Cross-Sectional and Longitudinal Inflation Asymmetries

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Abstract

This paper re-examines evidence relating mean inflation to cross-sectional inflation asymmetry, and investigates longitudinal asymmetry in disaggregated price series. The asymmetry test used possesses two important characteristics: it has high power, and it is not dominated by outliers. In contrast to Bryan and Cecchetti (1996), the results here suggest that there does exist significant positive correlation between mean inflation and cross-sectional inflation asymmetry. However, the explanatory power of median inflation is small. Longitudinal inflation asymmetry is evident in almost all the price series investigated here, regardless of frequency. This finding is intriguing, as neither money nor output growth is asymmetric.

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1. Introduction

When examining inflation across sectors, two interesting patterns show up: first, the aggregate rate of inflation is positively associated with variability of relative price changes; and second, the aggregate rate of inflation is positively associated with positive skewness in the cross-sectional distribution of price changes. Economists have long noted these positive correlations (see, e.g., Vining and Elwertowski (1976), and Domberger (1987)); indeed, the cross-sectional distribution of price changes is generally viewed as an important piece of empirical evidence regarding the sources, costs and consequences of inflation.[1] Most work has focused on the implications of the first pattern: see, e.g., Parks (1978), Cukierman (1979), Hercowitz (1981), and Fischer (1982); relatively few studies have explored implications of the second pattern (but see Marquez and Vining (1984)), despite the fact that this relationship is apparently stronger than the former. However, several recent papers have given renewed attention to this relationship and its implications. Ball and Mankiw (1995) have argued that the second pattern is a novel empirical prediction of, and thus lends support to, menu-cost models of price stickiness. In contrast, Balke and Wynne (1996, 1988) assert that no such conclusion is warranted; they proffer an alternative theory, building a multisectoral model with completely flexible prices, which can account for this correlation.

Yet is this empirical regularity a fact at all? Bryan and Cecchetti (1996) show that the observed positive correlation in the data could result entirely from a small sample property which plagues moments: a single outlier will tend to significantly shift both the sample mean and skewness in the same direction. Based upon their extensive Monte-Carlo work, they argue that "the entirety of the observed correlation can be explained by this bias." Their paper concludes:

[1] In particular, researchers generally attempt to use this evidence to support or to discriminate between alternative theories of price flexibility.

"We view these results as suggestive and worthy of further study." This paper's first major task is to undertake such further study, using empirical methods that are robust to this damaging criticism, in an attempt to clarify this issue.

Another less well-known but equally interesting feature of inflation data is that aggregate price indices display asymmetry in the distribution of first-differences. In fact, recent empirical work by Verbrugge (1998) indicates that longitudinal asymmetry in aggregate price index changes is all but ubiquitous in cross-country data. While two prior studies (Verbrugge (1997a), Tinsley and Krieger (1997)) have investigated the extent to which aggregate output asymmetries are reproduced in industry disaggregations, the extent to which extent aggregate *price* asymmetries are reproduced in more disaggregate price series has not yet been investigated.[2] If asymmetric motion is only apparent in aggregate price indices, it may simply be a result of aggregation, perhaps due to cyclical shifts in nominal variables. Conversely, finding significant asymmetries in more disaggregate price series may yield important clues about the nature of price adjustments at the micro level: for example, it may provide evidence for asymmetric price responses on the part of firms to positive and negative disturbances. On the other hand, ubiquitous price growth asymmetry may simply indicate asymmetry in the common and major long run driving force of such price changes: money supply growth.

The second task of this paper is to fill the aforementioned gap in the literature, and to investigate whether asymmetric money growth is in fact a candidate explanation. The methodology used is straightforward and transparent. As the measure of 'central tendency' of cross-sectional price changes, I utilize the median; as the measure of its asymmetry, I utilize the

[2] Tinsley and Krieger (1997), using *parametric* methods, find evidence for price asymmetries in several disaggregate price series. However, it is preferable to use nonparametric methods for initial investigations of asymmetry, as this avoids pre-judging the data characteristics (and will aid in the selection of the appropriate

nonparametric triples test of Randles et al. (1980) introduced in Verbrugge (1997b). Both measures are robust to outliers, and thus avoid the damaging criticism of Bryan and Cecchetti (1996). In addition, the triples test has excellent power properties, and is widely regarded as the asymmetry test of choice in the statistics literature. Using consumer and producer price data at monthly, quarterly and annual frequencies, I provide new evidence that the well-known observed correlation between the cross-sectional mean and asymmetry is indeed both positive and statistically significant (particularly at the monthly frequency). However, the explanatory power of median inflation is rather small. I further show that the longitudinal price change asymmetry which is so evident in aggregate price indices is also evident in almost all the disaggregate price series investigated here. This is rather intriguing, since I find that money growth is not asymmetric, suggesting that the source of this asymmetry must be located elsewhere. Adding to this puzzle is the following: other studies (Verbrugge (1997a), Krieger and Tinsley (1997)) have failed to locate associated asymmetry in many disaggregate output series.

The remainder of the paper is divided into four sections. Section 2 describes the methodology, and briefly reviews the triples test. Section 3 provides empirical results relating the cross-sectional median inflation to cross-sectional growth rate asymmetry. Section 4 provides empirical results on longitudinal asymmetry in disaggregate price series and measures of money. Section 5 concludes.

2. Methodology

I study two data sets. The first is composed of 36 components of the Consumer Price Index, available monthly from January 1967 to April 1996. The second is composed of 27 components of the Producer Price Index, monthly from January 1947 to December 1995. In both

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nonlinear time series model). Almost no nonparametric work has been conducted along these lines prior to this paper.

cases, there is a balanced panel over the entire sample period. Inflation rates at horizon *k* are defined in the obvious way, using log differencing of objects which are *k* months apart.

As noted above, the measure of central tendency used is the cross-sectional median price growth rate. As the measure of asymmetry, I use the nonparametric triples test of Randles et al. (1980). The intuitive basis of this test is the following: Take the sample of size *N* and look at all possible triples of members of the sample (i.e., at $\binom{N}{3}$ combinations). If 'most' of these triplets are right-skewed, infer that this is true of the underlying distribution. More formally, a triple of observations $\left(X_i, X_j, X_k\right)$ is a *right triple* (is skewed to the right) if the middle observation is closer to the smaller observation than it is to the larger. An example of a right triple:

—XX———X—

Let

$$f^*\left(X_i, X_j, X_k\right) := \tfrac{1}{3}\left[sign\left(X_i + X_j - 2X_k\right) + sign\left(X_i + X_k - 2X_j\right) + sign\left(X_j + X_k - 2X_i\right)\right] \quad (2.1)$$

The range of this function is $\left\{-\tfrac{1}{3}, 0, \tfrac{1}{3}\right\}$; a right triple is a triple which maps into1/3, and a left triple is defined analogously. The triples test statistic is given by

$$\frac{\hat{\eta} - \eta}{\sqrt{\hat{s}_{\hat{\eta}}^{2} / N}} \quad (2.2)$$

where

$$\hat{\eta} := \frac{1}{\binom{N}{3}} \sum_{i<j<k} f^*\left(X_i, X_j, X_k\right) \quad (2.3)$$

and

$$\hat{s}_{\hat{\eta}}^{2} / N := \frac{1}{\binom{N}{3}} \sum_{c=1}^{3} \binom{3}{c} \binom{N-3}{3-c} \hat{V}_c \quad (2.4)$$

where

$$\hat{V}_1 := \tfrac{1}{N}\sum_{i=1}^{N}\left(\hat{f}_1^*(X_i)-\hat{h}\right)^2 \text{ with } \hat{f}_1^*(X_i) := \frac{1}{\binom{N-1}{2}}\sum_{\substack{j<k \\ i\neq j, i\neq k}}\sum f^*\left(X_i, X_j, X_k\right) \quad (2.5)$$

$$\hat{V}_2 := \frac{1}{\binom{N}{2}}\sum_{j<k}\sum[\hat{f}_2^*\left(X_j, X_k\right)-\hat{h}]^2 \text{ with } \hat{f}_2^*(X_i, X_k) := \tfrac{1}{N-2}\sum_{\substack{i=1 \\ i\neq j\neq k}}\sum f^*\left(X_i, X_j, X_k\right) \quad (2.6)$$

and

$$\hat{V}_3 := \tfrac{1}{9}-\hat{h}^2 \quad (2.7)$$

$h = 0$ is the null hypothesis. The asymptotic distribution of the T-statistic is standard normal, so conventional critical values may be used.[3]

In investigating cross-sectional characteristics, for each data set, and for each frequency, I compute a time series of medians (one for each date) and another of triples statistics. In order to test for significant correlation, I regress the median on a constant, on the triples statistics, and on lags of the median. A positive coefficient with a large t-statistic will be interpreted as evidence for a significant and positive correlation between median inflation and asymmetry.

I also document growth rate asymmetry for each individual series, at the monthly, quarterly, and annual frequencies. As has been noted in previous work (Verbrugge, 1997a), longitudinal asymmetry in high-frequency data tends to be mitigated somewhat by temporal aggregation.

3. Empirical results: cross-sectional median inflation and growth rate asymmetry

Table 1A reports the regression results for CPI data at monthly, quarterly and annual frequencies; Table 1B does the same for PPI data. In the regressions, the left hand side variable

[3] While the test does not correct for serial correlation, a problem when one is investigating *longitudinal* asymmetry, Verbrugge (1997a,b, 1998) provide evidence that, for relatively lengthy series such as these, inference based upon conventional critical values will rarely be misleading.

is the median CPI (or PPI inflation) rate; the right hand side variables are variables describing the distribution of relative price changes. All regressions include at least nine months of lagged inflation to capture persistence.

The regressions confirm the positive relationship between asymmetry and inflation; the triples statistic is always significant. However, it contributes relatively little to the $\overline{R}^2$.[4] Thus, inflation levels and cross-sectional asymmetry are significantly, but not strongly, related. In contrast to the finding of Ball and Mankiw (1995), only a small fraction of innovations in inflation is explained by asymmetry, lending support to the criticism of Bryan and Cecchetti (1996).

4. Empirical results: longitudinal growth rate asymmetry in prices and money

Neftçi (1984) and DeLong and Summers (1986) revived interest in business cycle asymmetries, and subsequent work by Sichel (1993), McQueen and Thorley (1993), Rothman (1994), Ramsey and Rothman (1996), Barnhart and Dwyer (1996), Hinich and Rothman (1997), and Verbrugge (1997a,b, 1998) (among others) has highlighted the presence of various forms of asymmetry in economic time series (primarily in output and unemployment data). These authors have argued that the pattern of asymmetries discovered yields valuable clues about underlying economic mechanisms, is an invaluable aid in the selection of appropriate time series models, and that these asymmetries have potentially significant policy implications. Surprisingly, relatively little work has been done investigating longitudinal asymmetry in inflation rates. A notable exception is Verbrugge (1998), which finds that positive growth rate asymmetry in aggregate price indices is nearly ubiquitous across countries. One unresolved issue is the extent to which this asymmetry occurs in more disaggregated components of aggregate price indices. If

[4] Note that the contribution to $\overline{R}^2$ is highest at the annual frequency.

asymmetric motion is only apparent in aggregate price indices, it may simply be a result of aggregation, perhaps due to cyclical shifts in nominal variables. Conversely, finding significant asymmetries in more disaggregate price series may yield important clues about the nature of price adjustments at the micro level. Further, it is of interest to discover whether asymmetry is confined to a small number of components (or whether it is more prevalent), and to investigate the extent to which asymmetry survives temporal aggregation. If significant asymmetry is discovered in a large number of disaggregate price indices, the most natural conjecture would be that this is caused by growth in monetary aggregates.

The present paper is a step towards a systematic investigation of growth rate asymmetry in disaggregate price series, and towards ruling out the possibility that this is caused by asymmetry in money growth. Table 2 reports triples statistics of growth rates for the 29 PPI components and the 36 CPI components at the monthly, quarterly and annual frequencies. Positive growth rate asymmetry prevails in the vast majority of these components, though significance levels tend to fall with higher levels of temporal aggregation. Evidently asymmetry in aggregate price indices merely reflects asymmetry in the underlying components.

Table 3 reports triples statistics of growth rates for several monetary aggregates at the monthly, quarterly and annual frequencies. I use both simple monetary aggregates, and optimal monetary services aggregates (i.e., Divisia indices--see Barnett (1987)), with series running from 1967-1996. None of these aggregates possesses significant positive growth rate asymmetry, at any frequency; in fact, broad money is arguably *negatively* asymmetric. Evidently the positive growth asymmetry in price indices is not being caused by similar asymmetry in money growth. Interestingly, more rapid inflation tends to be associated with higher asymmetry: unreported regressions indicate a positive and marginally significant relationship between average inflation over the period for each series and its degree of asymmetry.[5] To add to this puzzle, Verbrugge (1997a) and Krieger and Tinsley (1997) fail to find growth rate asymmetry in many of the disaggregate *output* series they investigate.

5. Conclusion

Is higher inflation positively and significantly correlated with asymmetry in price changes across sectors? The evidence presented here suggests that, in accord with popular wisdom, it is. However, the explanatory power of median inflation is rather low, possibly suggesting that there is still much to be learned about cross-sectional price change asymmetry.

This paper also highlights an intriguing and potentially important empirical regularity: positive growth rate asymmetry is nearly ubiquitous in price data (while it is apparently absent in both money and many output series). There are three immediate implications. First, this asymmetry provides another dimension along which theories of price changes may be judged. Second, knowing this asymmetry exists aids in the selection of appropriate nonlinear time series models to capture the dynamics of inflation (see Granger, King, and White (1995) and Teräsvirta (1996)). Finally, it leads to interesting questions: what causes this (nearly ubiquitous) longitudinal asymmetry? Why is it correlated with average inflation? Why is it not found in money, and frequently not found in the associated output series? While Krieger and Tinsley (1997) is a preliminary step towards answering some of these questions, much more work clearly needs to be done. Borrowing a phrase from Bryan and Cecchetti, I "view these results as suggestive and worthy of further investigation."

[5] An interesting aside: eyeballing of the data indicates that the inflation paths of different industries vary to a remarkable degree, despite the fact that they share growth rate asymmetry.

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Table 1A

CPI Data

	Annual		Quarterly		Monthly	
	(1)	(2)	(1)	(2)	(1)	(2)
Constant	0.011 (1.61)	0.010 (1.71)	0.001 (2.13)	0.001 (2.28)	0.0003 (2.13)	0.0003 (2.78)
Inflation (-1)	0.76 (5.82)	0.65 (5.74)	0.84 (8.84)	0.80 (8.61)	0.49 (9.00)	0.45 (8.59)
Inflation (-2)			0.08 (0.69)	0.09 (0.78)	0.27 (4.56)	0.28 (4.76)
Inflation (-3)			-0.04 (0.37)	-0.04 (0.38)	0.21 (3.34)	0.20 (3.32)
Inflation (-4)					-0.11 (1.70)	-0.11 (1.75)
Inflation (-5)					-0.05 (0.75)	-0.03 (0.57)
Inflation (-6)					0.10 (1.53)	0.11 (1.87)
Inflation (-7)					0.09 (1.53)	0.08 (1.30)
Inflation (-8)					-0.03 (0.44)	-0.03 (0.60)
Inflation (-9)					-0.04 (0.83)	-0.04 (0.72)
Triples Statistic		0.22 (3.52)		0.02 (2.60)		0.01 (5.13)
$\overline{R}^2$	.55	.69	.77	.78	.78	.79

Note: values in parentheses are (absolute values of) the associated *t*-statistics.

Table 1B

PPI Data

	Annual		Quarterly		Monthly	
	(1)	(2)	(1)	(2)	(1)	(2)
Constant	0.011 (1.43)	0.002 (0.26)	0.001 (2.29)	0.001 (1.96)	0.0003 (2.45)	0.0003 (2.09)
Inflation (-1)	0.76 (5.83)	0.93 (8.17)	1.13 (12.08)	1.10 (11.88)	0.51 (9.62)	0.48 (9.64)
Inflation (-2)			-0.43 (3.13)	-0.38 (2.87)	0.40 (6.86)	0.40 (7.32)
Inflation (-3)			0.13 (1.44)	0.14 (1.49)	0.28 (4.55)	0.27 (4.68)
Inflation (-4)					-0.36 (5.67)	-0.34 (5.63)
Inflation (-5)					0.09 (1.28)	0.09 (1.47)
Inflation (-6)					0.05 (0.85)	0.06 (1.05)
Inflation (-7)					0.01 (0.15)	0.03 (0.48)
Inflation (-8)					-0.26 (4.55)	-0.25 (4.56)
Inflation (-9)					0.20 (3.69)	0.17 (3.32)
Triples Statistic		0.23 (3.87)		0.02 (2.55)		0.01 (6.89)
$\overline{R}^2$	.55	.71	.75	.76	.78	.81

Note: values in parentheses are (absolute values of) the associated *t*-statistics.

Table 2

Longitudinal Asymmetry

	CPI Data				PPI Data		
Component	Monthly	Quarterly	Annual	Component	Monthly	Quarterly	Annual
1	+.0420 (4.20)	+.0693 (3.86)	+.0795 (2.06)	1	+.0126 (1.26)	+.0031 (0.16)	+.0454 (1.04)
2	+.0378 (3.49)	+.0469 (2.42)	+.0825 (2.30)	2	+.0437 (4.25)	+.0466 (2.54)	+.0982 (2.67)
3	+.0537 (5.48)	+.0651 (3.69)	+.0958 (2.86)	3	+.0239 (2.30)	+.0269 (1.55)	+.0839 (2.79)
4	-.0032 (0.33)	+.0245 (1.50)	+.0363 (1.02)	4	+.0192 (1.75)	+.0324 (1.81)	+.0511 (1.38)
5	+.0915 (8.35)	+.1167 (6.62)	+.1518 (5.89)	5	+.0240 (2.32)	+.0319 (1.92)	+.0378 (1.00)
6	+.0815 (11.54)	+.0797 (8.93)	+.0653 (2.53)	6	+.0232 (1.57)	+.0201 (0.75)	+.0117 (0.21)
7	+.0314 (3.08)	+.0812 (5.23)	+.0837 (3.41)	7	+.0588 (5.34)	+.0839 (4.90)	+.0962 (3.07)
8	+.0779 (8.05)	+.0935 (5.78)	+.1169 (4.88)	8	+.0208 (1.89)	+.0150 (0.81)	+.0292 (0.68)
9	+.0245 (1.91)	+.0323 (1.71)	+.0887 (2.18)	9	+.0494 (4.29)	+.0659 (3.77)	+.0983 (2.70)
10	+.0309 (3.60)	+.0766 (6.33)	+.0755 (2.35)	10	+.0184 (1.42)	+.0281 (1.33)	+.0573 (1.34)
11	+.0493 (4.47)	+.0706 (4.77)	+.0677 (2.03)	11	+.0531 (5.07)	+.0703 (3.95)	+.1020 (4.07)
12	+.0107 (1.18)	+.0568 (3.58)	+.1162 (4.38)	12	+.0247 (2.37)	+.0407 (2.25)	+.0733 (2.11)
13	+.0433 (4.10)	+.0815 (4.58)	+.1228 (4.26)	13	+.0165 (1.42)	+.0326 (1.70)	+.0715 (1.45)
14	+.0782 (7.96)	+.0855 (5.33)	+.0792 (1.95)	14	+.0727 (7.51)	+.0994 (6.25)	+.1441 (5.37)
15	-.0136 (1.41)	+.0104 (0.58)	+.0133 (0.37)	15	+.0713 (7.77)	+.0959 (6.74)	+.1279 (4.40)
16	-.0107 (0.96)	-.0216 (1.46)	-.0169 (0.46)	16	+.0168 (1.73)	+.0135 (0.75)	+.0223 (0.61)
17	+.0097 (0.95)	+.0032 (0.15)	+.0859 (1.94)	17	+.0671 (6.67)	+.0827 (4.40)	+.1069 (2.99)
18	+0142 (1.31)	+.0504 (3.05)	+.0480 (1.13)	18	+.0392 (3.89)	+.0493 (2.67)	+.0411 (0.95)
19	-.0195 (2.01)	+.0053 (0.36)	-.0155 (0.47)	19	+.0691 (7.25)	+.0661 (4.31)	+.0923 (3.03)
20	+.0523 (6.66)	+.0657 (5.13)	+.0768 (3.28)	20	+.0794 (7.33)	+.1012 (7.43)	+.1341 (5.09)
21	+.0299 (2.53)	+.0476 (2.47)	+.0564 (1.63)	21	+.0998 (12.46)	+.1234 (11.10)	+.1516 (6.62)
22	+.0099 (0.99)	+.0161 (0.97)	+.0701 (2.28)	22	+.0817 (8.53)	+.1003 (6.09)	+.1321 (4.25)
23	+.0354 (2.99)	+.0384 (1.87)	+.0825 (1.65)	23	+.1052 (14.12)	+.1189 (10.23)	+.1294 (5.94)
24	+.0547 (6.15)	+.0842 (5.30)	+.0799 (2.34)	24	+.0774 (9.03)	+.1118 (8.15)	+.1281 (5.42)
25	+.0257 (2.72)	+.0578 (3.38)	+.0650 (1.71)	25	+.0774 (8.90)	+.0968 (6.94)	+.1102 (4.04)
26	+.0599 (6.61)	+.0571 (3.36)	+.0159 (0.38)	26	+.0723 (7.80)	+.1081 (7.51)	+.1367 (5.95)
27	+.0466 (3.99)	+.0620 (3.28)	+.1137 (3.49)	27	+.0747 (7.60)	+.0958 (8.05)	+.1066 (4.45)
28	-.0113 (1.28)	-.0336 (2.23)	-.0381 (1.25)	28	+.0434 (3.73)	+.0738 (4.71)	+.1190 (4.61)
29	+.0233 (2.40)	+.0127 (0.82)	+.0040 (0.13)	29	+.0416 (3.44)	+.0581 (2.71)	+.1005 (2.32)
30	+.0268 (3.01)	+.0707 (4.86)	+.0982 (3.24)				
31	+.0250 (2.93)	+.0405 (2.71)	-.0181 (0.61)				

32	+.1034 (11.76)	+.0545 (2.46)	+.0390 (0.81)
33	+.0268 (3.08)	+.0628 (4.20)	+.1044 (4.36)
34	+.0255 (2.70)	+.0429 (3.33)	+.0522 (1.39)
35	-.0070 (0.51)	+.0338 (1.89)	+.0412 (1.10)
36	+.0153 (1.30)	+.0312 (1.93)	+.0591 (1.85)

Note: Numbers in parentheses are the test statistic, which is asymptotically distributed standard normal.

Table 3
Money Growth Asymmetry

Series	Monthly	Quarterly	Annual
M1	-.0019 (0.20)	-.0043 (0.26)	-.0160 (0.40)
M2	.0093 (1.05)	.0082 (0.53)	-.0153 (0.52)
M3	-.0350 (4.01)	-.0456 (2.99)	-.0485 (1.62)
Nominal (Tornqvist-Theil) Monetary Services Index for M1	-.0060 (0.63)	-.0169 (0.96)	-.0312 (0.78)
Nominal (Tornqvist-Theil) Monetary Services Index for M2	.0052 (0.60)	.0103 (0.69)	-.0082 (0.25)
Nominal (Tornqvist-Theil) Monetary Services Index for M3	-.0189 (2.18)	-.0124 (0.85)	-.0146 (0.43)

Note: values in parentheses are (absolute values of) the associated *t*-statistics.