Review of Applied Economics, Vol. 3, No. 1-2, (2007) : 49-59

FRIEDMAN'S HYPOTHESIS AND CROSS-REGIONAL INFLATION DISPERSION

Gary L. Shoesmith*

This study shows that higher inflation is associated with increased inflation dispersion across U.S. cities and regions. Regression analysis indicates that cross-regional inflation variability is positively related to both inflation and inflation expectations based on consumer price inflation for 18 U.S. cities. Similar results are obtained after excluding five of the 18 cities that may be disproportionately impacted by energy shocks. In addition, cointegration analysis shows greater cross-regional price dispersion over time during the higher inflation period of 1978-1987 than during 1988-1997. These findings suggest that high inflation is associated with greater uncertainty for businesses and policy makers.

JEL Classifications: *E30, E31*

Keywords: *Urban inflation, Friedman's Hypothesis, Cointegration*

INTRODUCTION

Friedman's (1977) hypothesis regarding inflation has been analyzed in many papers in terms of the mean and variance of component inflation measures; the higher the overall level of inflation, the higher the variability of inflation at each point in time. Shoesmith (2000) pointed out that Friedman's (1977) reasoning also suggests that higher inflation might be associated with greater price dispersion among component inflation indexes *over time*. That is, in addition to increased dispersion across component measures of inflation at each point in time, higher inflation also may result in component price indexes drifting apart over time.

Regarding the uncertain dynamics of inflation, Friedman (1977, p. 466) states that, "A burst of inflation produces strong pressure to counter it. Policy goes from one direction to the other, encouraging wide variation in the actual and anticipated rate of inflation. And, of course, in such an environment, no one has single-valued anticipations. Everyone recognizes that there is great uncertainty about what actual inflation will be over any specific future interval." Friedman (1977, p. 466) also discusses the advantages of inflation indexing, but states that, "indexing is, even at best, an imperfect substitute for stability of the inflation rate. Price indexes are imperfect; they are available only with a lag and generally are applied to contract terms only with further lags." Thus, Friedman's discussion of inflation is as much about inflation uncertainty over time as it is about uncertainty at any point in time.

---

* Professor of Economics, Babcock Graduate School of Management, Wake Forest University, Winston-Salem, *E-mail: gary.shoesmith@mba.wfu.edu*

Confirming this added dimension of uncertainty, Shoesmith (2000) tests for cointegration among ten component consumer price indexes (CPIs) over the two ten-year time intervals of 1978-1987 and 1988-1997 and finds greater price integration during the lower inflation period of 1988-1997 than during 1978-1987. Specifically, only three cointegrating vectors were found among the ten price indexes during 1978-1987, compared to a minimum of five cointegrating vectors during 1988-1997.[1] Thus, the component indexes were less integrated (more dispersed) over time during the higher inflation period of 1978-1987 than during 1988-1997. This added uncertainty suggests even greater loss of economic efficiency associated with higher inflation.

Using CPI data from a cross-section of U. S. cities, Debelle and Lamont (1997) show a positive correlation between inflation and relative price variability (RPV) across component measures of inflation. Cities with above average inflation also have higher than average RPV.[2] Debelle and Lamont (1997) also point out that different cities do not have different monetary policies. This fact raises some interesting issues regarding price dispersion across cities and regions. Specifically, while some cities and regions may experience higher than average prices (e.g., due to higher real estate costs), prices and inflation across cities and regions should otherwise move together through time, or at least not diverge due to differing monetary policies. Therefore, it is of interest to investigate whether or not high inflation and the lack of "single-valued anticipations" among buyers and sellers in different geographic regions can be associated with greater price dispersion across U. S. cities and regions, just as higher inflation has been associated with greater price dispersion across different industries.

Like monetary policy, U. S. cities and regions are subject to the same nationwide shocks, particularly energy shocks. Some critics of the empirical research showing a positive relationship between the level and variability of inflation suggest that oil shocks are entirely responsible for the findings; see, for example, Bomberger and Makinen (1993). The use of cross-regional data avoids this problem to the extent that all U.S. cities and regions are similarly impacted by oil shocks. However, since energy shocks may impact some cities more or less than others due to differing industrial bases or climate, those cities can be excluded and the analysis repeated. Comparing the two sets of results helps clarify the importance of energy shocks.

Given the above, this study addresses two specific empirical issues. First, in Section II, regression analysis is used to investigate the relationship between inflation and inflation variability across 18 U.S. cities at each observation. The regression analysis is then repeated after excluding five cities that may be more or less impacted by energy shocks compared to the remaining 13 cities. Second, in Section III, cointegration analysis is used to investigate the degree of cross-regional price integration over time during the 1978-1987 and 1988-1997 periods, using the Bureau of Labor Statistics' four regional CPIs.

The regression results in Section II confirm that high inflation is associated with greater inflation variability across the 18 cities at each point in time. Similar results are obtained after restricting the analysis to 13 northern cities. In addition, the cointegration results in Section III show that the BLS's Northeast, Midwest, South and West regional CPIs are fully integrated (i.e., three cointegrating vectors) over the lower inflation period of 1988-1997, compared to only one cointegrating vector during the 1978-1987 period. Thus, the urban and regional results obtained here directly parallel previous research involving component measures of inflation.

INFLATION AND CROSS-REGIONAL INFLATION VARIABILITY

This section investigates the relationship between the overall level of inflation and inflation variability across U. S. cities. The analysis is patterned after Fischer's (1981) study involving inflation and inflation variability across inflation components. The source for all data is the BLS's Selective Data Access on the Internet. Annual CPI data for all urban consumers are used for the United States and the 18 cities of Atlanta, Boston, Chicago, Cincinnati, Cleveland, Detroit, Houston, Kansas City, Los Angeles, Milwaukee, Minneapolis-St. Paul, New York, Philadelphia, Pittsburgh, Portland, St. Louis, San Francisco and Seattle. Similar to Debelle and Lamont (1997), regression results are first obtained for 1954-1986, because after 1986 the BLS decreased the sample size and frequency of observations for city-level price indexes. The estimation period is then extended through 1997 to include all years prior to the BLS's major revision of the CPI formula in 1998, and once again through 2005 to obtain more current results.

The inflation rate for each year *t* is computed as the first difference in logs of each CPI series and expressed in per centage form:

$$\pi_{j\,t} = 100\,(\ln \mathrm{CPI}_{j\,t} - \ln \mathrm{CPI}_{j\,t-1}) \text{ for } j = \text{US and each of 18 cities.} \qquad (1)$$

Relative price variability for each year (RPV_t) is computed as the standard deviation of the 18 city inflation rates ($\pi_{j\,t}$) at each observation.

Figure 1 graphs π_{US} and RPV for the 18 U.S. cities over the years 1954-2005 and shows an overall positive relationship between the two series. Figure 1 also shows that the peaks in RPV lag those for U.S. inflation by one year following the inflation peaks of 1957, 1970 and 1974 and by three years following the inflation peak of 1980. A lagged relationship between π_{US} and RPV is consistent with Friedman's reasoning regarding inflation uncertainty and the time lags involved in price-indexing contracts.[3] Although a one-year lag is perhaps most consistent with Friedman's comments, the early 1980s episode may justifiably be an exception, given that inflation declined by 10.3 per cent over the three-year period 1980 to 1983. Based on Fischer's (1981) formulation of expected and unexpected inflation, this sudden drop in inflation results in negative unexpected inflation during this period. Given that the early 1980s experience is fairly unique, the regression analysis includes estimation results for both the 1954-1980 and 1954-1986 periods. The same equations are then estimated with data through 1997 and 2005.

To account for the possibility that oil shocks may impact some cities' inflation rates more than others and exaggerate the relationship between the level of inflation and cross-regional inflation variability, the analysis is repeated with the exclusion of five cities. First, Houston is excluded due to its heavy dependence on the oil industry. Second, Detroit is excluded due to the indirect impact oil shocks may have on the automobile industry. Third, the three southern cities of Atlanta, Los Angeles and San Francisco are excluded due to their milder climates. This leaves the 13 northern cities of Boston, Chicago, Cincinnati, Cleveland, Kansas City, Milwaukee, Minneapolis-St. Paul, New York, Philadelphia, Pittsburgh, Portland, St. Louis and Seattle.

Although some of the 13 northern cities may still be more or less impacted by oil shocks than others to a small degree, the comparative results between the two sets of cities should shed light on the importance oil shocks. Specifically, if the exclusion of Atlanta, Detroit, Houston, Los Angeles and San Francisco does not significantly impact the results, then it is unlikely that oil shocks play a major role within the remaining 13 cities. Figure 2 graphs π_{US} and RPV for the

Figure 1: U.S. Inflation (US_INFL, left scale) and Relative Price Variability (RPV_18, right scale). Inflation is Computed as $\pi_{US\,t} = 100\,(\ln CPI_{US\,t} - \ln CPI_{US\,t-1})$. RPV_t is the Standard Deviation of Inflation Rates Across the 18 U.S. Cities at Each Observation.

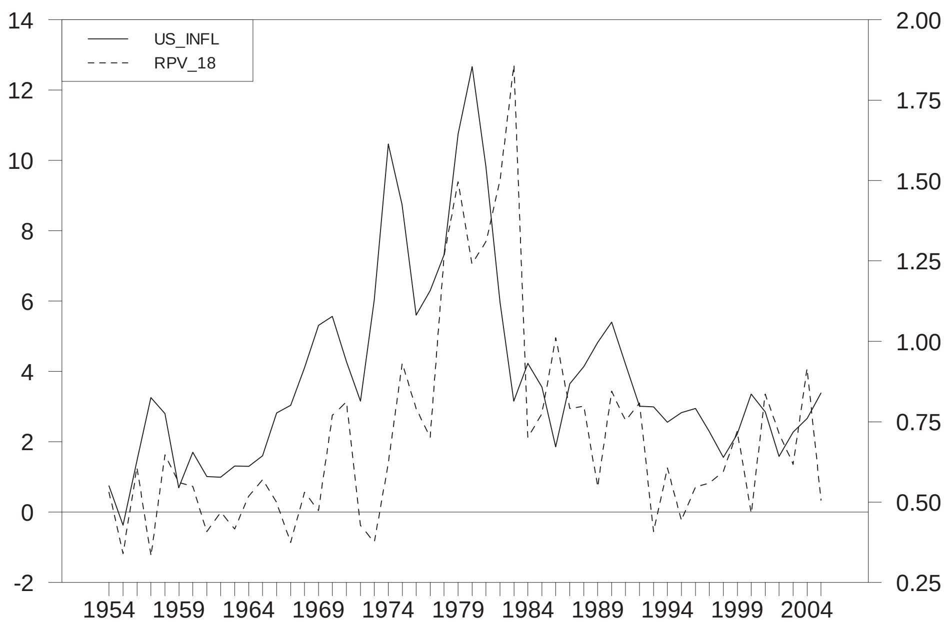
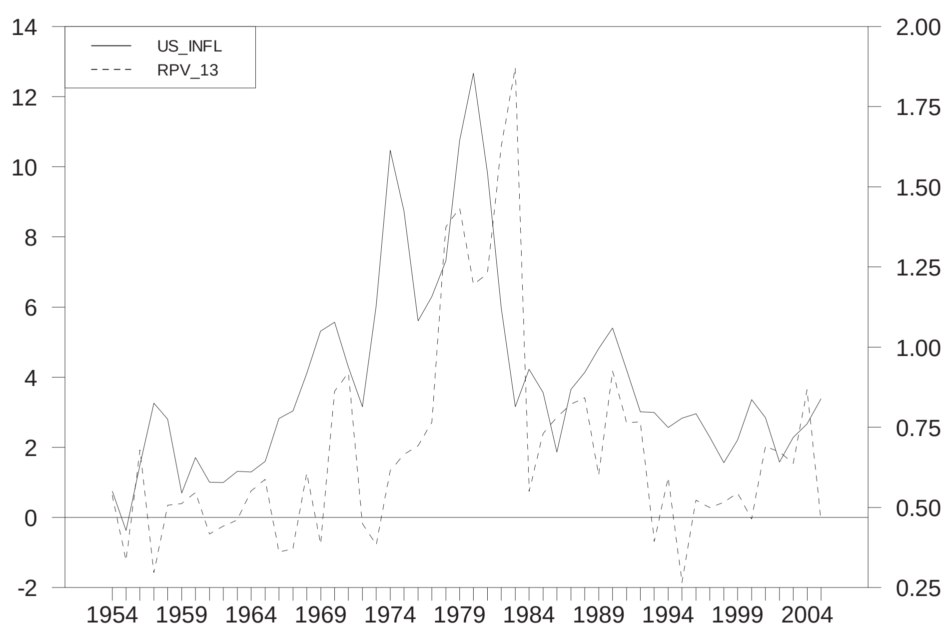


Figure 2: U.S. Inflation (Left Scale) and RPV Across 13 Northern Cities (Right Scale)



13 northern cities over the 1954-2005 period. Comparing Figures 1 and 2, there are few material differences between the two RPV series, except that the 1975 peak in RPV in Figure 1 does not occur in Figure 2, which may or may not be a result of the 1973-1974 oil shock. Otherwise, the 18-city and 13-city RPV patterns are quite similar. It also appears that oil shocks have had a smaller impact on inflation in recent years. For example, average crude oil prices increased from \$23 per barrel in 2001 to \$50 per barrel in 2005 (U.S. Department of Energy), yet Figures 1 and 2 show relatively little impact on U.S. inflation during 2001-2005.

Following Fischer (1981), Table 1 presents regression equations explaining RPV with inflation and unexpected inflation. Regressions 1-1 through 1-6 estimate RPV as a function of π_{US}, $\Delta\pi_{US}$ and $|\Delta\pi_{US}|$. Beginning with all 18 cities and the 1954-1980 period, regression 1-1 shows a positive and significant coefficient on π_{US}, but insignificant coefficients on $\Delta\pi_{US}$ and $|\Delta\pi_{US}|$. The coefficient on π_{US} indicates a positive relationship between inflation and cross-regional inflation variability for the years 1954-1980. Regression 1-2 estimates the same regression with data for the period 1954-1986. In this case, RPV is positively related to inflation at the .10 level and negatively related to $\Delta\pi_{US}$ at the .05 level. The negative relationship with $\Delta\pi_{US}$ appears to be due to the sharp drop in inflation in the early 1980s, while RPV remained high (Figure 1). Thus, regressions 1-1 and 1-2 highlight the exceptional experience of this period.

Including data through 1997, regression 1-3 in Table 1 shows that RPV is positively related to inflation and negatively related to $\Delta\pi_{US}$ at the .05 level and positively related to $|\Delta\pi_{US}|$ at the .10 level. The coefficient estimates on $\Delta\pi_{US}$ and $|\Delta\pi_{US}|$ are roughly equal but of opposite sign and indicate an asymmetric relationship between changes in inflation and RPV. A one per cent change in inflation results in roughly offsetting effects from $\Delta\pi_{US}$ and $|\Delta\pi_{US}|$, but a negative one per cent change in inflation results in a .14 increase (.069 + .071) in RPV. Again, this appears to reflect the early 1980s data on inflation and RPV. Extending the estimation period through 2005, the estimated coefficients (*t*-statistics) for the three respective independent variables are .048 (2.65), -.071 (-3.44) and .062 (1.69). This suggests little impact from the BLS's revision of the CPI in 1998. Nevertheless, the 1954-2005 results are not included in Table 1, given that roughly 61 per cent of total consumer spending was affected by the revision, with the expected affect being to reduce CPI inflation by .2 per centage points per year.

While the early 1980s experience might explain the coefficient estimates in regression 1-3, these results may also be due to the more general lagged relationship between inflation and RPV suggested by Friedman (1977) and observed in Figures 1 and 2. That is, RPV in the current year may be more closely related to inflation in the previous year. Re-estimating the regressions in 1-1 through 1-3 with each explanatory variable lagged one year, the results suggest greater emphasis on lagged inflation compared to changes in inflation. For example, in the case of equation 1-3, explanatory power is roughly the same ($R^2 = .60$), but the respective coefficient estimates (*t*-statistics) on once-lagged π_{US}, $\Delta\pi_{US}$ and $|\Delta\pi_{US}|$ are .080 (4.47), -.045 (-2.09) and .017 (.44). Similar observations are made for regressions 1-1 and 1-2.

Regressions 1-4 through 1-6 use RPV for the 13 northern cities as the dependent variable and estimate the same relationship over the 1954-1980, 1954-1986 and 1954-1997 periods. The results show the same pattern of significance with the exclusion of the five cities, although the level of significance for each explanatory variable is generally lower than in the corresponding regression in 1-1 through 1-3. Similar comparisons as those described above for the 18 cities are made by lagging each of the explanatory variables one year and by including data through 2005. Thus, it appears that oil shocks had only a minor impact on cross-regional inflation variability.

Regressions 2-1 through 2-6 in Table 1 explain RPV with measures of expected and unexpected inflation. The expected inflation rate $E\pi_{US}$ for each year *t* is computed as the one-year-ahead forecast of inflation based on a fourth-order autoregression of π_{US} estimated through year *t-1*. This formulation of expected inflation may better represent the lagged relationship between inflation and RPV observed in Figure 1; that is, given that $E\pi_{US}$ is an extrapolation of past inflation rates. Unexpected inflation in each period is computed as actual inflation π_{US} minus $E\pi_{US}$. Regression 2-1 estimates RPV as a function of $E\pi_{US}$, unexpected inflation and the absolute value of unexpected inflation over the 1954-1980 period. The results indicate a positive and significant coefficient on $E\pi_{US}$, but insignificant coefficients on the other two explanatory variables. The coefficient on $E\pi_{US}$ suggests that anticipated inflation is not neutral with respect to cross-regional RPV.[4]

Regression 2-2 estimates the same regression as 2-1, but with data for 1954-1986. The coefficient on $E\pi_{US}$ is again positive and significant. In this case, however, the coefficient on unexpected inflation of -.062 and the coefficient on the absolute value of unexpected inflation of .078 are both significant at the .05 level. These coefficients suggest an asymmetric relationship between RPV and changes in unanticipated inflation. One per cent positive unanticipated inflation ($\pi_{US} > E\pi_{US}$) results in a .016 (-.062 + .078) per cent increase in RPV, while one per cent negative unanticipated inflation ($\pi_{US} < E\pi_{US}$) results in a .14 (.062 + .078) per cent increase in RPV. Like regression 1-2, regression 2-2 appears to reflect the patterns of π_{US} and RPV during the early 1980s. Regression 2-3 shows the same pattern of significance for the years 1954-1997 and similar results are again obtained using data through 2005.

Again considering the possibility that inflation variability is more closely related to measures of inflation in the previous year, regressions 2-1 through 2-3 were re-estimated with each independent variable lagged one period. Explanatory power increases for each regression, with the coefficients on the two unexpected inflation terms becoming insignificant. For example, for 1954-1997, $R^2 = .66$ and the coefficient estimates (*t*-statistics) on the respective three independent variables are .120 (8.05), .022 (1.09) and -.007 (-.22). Thus, expected inflation in the previous year appears to provide a slightly better explanation of current-year inflation variability than the combination of current year expected and unexpected inflation.

Regressions 2-4 through 2-6 estimate the same relationships as regressions 2-1 through 2-3, but using RPV for the 13 northern cities. For each of the 1954-1980, 1954-1986 and 1954-1997 periods, the patterns of significance are essentially unchanged with the exclusion of the five cities. Using once-lagged explanatory variables, the 13-city results are again similar to the 18-city results, and likewise using data through 2005. Thus, oil shocks do not appear to be an important factor in the relationship between the level of inflation and cross-regional inflation variability.

In all, the regression results in Table 1 indicate that cross-regional inflation variability is positively related to both inflation and expected inflation and asymmetrically related to unanticipated inflation. However, re-estimating the regressions using once-lagged independent variables suggests that inflation variability may be better explained by past measures of inflation. Energy shocks do not appear to be a major factor and the results are not materially affected by extending the estimation period through 2005. Notably, the positive relationships found between cross-regional RPV and both inflation and expected inflation parallel previous findings involving inflation variability across component measures of inflation. Thus, high inflation is associated with an added dimension of uncertainty; that is, inflation uncertainty across different cities as well as different industries.

CROSS-REGIONAL PRICE INTEGRATION

To evaluate the degree of cross-regional price integration *over time*, CPI data from the BLS were obtained for U.S., Northeast, Midwest, South and West all urban consumers for the period of 1978-1997.[5] Data prior to 1978 were excluded due to the infrequent reporting of the regional series. Regional data for 1978-1986 are available every other month beginning in February 1978. Regional CPI data for 1987-1997 are available monthly. For consistency, a bimonthly frequency is used for all 20 years, resulting in 120 observations. The year 1997 is again chosen as the final year due to the BLS's 1998 CPI revision. The national year-over-year CPI inflation rate averaged 6.56 per cent during the ten-year period 1978-1987 and roughly half that rate at 3.52 per cent during the ten years 1988-1997.

In applying Johansen's (1988) technique, it is first verified that each of the seasonally-adjusted CPI series in natural logs is I(1); see Dickey and Fuller (1981).[6] Second, the optimal system lag length (p) for each system of four equations is determined using a likelihood ratio procedure based on a Chi-squared statistic for the unconstrained vector autoregression model in levels. This procedure involves successively testing shorter lag lengths as restrictions against longer lag lengths where the lag order is set uniformly across the four equations. For both the 1978-1987 and 1988-1997 periods, $p = 3$. Finally, because each of the ten-year time intervals contains only 60 observations, the Johansen (1988) test procedure is adjusted for small samples.[7] Formally, a vector x_t of n time series, each I(1), is said to be cointegrated if there exists an $n \times r$ vector α such that $z_t = \alpha x_t$ is stationary, i.e., I(0). With $r \leq n-1$ cointegrating vectors, there are $n - r$ remaining unit root combinations, which are called common trends.

Table 2 shows the eigenvectors (cointegrating vectors) for the two ten-year periods, along with maximal eigenvalue (λ_{max}) and trace test statistics. The null hypotheses of $r = 0$, $r \leq 1$ and $r \leq 2$ cointegrating vectors are tested successively. Beginning with 1978-1987, both the λ_{max} and trace tests indicate only one cointegrating vector.[8] This implies three common trends among the four regional CPI series during 1978-1987. In contrast, for the 1988-1997 period, both the λmax and trace tests indicate $r = 3$, implying a single common trend among the four regional CPI series. Thus, there is noticeably more integration (less dispersion) among the four regional CPIs during the years 1988-1997 than during 1978-1987.[9]

Another observation from Table 2 is that the components of each of the three cointegrating vectors for the 1988-1997 period sum to roughly zero. By substitution, this leads to the general equilibrium condition that, except for possible differences in means, $CPI_{Northeast} = CPI_{Midwest} = CPI_{South} = CPI_{West}$.[10] This implies a stable, parallel pattern among the four regional CPIs during the 1988-1997 period, along a single common trend. The equilibrium condition also provides further evidence that, for the lower inflation period of 1988-1997, there is less dispersion across regional CPIs.

Table 1
Regressions Explaining RPV with Inflation and Unexpected Inflation[a]

		Independent Variables						
Regr.	*Period*	π_{US}	$\Delta\pi_{US}$	$\lvert\Delta\pi_{US}\rvert$	*Constant*	*Rho*	R^2	*DW*
				18 U.S. Cities				
1-1	1954-1980	.067	-.036	-.005	.372	.40	.64	1.79
		(3.58*)	(-1.42)	(-.13)	(3.47*)			
1-2	1954-1986	.043	-.067	.067	.470	.44	.60	1.93
		(1.75⁺)	(-2.55*)	(1.48)	(3.33*)			
1-3	1954-1997	.047	-.069	.071	.431	.39	.60	2.00
		(2.36*)	(-3.13*)	(1.87⁺)	(4.28*)			
				13 Northern U.S. Cities				
1-4	1954-1980	.055	-.015	-.015	.400	.38	.53	1.77
		(2.62*)	(-.53)	(-.32)	(3.39*)			
1-5	1954-1986	.036	-.058	.072	.438	.40	.52	1.87
		(1.39)	(-2.04*)	(1.44)	(3.01*)			
1-6	1954-1997	.042	-.060	.076	.428	.37	.51	1.94
		(1.85⁺)	(-2.38*)	(1.74⁺)	(3.81*)			
		$E\pi_{US}$	Unexpected inflation	Absolute value of unexpected inflation	Constant			
				18 U.S. Cities				
2-1	1954-1980	.095	.047	-.036	.326	...	.65	1.66
		(4.09*)	(0.97)	(-.63)	(3.62*)			
2-2	1954-1986	.100	-.062	.078	.300	...	.67	1.99
		(5.67*)	(-2.44*)	(2.04*)	(3.75*)			
2-3	1954-1997	.099	-.054	.082	.272	...	.65	1.87
		(6.29*)	(-2.39*)	(2.47*)	(4.11*)			
				13 Northern U.S. Cities				
2-4	1954-1980	.080	.044	-.030	.335	.25	.57	1.57
		(3.06*)	(.84)	(-.50)	(3.15*)			
2-5	1954-1986	.092	-.064	.082	.277	...	.61	1.70
		(4.82*)	(-2.30*)	(1.98⁺)	(3.20*)			
2-6	1954-1997	.095	-.058	.090	.258	...	.59	1.60
		(5.37*)	(-2.28*)	(2.39*)	(3.46*)			

[a]The dependent variable for each regression is RPV, calculated as the standard deviation of inflation rates across either 18 or 13 U.S. cities at each yearly observation. Inflation $\pi_{US} = 100\ (\ln CPI_{US\ t} - \ln CPI_{US\ t-1})$. The expected inflation rate $E\pi_{US}$ in each period *t* is computed by a one-year-ahead forecast based on a fourth-order autoregression of $\pi_{US}(t)$, estimated through period *t-1*. Unexpected inflation is computed as $\pi_{US}(t) - E\pi_{US}(t)$. The Hildreth-Lu procedure is used to correct for serially correlated errors.

*Indicates significance at the .05 level, ⁺ at the .10 level.

Table 2
Cointegration Test Results[a]

CPI:	*1978-1987 Eigenvectors*				*1988-1997*[b] *Eigenvectors*			
Northeast	–12.85	5.74	14.18	3.83	–5.67	13.95	–1.63	–2.31
Midwest	8.63	17.17	17.59	5.73	–7.58	–2.74	4.60	1.37
South	.81	–29.46	–27.69	–12.01	9.00	1.85	–2.13	1.42
West	3.35	6.96	–4.00	1.53	4.04	–13.12	–1.42	.33
$\hat{\lambda}_{max}$	35.09*	15.43	7.38	2.46	27.90*	20.47^{+}	13.24^{+}	4.59
trace	60.37*	25.27	9.84	2.46	66.19*	38.30*	17.83^{+}	4.59

[a]Cointegration results are reported for the system of four regional CPIs (in natural logs) over the 1978-1987 and 1988-1997 periods using Johansen's (1988) test procedure adjusted for small samples. Cointegrating vectors (eigenvectors) are shown along with maximal eigenvalue and trace test statistics. *Indicates significance at the .05 level, $^{+}$ at the .10 level; for critical values, see Osterwald-Lenum (1992), Table 1.1*.
[b]1997 is chosen as the final year due to the BLS's revision of the CPI in 1998. However, cointegration results estimated for 1988-2005 again suggest that the four regional CPIs are fully integrated ($r = 3$), but with slightly lower confidence; the maximal eigenvalues statistics are (48.54 17.73 11.55 5.16) and the trace statistics are (82.98 34.44 16.71 5.16).

CONCLUSIONS

Previous studies based on component measures of inflation have shown a positive relationship between inflation and inflation variability. Greater price dispersion associated with higher inflation has been demonstrated across component inflation rates at each point in time and across component price indexes over time. This study shows that higher inflation can also be associated with greater price dispersion across cities and geographic regions.

Regression analysis shows that both higher inflation and inflation expectations are associated with increased cross-regional inflation variability, based on yearly CPI data for 18 U.S. cities over the 1954-1986 and 1954-97 periods. Regression results also show an asymmetric relationship between RPV and unanticipated inflation, which appears to be due to the experience of the early 1980s. However, further analysis suggests that inflation variability may be better explained using lagged inflation and inflation expectations, as implied by Friedman (1977) and observed in the data on U.S. inflation and RPV. Similar results are obtained after excluding five cities that may be more or less impacted by energy shocks than the remaining 13 northern cities. Finally, cointegration analysis shows greater cross-regional price dispersion over time during the higher inflation period of 1978-1987 than during 1988-1997. Extending the analyses through the post-CPI revision period of 1998-2005 does not materially affect the results. These findings indicate that high inflation is associated with greater uncertainty, and that this relationship cannot be explained by either energy shocks or monetary factors.

ACKNOWLEDGMENT

This research was supported by the research grants program of the Babcock Graduate School of Management, Wake Forest University.

NOTES

1. Using Johansen's (1988) test procedure, for 1978-1987, both the λ_{max} and trace tests indicated three cointegrating vectors, implying seven common price trends among the ten component series. For the lower inflationary period of 1988-1997, the λ_{max} test indicated five cointegrating vectors, while the trace test indicated seven cointegrating vectors, indicating a maximum of five common trends.
2. Debelle and Lamont also provide a detailed account of the extensive work done in this area.
3. This same lagged relationship might be expected in the inflation and component RPV data. This does not appear to be the case, however, based on Debelle and Lamont's (1997, p. 134) chart, which shows the same π_{US} series together with RPV defined as the standard deviation of inflation rates across 14 component CPIs. Otherwise, the data for 1954-1986 in Figure 1 are similar in many respects to the data in Debelle and Lamont's graph.
4. As pointed out by an anonymous referee, different cities may have differing expectations of inflation. Accounting for the differing expectations may be a topic for further research.
5. Construction of the regional CPIs is described in U.S. Department of Labor (1997).
6. Prior to testing for the order of integration, each of the four regional CPIs was seasonally adjusted based on multiplicative seasonality.
7. Reimers (1991) finds that, in small samples, the Johansen procedure over-rejects when the null is true and recommends using $(T - np)\log(1 - \lambda_i)$ instead of $T\log(1 - \lambda_i)$ in calculating the λ_{max} and trace test statistics, where *np* takes into account the number of estimated parameters, *n* being the number of variables and *p* the number of lags; see Banerjee, *et al.* (1993, p. 285-86). This small-sample correction is used in computing the Johansen cointegration test statistics.
8. The λ_{max} test is usually preferred to the trace test in determining the number of cointegrating vectors. Johansen and Juselius (1989, p. 19) explain that the power of the trace test is expected to be low, since it does not use the information that the last $n - r$ eigenvalues do not differ significantly from zero. They conclude that, "one would expect the maximum eigenvalue test to produce more clear cut results." Enders (1995, p. 393) comes to a similar conclusion.
9. As with Table 1, the results through 2005 are excluded from Table 2, given that the BLS's 1998 revision of the CPI affected 61 per cent of consumer spending. However, the cointegration results are not materially changed by extending the second estimation period through 2005; see footnote to Table 2 for details.
10. Hypothesis tests show that, for the 1988-1997 period, the $CPI_{Northeast}$ mean is significantly greater than the means for the other three regions. The CPI_{West} mean is, in turn, significantly greater than those for the Midwest and South. For the 1977-1987 period, there are no significant differences in the means of the four regional CPIs, which is not surprising, given that each CPI series has a base of 1982-1984 = 100.

REFERENCES

Banerjee, A., Dolado, J., Galbraith, J. W., and Hendry, D. F. (1993), *Co-integration, Error Correction, and the Econometric Analysis of Non-stationary Data*, New York: Oxford University Press.

Bomberger, W. A., and Makinen, G. E. (1993), "Inflation and Relative Price Variability: Parks' Study Reexamined", *Journal of Money, Credit and Banking,* 25: 854-61.

Debelle, G., and L., Owen (1997), "Relative Price Variability and Inflation: Evidence from U.S. Cities", *Journal of Political Economy,* 105: 132-152.

Dickey, D. A., and Fuller, W. A. (1981), "Likelihood Ratio Statistics for Autoregressive Time Series with a Unit Root", *Econometrica,* 49: 1057-1072.

Enders, W., (1995), *Applied Econometric Time Series*, New York: John Wiley & Sons.

Fischer, S. (1981), "Relative Shocks, Relative Price Variability, and Inflation", *Brookings Papers on Economic Activity*, no. 2: 381-431.

Friedman, M. (1977), "Nobel Lecture: Inflation and Unemployment", *Journal of Political Economy,* 85: 451-472.

Johansen, S. (1988), "Statistical Analysis of Cointegration Vectors", *Journal of Economic Dynamics and Control,* 12: 231-254.

Johansen, S., and Juselius, K. (1989), "The Full Information Maximum Likelihood Procedure for Inference on Cointegration-with Applications", Statistics Reprint, University of Copenhagen.

Osterwald-Lenum, M. (1992), "A Note with Quantiles of the Asymptotic Distribution of the Maximum Likelihood Cointegration Rank Test Statistics", *Oxford Bulletin of Economics and Statistics,* 54:, 461-472.

Reimers, H. E. (1991), "Comparisons of Tests for Multivariate Co-integration", Discussion Paper No. 58, Christian-Albrechts University, Kiel.

Shoesmith, G. L. (2000), "A Further Interpretation of Friedman's Hypothesis: The Cointegration of Component CPI Indexes", *Economics Letters,* 67: 49-52.

U.S. Department of Labor, Bureau of Labor Statistics (1997), "The Consumer Price Index", In *BLS Handbook of Methods*, Bulletin 2490: 167-202.