price variability on the real sector (documented in section 3.3).

Table 4, Panel A, shows the estimated regressions of real stock returns on various inflation measures for the overall period. Regression (1) shows a significant negative relation between stock returns and unexpected inflation UI_t. There is also a negative relation between stock returns and expected inflation, EI_{t-1}, though only marginally significant.[15] These results confirm the negative stock return-inflation relations reported by various researchers [see Bodie (1976), Jaffe and Mandelker (1976), Nelson (1976), Fama and Schwert (1977), Fama (1981) and Kaul (1987)].

However, it appears that these negative relations simply reflect the negative relation between stock return and relative price variability. Inclusion of the variability measure, $RVAR_t$, leads to significant attenuation in both the coefficients and t-statistics of EI_{t-1} and UI_t, and an increase in the explanatory power of the regression. In fact, the only variable which remains statistically significant is $RVAR_t$.

The sub-period evidence reported in table 4, Panels B and C, again shows that: (1) the negative relations between stock returns and inflation rate variables are driven by the 1966-1984 period, and (2) relative price

[15] The t-statistics in table 4 are again based on standard errors computed using White's (1980) heteroskedasticity-consistent method only for regressions in which the p-values of the chi-square statistics are less than 0.05.

variability, $RVAR_t$, statistically dominates the relation between stock returns and expected and unexpected inflation.[16]

3.5 Additional tests

Various tests were conducted to test the sensitivity of the results to the choice between annual and quarterly data, the definition and composition of the relative price variability, and adjustment for expected and unexpected relative price variability measures.

3.5.1 Annual versus quarterly data

The tests presented in tables 3 and 4 which use annual data are replicated in table 5 using quarterly data. Regression 1 in table 5 replicates the well documented negative relation between stock returns, and expected and unexpected inflation using quarterly data. Regressions (2) and (3) show that both the contemporaneous and the one quarter lead terms of the relative price variability measure are significantly negatively related to common stock returns. Regression (4) shows that, when included together, only the one quarter lead term remains significant; the contemporaneous term becomes insignificant. This is not surprising since the price information for the last month of the quarter becomes publicly available in the latter half of the first month of the next quarter [see Schwert (1981)].

Regressions (5) through (7) in table 5 include both the expected and unexpected inflation variables, along with the relative price variability measures, as regressors. In contrast with the annual results, the negative relative price variability effects no longer dominate the effects of expected

[16] Moreover, both EI_{t-1} and UI_t have no marginal explanatory power when included with $RVAR_t$; compare regressions (2) in panels B and C of table 4 with corresponding regressions (2) in table 3.

and unexpected inflation. Furthermore, in regression (7), only the one quarter lead measure of relative price variability is significantly negative. Finally, the explanatory power of the quarterly regressions is diminished. The adjusted coefficient of determination in table 5, regression (7), falls to one-half its level in the annual regression [see table 4, regression (2), panel A].

The quarterly regressions suggest caution in interpreting the findings of this paper. In particular, the quarterly results do not exhibit the statistical dominance of the relative price variability measures over the inflation rate variables. In light of the fact that the annual price data is less noisy than the quarterly data because the nonsynchronous measurement problems are not severe,[17] we prefer to rely on the annual evidence. In any case, even in the quarterly evidence there is a strong negative relation between stock returns and relative price variability. And this relation is again the most significant one in regressions which also include the expected and unexpected inflation rates. This clearly suggests that uneven inflation has adverse real effects on stock returns.

3.5.2 Definition and composition of relative price variability

The analysis presented in this paper (using price information on 535 products) was replicated using the BLS producer price data on 34 aggregate industry groupings. The results were generally similar, although the statistical significance of the negative relation between stock returns and relative price variability was lower. This is not surprising since such broad aggregation of the price data leads to significant loss of information in

17 An indication of the lack of nonsynchronous measurement problems in the annual data is that stock returns are significantly negatively related to contemporaneous relative price variability, but are not related to with the one-year lead measure.

computing the relative price variability measure. In fact, these results underline the importance of using disaggregate data to measure the economic effects of relative price variability.

3.5.3 Adjustment for unexpected relative price relativity

The analysis presented in this paper uses total relative price variability, rather than unexpected relative price variability. The use of the total relative price variability measure is dictated by the infeasibility of fitting time series models of expected variability for each of the 535 price series. The use of total variability in place of unexpected variability implicitly assumes that expected variability is constant. For the 34 industry producer price series, we did fit separate models of expected variability. However, this approach did not produce additional insights due to the loss of information from aggregation.

4. Summary and Conclusions

This paper studies the potential adverse effects of relative price variability on the real sector, and the extent to which such real effects are reflected in the negative relations between stock returns and expected and unexpected inflation witnessed in the U.S. in the post-war period. This investigation attempts to reconcile apparently independent lines of research in the financial-economic and macro-economic literatures.

Our results indicate that relative price variability has a significant lagged effect on real output. However, the adverse effects of such variability on future output are incorporated in current stock prices; stock returns are strongly negatively related to the contemporaneous relative price variability measure. Most importantly, the negative relations between stock returns and expected and unexpected inflation are dominated by the negative relation between stock returns and relative price variability in the (more reliable) annual regressions. Therefore, it appears that there are welfare costs of uneven inflation, and these costs are apparently reflected in the negative stock return-inflation rate relations.

The evidence presented in this paper has important policy implications. In particular, we empirically demonstrate that high and variable inflation could impose costs on the real sector of the economy by distorting the relative price signalling mechanism. To minimize such costs, a predictable monetary policy leading to low and steady levels of inflation [a la Friedman] would appear to be warranted.

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Appendix

In this section we present a simple model showing the adverse effects of relative price variability on firm values in a general setting. To formally demonstrate the proposed negative relation between changes in relative prices and firm values, consider a multiproduct production plan of a profit maximizing firm. Let (p', w') denote the vector of initial output and input prices which the firm faces to arrive at the profit maximizing production plan (y', x'), where y' denotes the vector of physical outputs produced and x' denotes the vector of inputs used. Since this production plan is profit maximizing, profit at (y', x') exceeds profits at any other production plan,

(1) $y'p' - x'w' > y''p' - x''w'$

where $y' \neq y''$ and/or $x' \neq x''$

The term yp denotes vector multiplication of y and p vectors and equals total revenues, xw denotes the vector multiplication of x and w vectors and equals total costs. The vector of output and input prices (p',w') is considered as relative prices. If all prices were to increase by the same factor, then the profit maximizing production plan (y',x') would not change. If the firm initially faces an another vector of output and input prices, (p'', w'') [not equal to (p',w')], then the profit-maximizing production plan is given by (y'', x''), such that profits at the production plan (y'', x'') exceed the profits at any other production plan, (y', x'). This is stated as follows;

(2) $y''p'' - x''w'' > y'p'' - x'w''$ for all $y'' \neq y'$ and/or $x'' \neq x'$

Now assume that a shock in relative prices occurs from (p', w') to (p'', w''). Let this price change be a relative price change only, so that output-input weighted price increases will exactly offset output-input weighted price decreases.

(3) $y''(p''-p') - x''(w''-w') = 0$

To demonstrate that such a relative price change would unambiguously decrease the profits if the firm cannot costlessly alter its production plan, define,

$$\text{PROFIT}_{12} = y'(p'' - p') - x'(w'' - w')$$

From (1),

(4) $(y'p'- x'w') - (y'p''-x'w'') > (y''p'-x''w') - (y'p''-x'w'')$

Substituting from (2) into (4) and collecting terms,

(5) $y'(p'-p'') -x'(w'-w'') > (y''p''-x''w'') - (y'p'' -x'w'')$

Substituting from (3) into (5)

(6) $y'(p'-p'') -x'(w'-w'') > 0$

(7) $-\text{PROFIT}_{12} > 0$, or $\text{PROFIT}_{12} < 0$

Therefore, if the firm cannot costlessly change its production plan, then operating at the initial production plan after a shock in relative prices reduces the firm's profits, hence, leading to a reduction in firm value. Furthermore, if a change in production plans in midstream is costly, then a change in relative prices will cause an unambiguous decline in firm value. In general, for any given firm, actual price changes may affect the prices of firm's outputs more or less than the prices of inputs, thereby producing additional valuation effects.

To demonstrate that the reduction in firm value increases with the degree of shock to the relative prices, consider a greater shock in prices from (p', w') to (p''', w''') such that,

(8) $p''' = p' + k\,(p'' - p')\ ,\ k > 1$

(9) and $w''' = w' + k\,(w'' - w')\ ,\ k > 1$

The change in the vector of output and input prices from (p',w') to (p''',w''') represents a shock that is k times larger than the change from (p',w') to (p'',w''). Using the arguments in (1) through (7), the profit maximizing production plan (y',x') at the price vector (p',w') is suboptimal at the new price vector (p''',w'''). Therefore, the price vector (p''',w''') is again associated with a decline in profits at the original production plan;

(10) $PROFIT_{13} = \ y'\,(p''' - p') - x'\,(w''' - w')\ <\ 0$

Substituting (8) and (9) in (10) and simplifying,

(11) $PROFIT_{13} =$

$$y'\,[(p' + k\,(p'' - p')) - p'] - x'\,[(w' + k\,(w'' - w')) - w'] =$$

$$k\ \ PROFIT_{12} < \ \ PROFIT_{12} < 0$$

Equation (11) states that the decline in profits increases with greater changes in relative prices. The arguments used to derive this proposition are general and do not require any special assumptions about the production functions or the market conditions. The only assumption required is that firms not be able to costlessly adjust their production plans in response to changes in relative prices. Furthermore, in an information efficient capital market, expected variability of relative prices will already be discounted in current stock prices. Consequently, only greater than expected variability will cause a decline in the market value of the firm. Hence, equation (11) forms the basis of the hypothesis tested in this study: If the costs of adjusting production plans to unanticipated changes in relative input and output prices is significant, then greater than expected changes in relative prices will be associated with decreases in firm value.

Table 1

Summary statistics for annual variables: 1948-1984.

Variable(x)[a]	$\hat{\rho}_1$[b]	$\hat{\rho}_2$	$\hat{\rho}_3$	$\hat{\rho}_4$	$\hat{\rho}_5$	$\bar{x}$[c]	s(x)[d]
VAR_T	0.37	0.00	-0.05	-0.08	-0.09	0.00044	0.00083
$RVAR_T$	0.58	0.07	0.05	0.08	-0.02	0.04083	0.01138
I_t	0.72	0.41	0.34	0.39	0.47	0.04062	0.03438
EI_{t-1}	0.60	0.32	0.31	0.36	0.42	0.04073	0.02867
UI_t	0.03	-0.33	-0.10	0.04	0.21	-0.00011	0.02214
RS_t	-0.03	-0.31	0.12	0.42	0.11	0.06625	0.17074
$DIIP_t$	-0.12	-0.21	-0.09	0.00	0.08	0.03869	0.05840

Notes:

(a) VAR_t = variance of the inflation rate for year t calculated using the aggregate producer price index; $RVAR_t$ = relative price variance; I_t = inflation rate caluclated using the consumer price index; EI_{t-1} = expected inflation rate for year t as of year t-1; UI_t = unexpected inflation rate for year t; RS_t = real rate of return on common stocks; $DIIP_t$ = growth rate of industrial production.

(b) $\hat{\rho}_t$ = sample autocorrelation at lag t. Under the hypothesis that the true autocorrelations are zero, standard errors of the estimated autocorrelations are about 0.16.

(c) $\bar{x}$ = estimated mean of the variable.

(d) s(x) = estimated standard deviation of the variable.

Table 2

Correlation matrix for annual inflation variables: 1948-1984.

Variable[a]	VAR_t	$RVAR_t$	I_t	EI_{t-1}	UI_t
VAR_t	1.00	0.81	0.38	0.07	0.49
$RVAR_t$		1.00	0.49	0.24	0.45
I_t			1.00	0.77	0.56
EI_{t-1}				1.00	-0.10
UI_t					1.00

Notes:

(a) VAR_t = variance of the inflation rate for year t; $RVAR_t$ = relative price variance; I_t = inflation rate for year t; EI_{t-1} = expected inflation rate for year t as of year t-1; UI_t = unexpected inflation rate for year t.

Table 3

Annual estimates of regressions of real variables on inflation variability measures.[a]

Regression no.	Estimated regression	$\bar{R}^2$ [b]	$s(\eta)$ [c]	$\hat{\rho}_1$ [d]
	Panel A: Overall period (1948-1984)			
(1)	$DIIP_t = \underset{(1.42)^e}{0.053} - \underset{(-0.41)}{0.357}\, RVAR_t + \eta_t$	0.00	0.05995	-0.13
(2)	$DIIP_t = \underset{(2.91)}{0.103} - \underset{(-1.89)}{1.596}\, RVAR_{t-1} + \eta_t$	0.07	0.05716	-0.18
(3)	$DIIP_t = \underset{(4.19)}{0.088} + \underset{(1.74)}{0.887}\, RVAR_t - \underset{(-2.90)}{2.123}\, RVAR_{t-1} + \eta_t$	0.06	0.05740	-0.21
(4)	$RS_t = \underset{(4.50)}{0.369} - \underset{(-3.79)}{7.357}\, RVAR_t + \eta_t$	0.22	0.15272	-0.10
(5)	$RS_t = \underset{(2.73)}{0.322} - \underset{(-4.73)}{9.032}\, RVAR_t + \underset{(1.23)}{2.859}\, RVAR_{t-1} + \eta_t$	0.22	0.15261	-0.12
(6)	$RS_t = \underset{(-1.20)}{-0.027} + \underset{(7.14)}{2.347}\, DIIP_{t+1} + \eta_t$	0.59	0.11089	0.18
	Panel B: Sub-period I (1948-1965)			
(1)	$DIIP_t = \underset{(0.16)}{0.020} + \underset{(0.20)}{0.674}\, RVAR_{t-1} + \eta_t$	0.00	0.06477	-0.34
(2)	$RS_t = \underset{(-0.44)}{-0.091} + \underset{(1.04)}{5.839}\, RVAR_t + \eta_t$	0.00	0.14675	-0.33
(3)	$RS_t = \underset{(0.81)}{0.027} + \underset{(4.29)}{1.876}\, DIIP_{t+1} + \eta_t$	0.52	0.10045	-0.05
	Panel C: Sub-period II (1966-1984)			
(1)	$DIIP_t = \underset{(2.94)}{0.100} - \underset{(-2.33)}{1.633}\, RVAR_{t-1} + \eta_t$	0.14	0.05278	0.06
(2)	$RS_t = \underset{(3.74)}{0.389} - \underset{(-3.72)}{8.289}\, RVAR_t + \eta_t$	0.43	0.13778	-0.07
(3)	$RS_t = \underset{(-1.73)}{-0.053} + \underset{(5.21)}{2.546}\, DIIP_{t+1} + \eta_t$	0.61	0.11455	0.23

Notes:

(a) $DIIP_t$ = growth rate of industrial production for year t; $RVAR_t$ = relative price variance; RS_t = real rate of return on common stocks.

(b) $\bar{R}^2$ = (adjusted) coefficient of determination.

(c) $s(\eta)$ = residual standard error.

(d) $\hat{\rho}_1$ = residual autocorrelation at lag 1. Under the hypothesis t the true autocorrelations are zero, the standard errors of the residual autocorrelations are about 0.16 and 0.24 for the overall and sub-period estimates, respectively.

(e) Heteroskedasticity-consistent t-statistics in parentheses [White (1980)].

Table 4

Annual estimates of regressions of real stock returns on inflation variable.[a]

Regression no.	Estimated regression	$\bar{R}^2$ [b]	$s(\eta)$ [c]	$\hat{\rho}_1$ [d]
	Panel A: Overall period (1948-1984)			
(1)	$RS_t = 0.141 - 1.755\ EI_{t-1} - 3.224\ UI_t + \eta_t$ (3.11)[e] (-1.93) (-2.72)	0.19	0.15557	-0.12
(2)	$RS_t = 0.318 - 1.202\ EI_{t-1} - 2.014\ UI_t - 4.883\ RVAR_t + \eta_t$ (3.24) (-1.16) (-1.42) (-2.10)	0.25	0.14993	-0.13
	Panel B: Sub-period I (1948-1965)			
(1)	$RS_t = 0.174 - 2.391\ EI_{t-1} - 1.377\ UI_t + \eta_t$ (2.90) (-0.96) (-0.67)	0.00	0.15026	-0.31
(2)	$RS_t = -0.093 - 2.779\ EI_{t-1} - 1.673\ UI_t + 7.230\ RVAR_t - \eta_t$ (-0.42) (-1.24) (-1.28) (1.25)	0.00	0.15074	-0.37
	Panel C: Sub-period II (1966-1984)			
(1)	$RS_t = 0.091 - 0.671\ EI_{t-1} - 5.606\ UI_t + \eta_t$ (0.94) (-0.38) (-3.10)	0.34	0.14815	-0.02
(2)	$RS_t = 0.295 - 0.202\ EI_{t-1} - 3.123\ UI_t - 5.541\ RVAR_t + \eta_t$ (2.03) (-0.13) (-1.73) (-2.09)	0.44	0.13601	-0.10

Notes:

(a) RS_t = real rate of return on common stocks for year t; EI_{t-1} = expected inflation rate for year t as of year t-1; UI_t = unexpected inflation rate for year t; $RVAR_t$ = relative price variance for year t.

(b) $\bar{R}^2$ = (adjusted) coefficient of determination.

(c) $s(\eta)$ = residual standard error.

(d) $\hat{\rho}_1$ = residual autocorrelation at lag 1. Under the hypothesis that the true autocorrelations are zero, the standard errors of the residual autocorrelations are about 0.16 and 0.24 for the overall and sub-period estimates, respectively.

(e) Heteroskedasticity-consistent t-statistics in parentheses [White (1980)].

Table 4

Annual estimates of regressions of real stock returns on inflation variable.[a]

Regression no.	Estimated regression	$\bar{R}^2$ [b]	$s(\eta)$ [c]	$\hat{\rho}_1$ [d]
	Panel A: Overall period (1948-1984)			
(1)	$RS_t = 0.141 - 1.755\, EI_{t-1} - 3.224\, UI_t + \eta_t$	0.19	0.15557	-0.12
	(3.11)[e] (-1.93) (-2.72)			
(2)	$RS_t = 0.318 - 1.202\, EI_{t-1} - 2.014\, UI_t - 4.883\, RVAR_t + \eta_t$	0.25	0.14993	-0.13
	(3.24) (-1.16) (-1.42) (-2.10)			
	Panel B: Sub-period I (1948-1965)			
(1)	$RS_t = 0.174 - 2.391\, EI_{t-1} - 1.377\, UI_t + \eta_t$	0.00	0.15026	-0.31
	(2.90) (-0.96) (-0.67)			
(2)	$RS_t = -0.093 - 2.779\, EI_{t-1} - 1.673\, UI_t + 7.230\, RVAR_t - \eta_t$	0.00	0.15074	-0.37
	(-0.42) (-1.24) (-1.28) (1.25)			
	Panel C: Sub-period II (1966-1984)			
(1)	$RS_t = 0.091 - 0.671\, EI_{t-1} - 5.606\, UI_t + \eta_t$	0.34	0.14815	-0.02
	(0.94) (-0.38) (-3.10)			
(2)	$RS_t = 0.295 - 0.202\, EI_{t-1} - 3.123\, UI_t - 5.541\, RVAR_t + \eta_t$	0.44	0.13601	-0.10
	(2.03) (-0.13) (-1.73) (-2.09)			

Notes:

(a) RS_t = real rate of return on common stocks for year t; EI_{t-1} = expected inflation rate for year t as of year t-1; UI_t = unexpected inflation rate for year t; $RVAR_t$ = relative price variance for year t.

(b) $\bar{R}^2$ = (adjusted) coefficient of determination.

(c) $s(\eta)$ = residual standard error.

(d) $\hat{\rho}_1$ = residual autocorrelation at lag 1. Under the hypothesis that the true autocorrelations are zero, the standard errors of the residual autocorrelations are about 0.16 and 0.24 for the overall and sub-period estimates, respectively.

(e) Heteroskedasticity-consistent t-statistics in parentheses [White (1980)].

Table 5

Quarterly regressions of real stock returns on inflation and relative price variability 1948-1984.[a]

Regression no.	Estimated regression	$\bar{R}^2$ [b]	$s(\eta)$ [c]	$\hat{\rho}_1$ [d]
(1)	$RS_t = \underset{(4.37)^e}{0.0402} - \underset{(-2.44)}{2.316}\ EI_{t-1} - \underset{(-2.71)}{2.559}\ UI_t + \eta_t$	0.09	0.07574	0.09
(2)	$RS_t = \underset{(3.44)}{0.0665} - \underset{(-2.73)}{4.886}\ RVAR_t + \eta_t$	0.04	0.07752	0.09
(3)	$RS_t = \underset{(4.28)}{0.0811} - \underset{(-3.60)}{6.319}\ RVAR_{t+1} + \eta_t$	0.08	0.07616	0.09
(4)	$RS_t = \underset{(4.27)}{0.0914} - \underset{(-1.03)}{2.137}\ RVAR_t - \underset{(-2.51)}{5.187}\ RVAR_{t+1} + \eta_t$	0.08	0.07614	0.09
(5)	$RS_t = \underset{(3.27)}{0.0631} - \underset{(-2.08)}{1.875}\ EI_{t-1} - \underset{(-2.51)}{2.285}\ UI_t - \underset{(-1.42)}{2.680}\ RVAR_t + \eta_t$	0.09	0.07548	0.07
(6)	$RS_t = \underset{(4.06)}{0.0792} - \underset{(-2.03)}{1.757}\ EI_{t-1} - \underset{(-2.18)}{1.990}\ UI_t - \underset{(-2.37)}{4.376}\ RVAR_{t+1} + \eta_t$	0.11	0.07456	0.07
(7)	$RS_t = \underset{(3.82)}{0.083} - \underset{(-1.86)}{1.668}\ EI_{t-1} - \underset{(-2.13)}{1.954}\ UI_t - \underset{(-0.40)}{0.836}\ RVAR_t - \underset{(-1.93)}{4.00}\ RVAR_{t+1} + \eta_t$	0.11	0.07478	0.07

Notes:

(a) RS_t = real rate of return on common stocks for quarter t; EI_{t-1} = expected inflation rate for quarter t as of quarter t-1; UI_t = unexpected inflation rate for quarter t; $RVAR_t$ = relative price variance for quarter t.

(b) $\bar{R}^2$ = (adjusted) coefficient of determination.

(c) $s(\eta)$ = residual standard error.

(d) $\hat{\rho}_1$ = residual autocorrelation at lag 1. Under the hypothesis that the true autocorrelations are zero, the standard errors of the residual autocorrelations is about 0.08.

(e) Heteroskedasticity-consistent t-statistics in parentheses [White (1980)].

Abstract: This paper attempts to bring together apparently independent lines of research from the financial-economics and macro-economics literatures by investigating the effects of relative price variability on real activity and stock returns. First, the relations between relative price variability and inflation are examined. Second, the real effects of relative price variability are documented. Finally, the effects of relative price variability on the previously documented relations between stock returns and expected and unexpected inflation are examined.