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Relative Price Variability, Real Shocks, and the Stock Market

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ABSTRACT

In this paper, we investigate the effects of relative price variability on output and the stock market and gauge the extent to which inflation proxies for relative price variability in stock return-inflation regressions. The evidence shows that the negative stock return-inflation relations proxy for the adverse effects of relative price variability on economic activity, particularly during the seventies, when the U.S. experienced oil supply shocks. Hence, it appears that inflation spuriously affects the stock market in two ways: the aggregate output link of Fama (1981) and the supply shocks reflected in relative price variability.

A NUMBER OF PAPERS have attempted to explain the anomalous negative relations between stock returns and inflation witnessed in the post-war period. One hypothesis that has held up well in light of empirical evidence suggests that the negative relation between stock returns and unexpected inflation simply reflects the more fundamental positive relation between stock returns and future real variables (see, e.g., Fama (1981), Geske and Roll (1983), and Kaul (1987, 1989)).

In this paper, we investigate the effects of relative price variability on output and the stock market and gauge the extent to which inflation proxies for relative price variability in stock return-inflation regressions. First, relative price variability can have detrimental effects on output and employment (see, e.g., Friedman (1977) and Barro (1976)). Second, absolute-relative price confusion models of the Lucas (1973) type suggest that monetary shocks can induce a positive relation between inflation and relative price variability (see, e.g., Cukierman (1983)). Hence, the negative stock return-inflation relations could simply be a reflection of the negative effects of relative price variability on the stock market.

We use data for the 1947–1985 period to test the various links of our hypothesis. The results indicate that relative price variability is positively related to both expected and unexpected inflation measures. Relative price variability also has a significant negative effect on output and the stock market. More importantly,

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the negative relations between stock returns and inflation appear to proxy for the negative effects of relative price variability on the stock market. In multiple regressions of stock returns on inflation measures and relative price variability, the effects of both expected and unexpected inflation are rendered insignificant.

The evidence also shows that the adverse effects of relative price variability on output and the stock market are largely a reflection of the supply shocks (as opposed to monetary shocks) witnessed in the seventies. The OPEC oil crisis of 1973–1974, in particular, appears to have had a major detrimental effect on output and the stock market. Nevertheless, controlling for the effects of future output growth does not attenuate the effect of relative price variability on the stock market. Hence, it appears that inflation spuriously affects the stock market in two ways: the aggregate output link suggested by Fama (1981) and the supply shocks reflected in relative price variability particularly in the seventies.

Section I provides a brief discussion of the various issues related to the effects of inflation (both the level and variability) on output and stock returns. Section II describes the data used in this paper. The empirical evidence is presented in Section III. A brief summary and conclusions are contained in Section IV.

I. Inflation, Relative Price Variability, and the Stock Market

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 unexpected inflation and changes in expectations of future real activity. Stock returns are, however, positively related to changes in expectations of future real activity. Consequently, the negative relations between stock returns and unexpected inflation are spurious to the extent that they proxy for the positive relations between stock returns and future real variables. Geske and Roll (1983) and Kaul (1987, 1989) consider money supply responses which could either strengthen or attenuate such negative relations. These papers, however, do not really explain the intriguing negative relation between expected stock returns and expected inflation.

In this paper, we argue that two additional aspects of the inflationary process are pertinent to an explanation of the stock return-inflation relations. First, relative price variability may have adverse effects on the economy. In his Nobel lecture, Friedman (1977) argues that relative price variability, accompanying high and variable inflation, could have detrimental effects on output and employment. Such detrimental effects would arise mainly because of 1) a reduction in the information content of relative prices and a consequent misallocation of resources (also see Alchian (1970) and Hayek (1945)) and 2) the implementation of more costly institutional arrangements (e.g., more frequent contracting) which would, in turn, lead to a decrease in measured output (see Gray (1978)). Barro (1976) and Cukierman (1982) formally show that increased relative price variability does cause an efficiency loss to the extent that it leads to an increase in the dispersion of actual output around the full information output level. However, major shocks to oil prices during the seventies resulted in decreases in output. Rasche and Tatom (1981) show that the 1973–1977 oil price shocks resulted in a

7% decline in output. Consequently, it is important to separate out the adverse economic effects of supply shocks, particularly in the seventies, from the adverse effects of relative price variability in general.

Second, inflation uncertainty, in particular relative price variability, may be positively related to both expected and unexpected inflation. Absolute-relative price confusion models have demonstrated that movements in relative prices and unanticipated changes in the aggregate price level are positively related through their common dependence on monetary shocks (see, e.g., Barro (1976), Cukierman (1979), Hercowitz (1981), and Parks (1978)). In contrast to the above-mentioned studies, Sheshinski and Weiss (1977) rely on sticky prices to obtain a positive relation between *expected* inflation and price variability (see also Mussa (1977)). Therefore, both expected and unexpected inflation rates can be positively related to relative price variability.

Hence, relative price variability, which tends to be high when inflation is high, could have detrimental effects on output and the stock market. Consequently, in this paper we investigate the effects of relative price variability on output and the stock market and gauge the extent to which inflation measures proxy for relative price variability in stock return-inflation regressions.

II. Data Description

The variables used in this paper are constructed for the 1947–1985 period. The choice of this sample period is based on two considerations: (i) price data for a large array of products are available only after 1947, and (ii) most papers which investigate stock return-inflation relations also use post-war data. Hence, the results of this paper can be readily compared to existing empirical evidence.

A. Inflation Variability Measures

The prices used to construct the relative price variability measure, $RVAR_t$, are the price indices of the components of the Producer Price Index (PPI) at the item/product level for the 1947–1985 period. 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. To avoid biases due to changes in sample size and composition, we used 536 products for which an unbroken series of price observations exists between 1947 and 1985.

There are fifteen broad categories of commodities represented in our sample. These categories are: farm products; processed foods and feeds; textile products and apparel; leather and related products; fuels and related products and power; chemicals and allied products; rubber and plastic products; lumber and wood products; pulp, paper, and allied products; metals and metal products; machinery and equipment; furniture and household durable; non-metallic mineral products; transportation equipment; and miscellaneous products.

The use of such disaggregated data is suggested by the absolute-relative price confusion models. Fischer (1981) points out that, if the misallocation of resources caused by noisy relative price signals arises from excessive search, "it is possible that search would take place only in response to believed differences in prices of very similar goods" (p. 391). 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, prices of the wide spectrum (and large number) of commodities in the sample provide a good approximation of the general relative price instability during the post-war period.

The individual-product monthly inflation rates are computed as the first difference of the logarithms of prices. Average values and the relative price variability measure, $RVAR_t$, are calculated using

$$\Delta P_t = \frac{1}{N} \sum_j \Delta P_{jt}, \tag{1}$$

$$RVAR_t = \frac{1}{N} \sum_j (\Delta P_{jt} - \Delta P_t)^2, \tag{2}$$

where P_{jt} is the price at time t of product j, $\Delta P_{jt} = \log P_{jt} - \log P_{j,t-1}$, and N is the number of commodities included in the measure.[1] Due to missing observations, there are minor month-to-month variations in the actual number of products in our sample.

Relative price variability in post-war U.S. may be a reflection of real supply shocks (in particular, the oil shocks witnessed in the seventies and eighties), rather than monetary shocks. To gauge the importance of supply shocks in the determination of relative price variability and its relation with output and stock returns, we construct a variability measure of fuel/oil-related products only, $RVARO_t$, by averaging the squared deviations of oil and fuel prices around the overall producer price index. This variable serves as our measure of real supply shocks.

The annual relative price variability measures are constructed by cumulating the twelve monthly estimates 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 twelve, rather than one, observations of the variance of the inflation rates of the individual components of the PPI.[2]

[1] Strictly speaking, $RVAR_t$ is the variance of relative price changes, but for convenience we will refer to it as relative price variability. Moreover, as Cukierman (1983) points out, relative price uncertainty and variability are not necessarily identical. Ideally, we should use an uncertainty measure. However, Cukierman also shows that variability and uncertainty in relative prices are positively related (under reasonable restrictions), and therefore the use of relative price variability as a substitute for relative price uncertainty may be reasonable.

[2] Since the measure of relative price variability is based on PPI (rather than CPI) data, it is unlikely to be affected by errors due to nonsynchronous measurement of prices across products. Fama and Schwert (1979) suggest that only 50% of the prices and locations used to construct the CPI are sampled every month. On the other hand, despite significant changes in product coverage and sampling techniques, almost all of the PPI products have always been sampled around the same day *each* month. Only price indices for natural gas and some industrial chemicals are based on data which are one month old. Hence, the problems associated with nonsynchronous measurement of different producer price indices are likely to be trivial compared to the measurement errors in consumer price indices. A detailed discussion of the PPI and its components is in Bureau of Labor Statistics Bulletin No. 2285, *Handbook of Methods* (1988). (See also the Council on Wage and Price Stability *Wholesale Price Index: Review and Evaluation* (1977).)

Most of the models related to relative price variability also hypothesize a positive relation between the variability of the overall inflation rate and relative price variability. Accordingly, we construct an annual measure of the variance of the overall inflation rate, VAR_t, using the PPI. We use monthly values of the unexpected component of the inflation rate (based on an ARIMA model) to estimate the annual variance of the inflation rate. This procedure improves the precision of VAR_t since we use twelve nonoverlapping observations per annual estimate of the variable.

Specifically, the variance estimate for a particular year T is given by

$$VAR_T = \sum_{t=1}^{12} \left[\Delta PPI_t^u - \frac{1}{12} \sum_{t=1}^{12} \Delta PPI_t^u \right]^2, \tag{3}$$

where ΔPPI_t^u is the unexpected component of the inflation rate calculated using the PPI.[3]

B. Inflation Variables

We use three inflation variables in our study. The variable I_t is the inflation rate for period t calculated from the U.S. Consumer Price Index (CPI) obtained from the *Survey of Current Business, Business Statistics, 1986.* 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.

We use ARIMA time series models to obtain the short-term expected inflation rates from the overall inflation rate. The annual expected inflation series, EI_{t-1}, is constructed by multiplying the expected inflation estimate for the first quarter of each year by four. This procedure is valid since shorter term expected inflation estimates are close to a random walk (see Nelson and Schwert (1977), Fama (1981), and Kaul (1987)). The realized inflation rates are regressed on the resulting annual estimates, and the estimated regression (with standard errors of the estimated coefficients in parentheses) is[4]

$$\underset{}{I_t} = \underset{(0.007)}{0.0020} + \underset{(0.137)}{0.948}\ EI_{t-1} + \eta_t, \tag{4}$$

$$\bar{R}^2 = 0.573,\ s(\eta) = 0.02272,\ \hat{\rho}_1 = 0.04.$$

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 0.04 and all higher-order autocorrelations are close to zero), and 3) low residual standard error, $s(\eta)$. However, since the regression is estimated *in-sample,* it is not surprising that the inflation forecasts exhibit such properties.

[3] A third-order autoregressive process was a satisfactory model for the PPI inflation rate.

[4] OLS standard errors of the coefficients are reported because White's (1980) chi-square statistic revealed no evidence of heteroskedasticity at conventional significance levels.

C. Real Variables

The growth rate of output, $DIIP_t$, is measured as the first difference in the logarithms of the levels of the Index of Industrial Production (IIP) published in the *Survey of Current Business, Business Statistics, 1986.*

Finally, we measure the real rate of return on common stock, RS_t, as the difference between the continuously compounded return on the New York Stock Exchange (NYSE) value-weighted market portfolio and the inflation rate calculated using the CPI. The stock return data are obtained from the Center for Research in Security Prices (CRSP).

III. Empirical Evidence

To test the various links of our hypothesis, we analyze annual data in detail. The predominant reason for relying on annual data is the well known measurement problems associated with short-term producer price data. First, there is a lag of more than one month between collection and announcement of price information by the Bureau of Labor Statistics. This timing problem could lead to nonsynchronous measurement of the short-term (monthly and quarterly) price variability measures and the other variables used in this paper. In fact, Schwert (1981) presents evidence of leakage of information prior to the announcement of the price information. (See also Huberman and Schwert (1985) for related evidence based on Israeli data.) This measurement problem should be relatively minor in annual data.[5] Second, there is evidence of strong seasonality in monthly and quarterly output that appears to be unrelated to inflation (see, e.g., Fama (1981) and Kaul (1987)).

Finally, Stigler and Kindahl (1970) show that the U.S. producer price series do not always reflect discounts from list prices. The measurement error in the prices is considerably reduced in the *annual* inflation rates of the individual products. Stigler and Kindahl construct indices corresponding to the PPI and find that the discrepancies between the indices are less pronounced for one-year, as opposed to shorter, intervals (see also Hercowitz (1982)). However, this measurement problem is unlikely to have changed drastically over our sample period. Although the Bureau of Labor Statistics has increasingly insisted on transaction prices from the industry reporters, even as early as 1967 only 20% of the commodity indices were based on list prices.

A. Summary Statistics

Table I shows the summary statistics (autocorrelations, means, and standard deviations) for the annual measures of relative price variability, inflation, stock returns, and output. We report the annual evidence for the 1949–1984 period because we lose one observation on each end of the sample period since we use lagged variability measures and lead output variables in the regression analysis.

[5] Preliminary tests using monthly and quarterly data suggest that the measurement errors in short-term producer prices are much more severe than in annual data. For example, due to nonsynchronous measurement problems, quarterly stock returns are correlated with up to two-quarter lead price variability measures. This phenomenon is not witnessed in annual data.

Table I

Summary Statistics for Annual Variables, 1949–1984

This table provides the mean, $\bar{x}$, standard deviation, $s(x)$, and autocorrelations, ρ_t, $t = 1,\cdots,5$, for all the variables used in the study. Under the hypothesis that the true autocorrelations are zero, the standard error of the estimated autocorrelations is about 0.16. VAR_t is the variance of overall inflation calculated using the unexpected PPI inflation rate, $RVAR_t$ is the relative price variability of all products, $RVARO_t$ is the relative price variability of only oil products. I_t is the inflation rate calculated using the CPI, EI_{t-1} is the expected inflation rate for year t as of year $t-1$, UI_t is the unexpected inflation rate for year t, RS_t is the real rate of return on common stock, and $DIIP_t$ is the growth rate of industrial production.

Variable (x)	$\bar{x}$	$s(x)$	$\hat{\rho}_1^b$	$\hat{\rho}_2$	$\hat{\rho}_3$	$\hat{\rho}_4$	$\hat{\rho}_5$
VAR_t	0.00046	0.00098	0.39	−0.03	−0.08	−0.09	−0.09
$RVAR_t$	0.04281	0.01156	0.58	0.08	0.07	0.10	−0.01
$RVARO_t$	0.00958	0.01708	0.35	−0.09	−0.11	−0.04	0.07
I_t	0.04101	0.03478	0.70	0.41	0.35	0.38	0.46
EI_{t-1}	0.04118	0.02807	0.59	0.35	0.33	0.38	0.42
UI_t	−0.00016	0.02244	0.00	−0.24	−0.10	0.03	0.20
RS_t	0.07825	0.17113	−0.04	−0.31	0.12	0.42	0.10
$DIIP_t$	0.03859	0.05923	−0.12	−0.21	−0.09	0.00	0.08

All the price variability measures exhibit significant first-order autocorrelations, while higher order autocorrelations are close to zero. On the other hand, both the actual and expected inflation rates, I_t and EI_{t-1}, respectively, exhibit highly autocorrelated behavior, while the unexpected inflation series, UI_t, has autocorrelations which are close to zero at all lags. Finally, both the real variables—real stock returns, RS_t, and the growth rate of output, $DIIP_t$—behave like white noise. The estimated autocorrelations for each of the variables are close to zero at all lags.

A.1. Correlations Between the Inflation Measures

Table II 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. First, relative price variability and the variance of the overall rate of inflation are highly positively related. This evidence supports the findings of Vining and Elwertowski (1976).

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 (1981), Hercowitz (1981), and Parks (1978). The strong positive correlation between unexpected inflation and the price volatility measures suggests an intriguing type of conditional skewness. In particular, positive shocks to the inflation process (i.e., $UI_t > 0$) are due to a few big product price increases, while negative values of UI_t seem to be associated with situations in which most product prices remain unchanged *relative to each other*.

There also exists a positive relation between $RVAR_t$ and EI_{t-1} which lends some (albeit weak) support to the costly price adjustment models. Hence, both

Table II

Correlation Matrix for Annual Inflation Variables: 1949–1984

This table provides the annual correlations between the inflation variables used in this study. VAR_t is the variance of overall inflation calculated using the unexpected PPI inflation rate, $RVAR_t$ is the relative price variability of all products, $RVARO_t$ is the relative price variability of only oil products, I_t is the inflation rate calculated using the CPI, EI_{t-1} is the expected inflation rate for year t as of year $t-1$, and UI_t is the unexpected inflation rate for year t.

Variable	VAR_t	$RVAR_t$	$RVARO_t$	I_t	EI_{t-1}	UI_t
VAR_t	1.00	0.84	0.65	0.39	0.06	0.52
$RVAR_t$		1.00	0.82	0.51	0.26	0.46
$RVARO_t$			1.00	0.53	0.36	0.37
I_t				1.00	0.77	0.59
EI_{t-1}					1.00	−0.07
UI_t						1.00

expected and unexpected inflation rates are positively correlated with our measure of relative price variability. Another significant aspect of the correlations in Table II is that the measure of relative price variability is strongly positively related to the supply shock variable, $RVARO_t$. The two variables have an estimated correlation coefficient of 0.82. Also, $RVARO_t$ has significant positive correlations with all the inflation level measures.

Figure 1 displays time series plots of the three price volatility measures, $RVAR_t$, $RVARO_t$, and VAR_t. It is apparent that most of the variation in all three series is concentrated in the second half of the sample period (in particular, the seventies). The most interesting aspect of the plots is that the time variation in relative price variability of all products, $RVAR_t$, appears to closely reflect movements in relative price variability of oil products, $RVARO_t$. Similar movements in $RVAR_t$ and $RVARO_t$, along with a high correlation of 0.82 between them, suggest that relative price variability in the post-war period is largely due to real shocks, rather than monetary shocks. Figure 1 also reveals the critical importance of the 1973–1974 OPEC oil crisis in determining the behavior of relative price variability in the post-war period. A more detailed analysis of the relative effects of $RVAR_t$ and $RVARO_t$ on the economy is presented in Section III.*D*.

B. 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 are shown in Table III. An investigation of the residuals of the regressions reveals significant heteroskedasticity in some cases. Accordingly, we compute standard errors based on White's (1980) heteroskedasticity-consistent method and report the corresponding t-statistics for regressions in which there is evidence of heteroskedasticity at conventional significance levels (using White's chi-square statistic).[6] Standard OLS t-statistics are reported for all other regressions. This

[6] Standard errors based on Newey and West's (1987) heteroskedasticity- and autocorrelation-consistent method yield similar inferences.

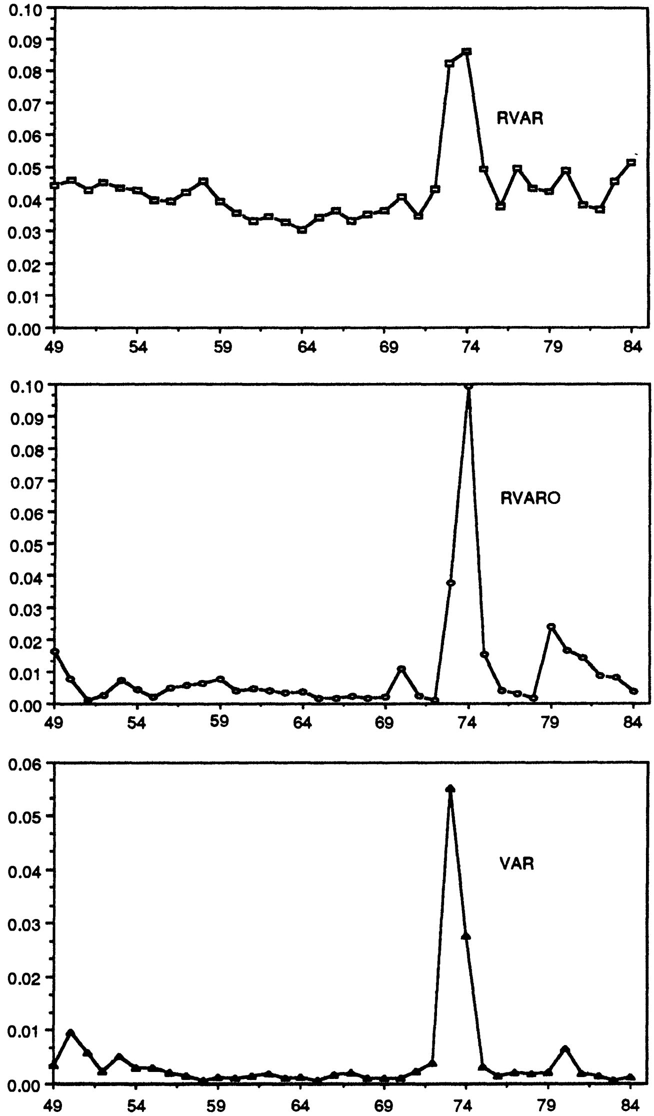

Figure 1. Time series plots of *RVAR*, *RVARO*, and *VAR*, 1949–1984. *RVAR* is the relative price variability of all products, *RVARO* is the relative price variability of only oil products, and *VAR* is the variance of the overall inflation rate calculated using the unexpected PPI inflation rate.

procedure is adopted in all tables that follow. Also, we replicated all the tests reported in this paper using the variance of the overall inflation rate, VAR_t, in lieu of $RVAR_t$. Although the results were similar, the effects of $RVAR_t$ on output and stock returns were stronger; $RVAR_t$ statistically dominated VAR_t in regressions which included both variables as regressors.

Regressions (1) and (2) in Table III, Panel A, report the contemporaneous and lagged relations between the growth rate of industrial production, $DIIP_t$, and the

Table III

Annual Estimates of Regressions of Real Output and Real Stock Returns on Relative Price Variability, and Real Stock Returns on Future Real Output, 1949–1984

This table provides the annual estimates of regressions of growth rate of industrial production (*DIIP*) on current and lagged measures of relative price variability (*RVAR*); real stock returns (*RS*) on future growth rate of industrial production; and real stock returns on current and lagged measures of relative price variability. t-statistics are in parentheses below the estimated coefficients. For regressions in which the p-values of the chi-square test statistics for heteroskedasticity are less than 0.05, the t-statistics are based on standard errors computed using White's (1980) heteroskedasticity-consistent method. $\bar{R}^2$ is the adjusted coefficient of determination, $s(\eta)$ is the residual standard error, and $\hat{\rho}_1$ is the 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 subperiod estimates, respectively. The F-statistic tests the hypothesis that the estimated coefficients of all the independent variables are jointly zero. These statistics are corrected for heteroskedasticity for regressions in which p-values of the chi-square test statistics for heteroskedasticity are less than 0.05.

Regression No.	Estimated Regression					$\bar{R}^2$	$s(\eta)$	$\hat{\rho}_1$	F-statistic (p-value)
	Panel A: Overall Period (1949–1984)								
(1)	$DIIP_t =$	0.056	−	0.412	$RVAR_t + \eta_t$	−0.023	0.05900	−0.13	0.221
		(1.45)		(−0.47)					(0.641)
(2)	$DIIP_t =$	0.115	−	1.743	$RVAR_{t-1} + \eta_t$	0.099	0.05411	−0.10	4.850
		(3.29)		(−2.20)					(0.035)
(3)	$RS_t =$	−0.016	+	2.317	$DIIP_{t+1} + \eta_t$	0.584	0.11044	0.23	50.042
		(−0.71)		(7.07)					(0.000)
(4)	$RS_t =$	0.385	−	7.167	$RVAR_t + \eta_t$	0.212	0.15194	−0.10	15.377
		(4.73)		(−3.92)					(0.000)
(5)	$RS_t =$	0.172	−	2.202	$RVAR_{t-1} + \eta_t$	−0.007	0.17172	−0.06	0.246
		(0.96)		(−0.50)					(0.620)
	Panel B: Subperiod I (1949–1965)								
(1)	$DIIP_t =$	0.150	−	2.638	$RVAR_t + \eta_t$	−0.019	0.06339	−0.36	0.702
		(1.20)		(−0.84)					(0.415)
(2)	$DIIP_t =$	0.058	−	0.080	$RVAR_{t-1} + \eta_t$	−0.067	0.05929	−0.20	0.001
		(0.49)		(−0.03)					(0.979)
(3)	$RS_t =$	0.035	+	1.880	$DIIP_{t+1} + \eta_t$	0.523	0.10030	0.01	18.529
		(1.02)		(4.31)					(0.001)
(4)	$RS_t =$	−0.118	+	6.479	$RVAR_t + \eta_t$	−0.013	0.14612	−0.33	1.211
		(−0.52)		(1.10)					(0.271)
(5)	$RS_t =$	−0.098	+	5.936	$RVAR_{t-1} + \eta_t$	−0.024	0.14695	−0.36	1.104
		(−0.44)		(1.05)					(0.294)
	Panel C: Subperiod II (1966–1984)								
(1)	$DIIP_t =$	0.032	−	0.011	$RVAR_t + \eta_t$	−0.059	0.05838	0.05	0.000
		(0.72)		(−0.01)					(0.991)
(2)	$DIIP_t =$	0.106	−	1.698	$RVAR_{t-1} + \eta_t$	0.157	0.05075	0.06	6.419
		(3.03)		(−2.53)					(0.011)
(3)	$RS_t =$	−0.046	+	2.520	$DIIP_{t+1} + \eta_t$	0.582	0.11585	0.23	26.023
		(−1.53)		(5.10)					(0.000)
(4)	$RS_t =$	0.376	−	7.625	$RVAR_t + \eta_t$	0.356	0.14374	−0.10	23.101
		(4.42)		(−4.80)					(0.000)
(5)	$RS_t =$	0.106	−	1.778	$RVAR_{t-1} + \eta_t$	−0.036	0.18228	−0.06	0.136
		(0.53)		(−0.37)					(0.713)

measure of relative price variability, $RVAR_t$, for the overall period. 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 statistically significant negative coefficient. Moreover, the contemporaneous measure, $RVAR_t$, *has no marginal explanatory power when included with* $RVAR_{t-1}$ (regression not reported). This evidence indicates that desired changes in both production levels and composition, in response to changes in relative prices, are costly and require time.[7] (For similar evidence, See Blejer and Leiderman (1980), Holland (1986), Levi and Makin (1980), and Mullineaux (1980).)

On the other hand, changes in stock prices reflect changes in the market's expectation of *future* real activity. Regression (3) in Table III shows that future real activity growth, $DIIP_{t+1}$, is significantly positively related to current real stock returns, RS_t, and explains about 58% 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 III are consistent with this hypothesis. Regression (4) shows that there is a strong negative relation between stock returns and the contemporaneous variability measure, but the lagged variability measure has no significant relation with RS_t (see regression (5)).

C. Real Stock Returns, Inflation, and Relative Price Variability

In this section, we analyze the relations between stock returns and inflation and investigate whether these relations simply proxy for the negative effects of relative price variability on the real sector. Table IV, 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 both expected and unexpected inflation rates. These results confirm the negative stock return-inflation relations reported by various researchers (see, e.g., 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 to an increase in the explanatory power of the regression (see regression (2)). An F-test for the hypothesis that the coefficients of both EI_{t-1} and UI_t are jointly zero cannot be rejected at conventional significance levels. The computed F-statistic (corrected for heteroskedasticity) is 1.330, with a p-value of 0.279. The negative effect of $RVAR_t$, however, remains significant.

In regression (3) we also include the growth rate of future real activity, $DIIP_{t+1}$, to gauge whether the negative effects of relative price variability on the stock market are accounted for by the proxy hypothesis suggested by Fama (1981). Interestingly enough, the coefficient of $RVAR_t$ remains significant at the 5%

[7] The current growth rate of output, $DIIP_t$, is not significantly related to future relative price variability, $RVAR_{t+1}$. The correlation coefficient is 0.16.

Table IV

Annual Estimates of Regressions of Real Stock Returns on Inflation Variables and Future Real Output, 1949–1984

This table provides the annual estimates of regressions of real stock returns (RS) on expected inflation (EI) and unexpected inflation (UI); real stock returns on expected inflation, unexpected inflation, and relative price variability ($RVAR$); and real stock returns on expected inflation, unexpected inflation, relative price variability, and future growth rate of industrial production ($DIIP$). t-statistics are in parentheses below the estimated coefficients. For regressions in which the p-values of the chi-square test statistics for heteroskedasticity are less than 0.05, t-statistics are based on standard errors computed using White's (1980) heteroskedasticity-consistent method. $\bar{R}^2$ is the adjusted coefficient of determination, $s(\eta)$ is the residual standard error, and $\hat{\rho}_1$ is the 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 subperiod estimates, respectively. The F-statistic tests the hypothesis that the estimated coefficients of all the independent variables are jointly zero. These statistics are corrected for heteroskedasticity for regressions in which p-values of the chi-square test statistics for heteroskedasticity are less than 0.05.

Regression No.	Estimated Regression	$\bar{R}^2$	$s(\eta)$	$\hat{\rho}_1$	F-statistic (p-value)
Panel A: Overall Period (1949–1984)					
(1)	$RS_t = 0.143 - 1.592\ EI_{t-1} - 3.133\ UI_t + \eta_t$	0.176	0.15535	−0.14	4.736
	$(3.08)\quad(-1.70)\quad(-2.67)$				(0.016)
(2)	$RS_t = 0.324 - 1.016\ EI_{t-1} - 1.951\ UI_t$	0.230	0.15020	−0.15	6.115
	$(3.24)\quad(-0.94)\quad(-1.39)$				(0.002)
	$- 4.769\ RVAR_t + \eta_t$				
	(-2.07)				
(3)	$RS_t = 0.120 + 0.522\ EI_{t+1} - 0.355\ UI_t$	0.612	0.10662	0.21	31.053
	$(1.69)\quad(0.69)\quad(-1.09)$				(0.000)
	$- 3.493\ RVAR_t + 2.116\ DIIP_{t+1} + \eta_t$				
	$(-2.48)\quad(6.39)$				

Table IV—*Continued*

Regression No.	Estimated Regression	$\bar{R}^2$	$s(\eta)$	$\hat{\rho}_1$	F-statistic (p-value)
	Panel B: Subperiod I (1949–1965)				
(1)	$RS_t = \underset{(2.96)}{0.182} - \underset{(-0.92)}{2.809}\ EI_{t-1} - \underset{(-0.26)}{0.689}\ UI_t + \eta_t$	−0.073	0.15037	−0.32	0.459 (0.641)
(2)	$RS_t = \underset{(-0.38)}{-0.122} - \underset{(-1.20)}{2.005}\ EI_{t-1} - \underset{(-0.55)}{1.838}\ UI_t$ $+ \underset{(0.91)}{7.411}\ RVAR_t + \eta_t$	−0.094	0.15187	−0.36	1.908 (0.178)
(3)	$RS_t = \underset{(-2.42)}{-0.424} + \underset{(1.46)}{2.337}\ EI_{t-1} - \underset{(-1.69)}{1.966}\ UI_t$ $+ \underset{(2.57)}{10.408}\ RVAR_t + \underset{(8.90)}{2.074}\ DIIP_{t+1} + \eta_t$	0.542	0.09824	−0.26	23.938 (0.000)
	Panel C: Subperiod II (1966–1984)				
(1)	$RS_t = \underset{(0.81)}{0.076} - \underset{(-0.43)}{0.730}\ EI_{t-1} - \underset{(-2.33)}{4.363}\ UI_t + \eta_t$	0.181	0.16214	−0.08	2.897 (0.084)
(2)	$RS_t = \underset{(2.22)}{0.309} - \underset{(-0.01)}{0.008}\ EI_{t-1} - \underset{(-0.83)}{1.636}\ UI_t$ $- \underset{(-2.40)}{6.122}\ RVAR_t + \eta_t$	0.299	0.14996	−0.14	6.691 (0.004)
(3)	$RS_t = \underset{(-0.16)}{-0.013} + \underset{(3.20)}{2.572}\ EI_{t-1} + \underset{(0.56)}{0.740}\ UI_t$ $- \underset{(-3.83)}{4.269}\ RVAR_t + \underset{(7.51)}{2.634}\ DIIP_{t+1} + \eta_t$	0.743	0.09075	−0.07	74.893 (0.000)

level, which suggests that one-year lead output growth does not incorporate the adverse effects of relative price variability on the stock market.

D. The Role of Supply Shocks

Relative price variability in the U.S. during the post-war period could largely be a reflection of real, as opposed to monetary, shocks. To gauge the importance of supply shocks in the determination of relative price variability and its relation with output and stock returns, we (i) analyze the data over two equal-sized subperiods, 1949–1965 and 1966–1984, and (ii) use a measure of supply shocks in our tests.

D.1. The Subperiod Evidence

The time series plots in Figure 1 show that most of the variability in $RVAR_t$ is during the second half of our sample period. Also, the summary statistics of the various variables suggest that the data are nonstationary across the two subperiods. For example, the second subperiod (in comparison with the first) is characterized by substantially higher (two- to three-fold) means of both the inflation rate and the inflation variability measures. In contrast, the means of both real stock returns and output growth are substantially lower. Such mean-nonstationarity further emphasizes the importance of subperiod analysis to determine the effects of real shocks on stock return-inflation relations.

We therefore re-estimate the various regressions over the two subperiods and report the results in Tables III and IV, Panels B and C, respectively. The evidence in Table III shows that 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 subperiod. There are no significant relations between the variability measure and the real variables in the 1949–1965 subperiod, while the relations are significantly negative in the 1966–1984 subperiod. These results, and the plots in Figure 1, suggest that relative price variability in the post-war period is largely a reflection of real (rather than monetary) shocks witnessed in the seventies.[8] The variation in $RVAR_t$ in the fifties and sixties was much lower, and hence it is not surprising that we find no relation between relative price variability and the real variables.

The results in Table IV corroborate the subperiod evidence reported in Table III.[9] First, the significant negative stock return-inflation rate relations appear to be driven by the 1966–1985 subperiod, as is the negative relation between stock returns and relative price variability. Second, $RVAR_t$ statistically dominates the negative relation between stock returns and inflation during the second subperiod.

The subperiod analysis suggests that high levels of relative price variability in the second subperiod, and their detrimental effects on output and stock returns,

[8] This finding supports the evidence presented by Hercowitz (1982) and Taylor (1981). However, it does not generalize to all situations. For example, Hercowitz (1981) shows that monetary shocks played a significant role in the relative price dispersion witnessed during the German hyperinflation.

[9] We re-estimate the inflation forecast models for each subperiod separately because there is evidence that the time series process for the inflation rate changed over the two subperiods.

are largely a reflection of supply shocks (in particular, oil shocks) prevalent during the seventies.[10] The possibility that our measure of relative price variability is reflecting exogenous real shocks is also suggested by the evidence that, in the first subperiod (fifties and sixties), $RVAR_t$ has insignificant relations with both output and stock returns.

D.2. A Direct Test

To gauge the effects of supply shocks on stock return-inflation relations more effectively, we employ a more direct test. Specifically, we use a dispersion measure based on only oil-related products, $RVARO_t$, to isolate the effects of real shocks. Table V reports regressions of real variables on the relative price variability measure, $RVAR_t$, and the real shock variable, $RVARO_t$.

Regression (1) shows that the lagged measure of oil shocks has a significant negative effect on output. Moreover, $RVARO_{t-1}$ explains almost twice the variation in output growth than does $RVAR_{t-1}$ (18.6% vs. 9.9%). A more direct comparison of the relative effects of the two variables on output can be made in regression (2). Inclusion of $RVARO_{t-1}$, in addition to $RVAR_{t-1}$, causes the effects of the latter to become insignificant. The coefficient of $RVARO_{t-1}$, however, remains significant. Hence, the adverse effects of inflation uncertainty, in particular relative price variability, on output documented in earlier studies appear to be largely a reflection of real supply shocks. Also, given the behavior of relative price variability in the post-war period (see Figure 1), the OPEC oil crisis of 1973–1974 appears to be a particularly critical supply shock.

The simple and multiple regressions of real stock returns on $RVAR_t$ and $RVARO_t$ yield similar results (see regressions (3) and (4)). The negative relation between RS_t and $RVAR_t$ appears to be largely a reflection of the adverse effects of real supply shocks on the stock market. $RVAR_t$ has no marginal explanatory power when included with $RVARO_t$ in the stock return regression, while the latter remains statistically significant.

Regression (5), Table V, shows that the oil shock measure, $RVARO_t$, alone is sufficient to render the negative stock return-inflation relations insignificant. Inclusion of $RVARO_t$ leads to a drop in the t-statistics of the estimated coefficients of expected and unexpected inflation from -1.70 and -2.67 to -0.68 and -1.52, respectively. An F-test for the hypothesis that the effects of both EI_{t-1} and UI_t are jointly zero cannot be rejected at conventional significance levels. The computed F-statistic (corrected for heteroskedasticity) is 1.305, with a p-value of 0.285. Finally, inclusion of future real activity leads to attenuation in both the coefficient and t-statistics of $RVARO_t$ (see regression (6)). However, the estimated coefficient of $RVARO_t$ remains significant at the 5% level. This result suggests that the one-year lead output growth measure does not completely incorporate the impact of oil shocks during the seventies.

[10] This result is contrary to the evidence in Hamilton (1983), who finds that most recessions *before* 1970 were also preceded by dramatic increases in oil prices. Of course, in relative terms, the oil shocks of the seventies and eighties were probably much more severe than those witnessed in the pre-1970 era. Consequently, we are able to detect the effects of relative price variability on output and the stock market much more readily in the second subperiod.

Table V

Annual Estimates of Regressions of Real Output on Relative Price Variability Measures, and Real Stock Returns on Inflation Variables and Future Real Output, 1949–1984

This table provides the annual estimates of regressions of growth rate of industrial production ($DIIP$) on the lagged measure of relative price variability of only oil products ($RVARO$); growth rate of industrial production on lagged measures of relative price variability of all products ($RVAR$) and relative price variability of only oil products; real stock returns (RS) on relative price variability of only oil products; real stock returns on relative price variability of all products and relative price variability of only oil products; real stock returns on expected inflation (EI), unexpected inflation (UI), and relative price variability of only oil products; and real stock returns on expected inflation, unexpected inflation, relative price variability of only oil products, and future growth rate of industrial production. t-statistics are in parentheses below the estimated coefficients. For regressions in which the p-values of the chi-square test statistics for heteroskedasticity are less than 0.05, the t-statistics are based on standard errors computed using White's (1980) heteroskedasticity-consistent method. $\bar{R}^2$ is the adjusted coefficient of determination, $s(\eta)$ is the residual standard error, and $\hat{\rho}_1$ is the residual autocorrelation at lag 1. Under the hypothesis that the true autocorrelations are zero, the standard error of the residual autocorrelation is about 0.16. The F-statistic tests the hypothesis that the estimated coefficients of all the independent variables are jointly zero. These statistics are corrected for heteroskedasticity for regressions in which p-values of the chi-square test statistics for heteroskedasticity are less than 0.05.

Regression No.	Estimated Regression	$\bar{R}^2$	$s(\eta)$	$\hat{\rho}_1$	F-statistic (p-value)
(1)	$DIIP_t = 0.055 - 1.528\ RVARO_{t-1} + \eta_t$	0.186	0.05142	−0.08	9.020
	(5.62) (−3.00)				(0.005)
(2)	$DIIP_t = 0.043 + 0.317\ RVAR_{t-1}$	0.163	0.05214	−0.09	36.980
	(1.23) (0.36)				(0.000)
	$- 1.704\ RVARO_{t-1} + \eta_t$				
	(−3.12)				
(3)	$RS_t = 0.127 - 5.102\ RVARO_t + \eta_t$	0.238	0.14942	−0.12	11.909
	(4.44) (−3.45)				(0.002)
(4)	$RS_t = 0.240 - 3.013\ RVAR_t$	0.229	0.15026	−0.10	29.349
	(2.09) (−0.99)				(0.000)
	$- 3.343\ RVARO_t + \eta_t$				
	(−2.03)				
(5)	$RS_t = 0.143 - 0.179\ EI_{t-1} - 2.030\ UI_t$	0.257	0.14755	−0.15	16.902
	(3.11) (−0.68) (−1.52)				(0.000)
	$- 3.695\ RVARO_t + \eta_t$				
	(−3.79)				
(6)	$RS_t = -0.008 + 0.506\ EI_{t-1} - 0.701\ UI_t$	0.596	0.10872	0.15	30.933
	(−0.20) (0.64) (−0.69)				(0.000)
	$- 1.919\ RVARO_t + 2.053\ DIIP_{t+1} + \eta_t$				
	(−2.34) (6.517)				

IV. Summary and Conclusions

In this paper, we investigate the effects of relative price variability on output and stock returns and gauge the extent to which inflation proxies for relative price variability in stock return-inflation regressions. The evidence shows that the negative relations between stock returns and expected and unexpected inflation proxy for the negative effects of relative price variability on the stock market.

However, the adverse effects of relative price variability on output and the stock market are largely a reflection of the supply shocks witnessed in the seventies. The OPEC oil crisis of 1973–1974, in particular, appears to have had a major detrimental effect on output and the stock market. Nevertheless, controlling for the effects of future output growth does not attenuate the effect of relative price variability on stock returns. Hence, it appears that inflation spuriously affects the stock market in two ways: the aggregate output link suggested by Fama (1981) and the supply shocks reflected in relative price variability particularly in the seventies.

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