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Asymmetric price adjustment in the small ☆

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ABSTRACT

Analyses of a large retail scanner price data set reveal a new and surprising regularity – small price increases occur more frequently than small price decreases for price changes of up to 10¢. That is, we find asymmetric price adjustment "in the small." Furthermore, it turns out that inflation offers only a partial explanation for the finding. Indeed, substantial proportion of the asymmetry remains unexplained, even after accounting for the inflation. For example, the asymmetry holds also after excluding periods of inflation from the data, and even for products whose price had not increased. The findings hold for different aggregate and disaggregate measures of inflation and also after allowing for lagged price adjustments.

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1. Introduction

A longstanding question in the price adjustment literature is whether or not prices adjust asymmetrically (Ball and Mankiw, 1994; Carlton, 1986; Mankiw and Romer, 1991). Although economists have devoted considerable attention to this issue (recent studies include Davis and Hamilton, 2004; Rotemberg, 2005; Peltzman, 2000), the link between asymmetry and the size of price changes has not received much attention.[1]

This paper studies retail price data from a large US supermarket chain and offers evidence on a new and unusual type of asymmetric price adjustment. The data set itself is quite large containing about 100 million weekly price observations for 18,037 products. The analysis of the data reveals a surprising regularity – small price increases are more frequent than small price decreases for price changes of up to about 10 cents. Furthermore, it turns out that inflation can explain some of the asymmetry. Inflation, however, fails to explain it fully. For example, the asymmetry is present even if one considers only a deflation-period sample, or if one focuses only on the products whose prices have not increased. The findings are robust across different measures of inflation (aggregate and disaggregate), and to lagged price adjustments.

The paper is organized as follows: Section 2 describes the data, Section 3 discusses the findings, Section 4 addresses robustness, Section 5 offers possible explanations and Section 6 concludes.

2. Data

The study uses scanner price data from Dominick's – a large supermarket chain in the Chicago metro area, operating 94 stores with a market share of 25%. In 1999, the US retail grocery sales reached $435 billion. Dominick's – thus – represents a major class of the retail trade. Moreover, the sales of large supermarket chains constitute about 14% of the total retail sales of about $2.25 trillion. Retail sales account for about 9.3% of the GDP, and thus our data represent as much as 1.3% of the GDP, which seems substantial.

The data set consists of up to 400 weekly observations of retail prices in 27 product categories representing 30% of the chain's revenue, from September 14, 1989 to May 8, 1997, although the length of individual series vary.[2] The data contains the actual transaction prices paid at the cash register.[3] Table 1 displays the list of the product categories that are included in the data set along with some general descriptive statistics.

3. Empirical findings

Before presenting the findings, consider a sample series from the data. Fig. 1 displays the weekly prices of Heritage House frozen concentrate orange juice, 12 oz, from Dominick's Store No. 78. The series contain the following "small" price changes:

(a) **1¢**: 9 *positive* (weeks 13, 237, 243, 245, 292, 300, 307, 311, and 359) and 6 *negative* (weeks 86, 228, 242, 275, 386, and 387);
(b) **2¢**: 7 *positive* (weeks 248, 276, 281, 285, 315, 319, and 365) and 1 *negative* (week 287);
(c) **3¢**: 3 *positive* (weeks 254, 379, and 380) and 2 *negative* (weeks 203 and 353);
(d) **4¢**: 4 *positive* (weeks 23, 197, 318, and 354) and 1 *negative* (week 229); and
(e) **5¢**: 1 *positive* (week 280) and 1 *negative* (week 302).

Thus, in this series there are more positive than negative price changes up to 4¢. Below the paper studies the pattern of price changes for the full sample as well as for the individual categories, to determine whether this pattern holds more generally.

3.1. Findings for the full sample

Fig. 2 shows the cross-category average frequency of positive and negative price changes. A robust regularity is immediately apparent: there are more "small" price increases than decreases which we call *asymmetry "in the small."* The asymmetry lasts for price changes of up to about 10–15 cents, which is about 5% of the average retail supermarket price of about $2.50 (Levy et al., 1997; Bergen et al., 2008). Beyond that, the two lines crisscross each other and thus, the systematic asymmetry disappears.

[1] Asymmetric price adjustment has been studied for gasoline (e.g., Davis and Hamilton, 2004), fruit and vegetables (e.g., Ward, 1982), banking (e.g., Hannan and Berger, 1991), processed food (e.g., Ray et al., 2006), manufacturing (e.g., Blinder et al., 1998), and across a broad range of consumer product markets (e.g., Peltzman, 2000; Müller and Ray, 2007).

[2] The findings for two categories, beer and cigarettes, are not discussed because the products included in these categories are highly regulated (Besley and Rosen, 1999, footnote 6). Their plots, however, are included in the supplementary appendix. See Barsky et al. (2003) and Chevalier et al. (2003) for more details about the data.

[3] If the item was on sale or if the retailer's coupon was used, then the data reflect that. The prices are set on a chain-wide basis but there is some variation across the stores. The analyses discussed in this paper, use the data available from all stores.

Table 1
Descriptive statistics of Dominick's data

Category	Number of observations	Proportion of the total	Number of products	Number of stores	Mean price	Std. dev.	Min. price	Max. price
Analgesics	3,059,922	0.0310	638	93	$5.18	$2.36	$0.47	$23.69
Bath soap	418,097	0.0042	579	93	$3.16	$1.60	$0.47	$18.99
Bathroom tissue	1,156,481	0.0117	127	93	$2.10	$1.68	$0.25	$11.99
Beer	1,970,266	0.0200	787	89	$5.69	$2.70	$0.99	$26.99
Bottled juice	4,324,595	0.0438	506	93	$2.24	$0.97	$0.32	$8.00
Canned soup	5,549,149	0.0562	445	93	$1.13	$0.49	$0.23	$5.00
Canned tuna	2,403,151	0.0244	278	93	$1.80	$1.07	$0.22	$12.89
Cereals	4,747,889	0.0481	489	93	$3.12	$0.76	$0.25	$7.49
Cheeses	7,571,355	0.0767	657	93	$2.42	$1.12	$0.10	$16.19
Cigarettes	1,810,614	0.0183	793	93	$7.69	$7.90	$0.59	$25.65
Cookies	7,634,434	0.0774	1124	93	$2.10	$0.63	$0.25	$8.79
Crackers	2,245,305	0.0228	330	93	$2.01	$0.57	$0.25	$6.85
Dish detergent	2,183,013	0.0221	287	93	$2.34	$0.90	$0.39	$7.00
Fabric softeners	2,295,534	0.0233	318	93	$2.82	$1.45	$0.10	$9.99
Front-end-candies	3,952,470	0.0400	503	93	$0.61	$0.24	$0.01	$6.99
Frozen dinners	1,654,051	0.0168	266	93	$2.37	$0.89	$0.25	$9.99
Frozen entrees	7,231,871	0.0733	898	93	$2.33	$1.06	$0.25	$15.99
Frozen juices	2,373,168	0.0240	175	93	$1.39	$0.45	$0.22	$6.57
Grooming products	4,065,691	0.0412	1381	93	$2.94	$1.37	$0.49	$11.29
Laundry detergents	3,302,753	0.0335	581	93	$5.61	$3.22	$0.25	$24.49
Oatmeal	981,106	0.0099	96	93	$2.65	$0.66	$0.49	$5.00
Paper towels	948,550	0.0096	163	93	$1.50	$1.41	$0.31	$13.99
Refrigerated juices	2,176,518	0.0221	225	93	$2.24	$0.91	$0.39	$7.05
Shampoos	4,676,731	0.0474	2930	93	$2.95	$1.79	$0.27	$29.99
Snack crackers	3,509,158	0.0356	420	93	$2.18	$0.57	$0.10	$8.00
Soaps	1,834,040	0.0186	334	93	$2.51	$1.48	$0.10	$10.99
Soft drinks	10,547,266	0.1069	1608	93	$2.34	$1.89	$0.10	$26.02
Toothbrushes	1,852,487	0.0188	491	93	$2.18	$0.85	$0.39	$9.99
Toothpastes	2,997,748	0.0304	608	93	$2.43	$0.89	$0.31	$10.99
Total	98,691,750	1.0000	18,037	93				

Notes:
1. The data are weekly.
2. The figures in the table are based on all price data of Dominick's in its 93 stores for 400 weeks from September 14, 1989 to May 8, 1997.
3. The data are available at: http://gsbwww.uchicago.edu/kilts/research/db/dominicks/.

Table 2 reports the category level asymmetry thresholds based on z-test results. Under the null, there should be equal number of price increases and decreases for each size of price change. We define an "asymmetry threshold" as *the last point at which the asymmetry is supported statistically*, that is, the last point at which the frequency of price increases exceeds the frequency of price decreases of the same absolute magnitude ($z \geqslant 1.96$).[4] According to column 1 of Table 2, in four categories the asymmetry threshold falls below 5¢, and in two categories it exceeds 25¢. In most categories, however, the asymmetry threshold falls in the range of 5¢–25¢, averaging 11.3¢".[5]

3.2. Findings for low-inflation and deflation periods

The most immediate explanation for these findings might be inflation. During the sample period, the US was experiencing a moderate inflation, with an annual rate of between 5% (the first year of the sample) and 2.5% (last year of the sample).[6] During inflation one expects to see more price increases than decreases (Ball and Mankiw,

[4] Out statistical procedure allows for no asymmetry as well as for reverse asymmetry. The current analysis does not find any such case. Similarly, there are very few of them in later analyses (see Table 3 and the supplementary appendix).

[5] Considering price changes of up to 50¢ is sufficient given our focus on small price changes. We have actually calculated the price changes of all sizes, and found that most price changes are indeed smaller than 50¢. The full sample contains a total of 10,298,995 price increases and 9,438,350 price decreases, and thus in total, there are more price increases than decreases. Further, 1¢, 2¢, 3¢, 4¢, and 5¢ increases account for 3.60%, 3.50%, 3.39%, 3.30%, and 3.20% of all price increases, respectively. In other words, 17.09% of the price increases are of 5¢ or less. In contrast, 1¢, 2¢, 3¢, 4¢, and 5¢ decreases account for 2.49%, 2.88%, 2.75%, 2.99%, and 2.88% of all price increases, respectively. In other words, 14.00% of price decreases are of 5¢ or less. Thus, the asymmetry holds at the aggregate level as well.

[6] These findings cannot be explained by promotions or sales, as promotions likely generate more price decreases than increases, which is opposite to what is observed in our data. In addition, a sale-related temporary price reduction is usually followed by a price increase (Rotemberg, 2005). Price promotions, therefore, cannot produce the observed asymmetry.

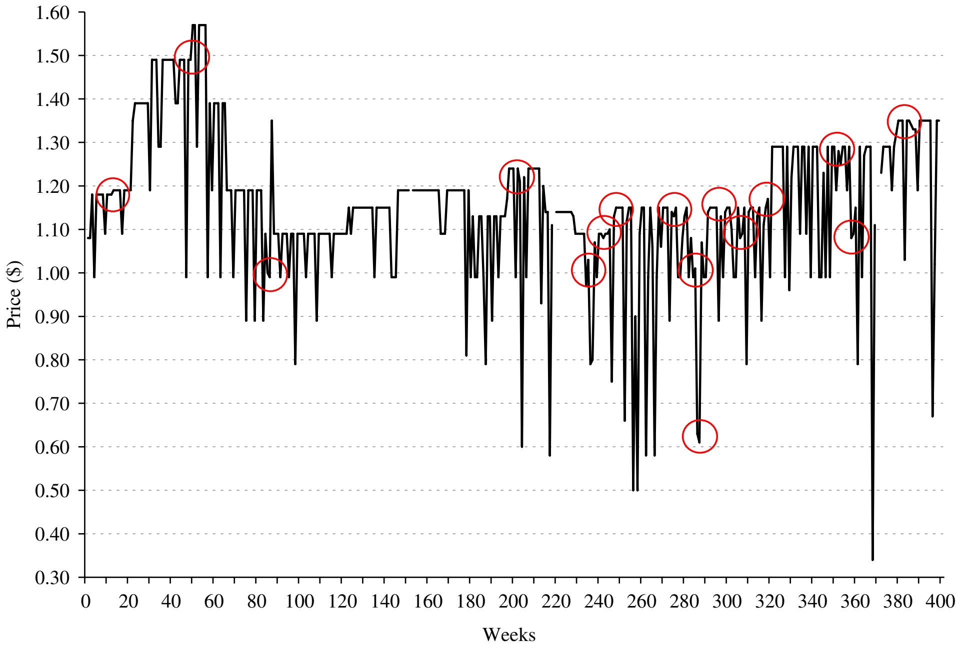

Fig. 1. Price of frozen concentrate orange juice, Heritage House, 12 oz (UPC = 3828190029, Store 78), September 14, 1989–May 8, 1997 (*Source*: Dutta et al., 2002; Levy et al., 2002).
Notes: 1. Week 1 = the week of September 14, 1989, and Week 399 = the week of May 8, 1997.
2. There are six missing observations in the series.
3. The series contain many small price changes. Some of them are indicated by the circles.
4. Section 3 of the text provides the exact list of all price changes of 5 cents or less.

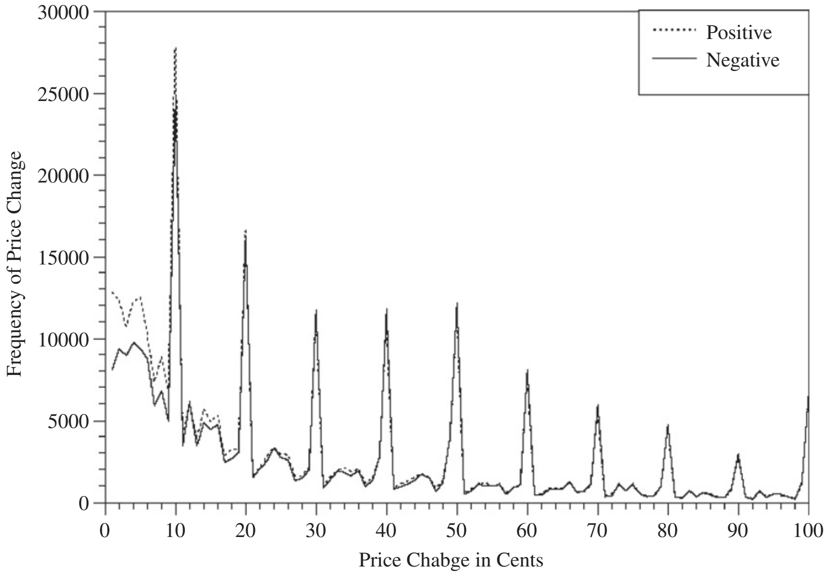

Fig. 2. Average frequency of positive and negative price changes, all 29 catagories.

1994).[7] Therefore, it will be useful to ask whether or not the asymmetry holds when inflationary periods are excluded from the data. Given our large sample, such an analysis is indeed feasible.

To answer this question, two specific analyses were conducted. The first analysis includes only those observations during which the *monthly* PPI inflation does not exceed 0.1%, which is defined here as a *low-inflation* period. The second

[7] A counter-argument to this idea is that if the reason for the asymmetry was inflation, then one would see the asymmetry not only "in the small" but also "in the large." The data, however, do not exhibit asymmetry "in the large".

Table 2
Asymmetry thresholds in cents based on PPI-measure of price level

Category	Full sample	Low-inflation sample	Deflation sample
Analgesics	30	10	10
Bath soap	6	0	0
Bathroom tissues	6	4	4
Bottled juices	12	15	12
Canned soup	12	12	10
Canned tuna	1	2	1
Cereals	29	24	1
Cheeses	9	9	9
Cookies	11	11	9
Crackers	10	2	4
Dish detergent	5	4	6
Fabric softeners	5	11	7
Front-end-candies	5	5	5
Frozen dinners	2	10	6
Frozen entrees	20	22	0
Frozen juices	9	9	10
Grooming products	20	12	12
Laundry detergents	16	13	17
Oatmeal	25	2	5
Paper towels	2	2	2
Refrigerated juices	15	9	6
Shampoos	0	10	10
Snack crackers	11	2	2
Soaps	1	1	1
Soft drinks	5	3	5
Tooth brushes	20	3	3
Tooth pastes	18	14	6
Average	11.3	8.2	6.2

Notes:
1. PPI = Producer Price Index.
2. Low inflation sample includes the periods during which the monthly change in the PPI does not exceed 0.1%.
3. Deflation sample includes the periods during which the monthly change in the PPI does not exceed 0%.
4. The figures reported in the table are the cutoff points of what might constitute a "small" price change for each category. The cutoff point is the last point at which the asymmetry is supported statistically ($z \geq 1.96$). Thus, for example, in the Analgesics category, when the full sample is used, there is asymmetry (more frequent price increases than decreases) for price changes of up to 30 cents.
5. "0" means that there is no asymmetry.

analysis includes only those observations in which the *monthly* PPI inflation rate is non-positive, which is defined here as a *deflation*-period.[8]

For the low-inflation sample (the middle column in Table 2), the asymmetry threshold is 8.2¢ on average. At the category level, the asymmetry holds in all but one category (bath soap), with some decrease in the thresholds, the majority falling between 2¢ and 20¢. In the deflation period sample (the last column in Table 2), the threshold is 6.2¢, on average. At the category level, asymmetry "in the small" is still found for all but two categories, bath soap and frozen entrees.

Thus, the asymmetry decreases from 11.3¢ in the full sample to 8.2¢ in the low-inflation sample, and to 6.2¢ in the deflation sample, indicating that inflation accounts for about a half of the asymmetry. This suggests that inflation is indeed playing a role in the asymmetry. However, a sizeable fraction of the asymmetry still remains unexplained.

3.3. *Asymmetry and aggregate inflation*

In our data, deflation months are scattered throughout the sample period. To check further how asymmetry varies with inflation, therefore, the asymmetry threshold for each product category for each year was calculated (Table 3, columns A-G). This analysis revealed a negative relationship between asymmetry and inflation: over time, the asymmetry increased as inflation decreased (with PPI, $t = 1.87$, $df = 171$, $p = .03$; with CPI, $t = 3.15$, $df = 171$, $p < .01$; with CPI-Chicago, $t = 2.04$, $df = 171$, $p < .05$).

[8] The frequency plots for the low inflation and the deflation periods are included in the supplementary appendix available upon request.

Table 3
Relationship between asymmetry and inflation, asymmetry thresholds in cents

Categories	Asymmetry and aggregate inflation							Asymmetry and disaggregate inflation				
	1990 A	1991 B	1992 C	1993 D	1994 E	1995 F	1996 G	WI H	MI1 I	AI1 J	MI2 K	AI2 L
Analgesics	(1)	7	8	3	0	8	3	7	4	(1)	12	0
Bath soap	–	–	0	(1)	0	0	(1)	0	(1)	0	0	(1)
Bathroom tissues	3	1	1	4	6	9	5	12	6	6	12	12
Bottled juices	15	0	4	7	5	1	18	27	33	29	28	39
Canned soup	0	12	0	10	11	8	9	18	19	2	19	18
Canned tuna	1	1	2	2	1	0	2	11	7	7	6	10
Cereals	4	24	0	25	19	1	12	4	4	2	2	10
Cheeses	(1)	5	1	9	2	2	23	11	18	12	18	12
Cookies	4	(1)	4	8	14	3	10	6	3	10	2	2
Crackers	1	2	1	2	4	1	10	1	12	10	11	2
Dish detergent	(3)	2	2	10	4	2	11	2	6	2	2	2
Fabric softeners	0	5	11	5	1	1	1	20	4	10	20	20
Front-end-candies	(1)	1	1	15	0	1	10	5	2	9	9	9
Frozen dinners	–	–	9	4	1	1	1	6	5	5	1	1
Frozen entrees	(1)	0	10	10	(1)	1	20	2	16	16	8	14
Frozen juices	0	(2)	2	3	9	9	9	10	12	3	12	1
Grooming prod.	–	–	12	20	5	1	16	2	3	3	2	3
Laundry detergent	(4)	3	2	9	1	1	2	2	1	2	2	1
Oatmeal	–	5	12	4	1	2	9	9	13	6	19	16
Paper towels	1	0	1	1	2	9	1	3	3	13	4	5
Refrigerated juices	0	4	2	8	3	9	25	8	(1)	8	(1)	8
Shampoos	–	–	6	20	2	(1)	(1)	11	2	2	2	2
Snack crackers	(2)	0	2	2	1	12	9	1	1	1	1	1
Soaps	–	–	4	6	1	1	1	0	8	8	3	8
Soft drinks	1	(1)	(1)	5	3	4	13	1	1	1	1	1
Tooth brushes	(1)	8	8	(1)	3	7	1	20	18	20	16	18
Tooth pastes	1	7	0	6	2	12	(1)	9	6	6	6	6
Average	0.8	3.8	3.9	7.3	3.7	3.9	8.1	7.70	7.59	7.11	8.04	8.15

Notes:
1. A—1990; B—1991; C—1992; D—1993; E—1994; F—1995; G—1996.
2. H—Weekly Index; I—Monthly Index 1; J—Annual Index 1; K—Monthly Index 2; L—Annual Index 2.
3. The figures in the table are the estimated asymmetry thresholds.
4. The figures in parentheses indicate a reverse asymmetry, and "0" means that there is no asymmetry.

3.4. Asymmetry and disaggregate inflation

Aggregate inflation during the sample period was not too variable. Therefore, a more disaggregated inflation measure was constructed by generating a weekly index (WI) of Dominick's category-level prices using the method of Chevalier et al. (2003).[9]

From the WI two monthly (MI) and two annual (AI) indices were derived. The monthly indices MI1 and MI2 were formed by setting the MI equal to the WI value of the last week of the month, and to the average of the weekly indices over the month, respectively. Similarly, the two annual indices AI1 and AI2 were formed by setting the AI equal to the WI of the last week of the year, and to the average of the weekly indices over the year, respectively.

Using the five category-level price indices, the deflationary periods were identified, and the asymmetry thresholds were calculated for each category.[10] The five new analyses generated a total of 135 (5×27) asymmetry thresholds. The findings, shown in columns H-L of Table 3, confirm the presence of asymmetry in the small: 92% (125/135) of the asymmetry thresholds are positive, while only 4% (5/135) are 0, and 4% (5/135) are -1.[11] The asymmetry thresholds range between 7.11¢ and 8.15¢, with an average of 7.72¢.

[9] See, Chevalier et al., Section 2-E, pp. 22–23, for details.

[10] The disaggregate price indices indicate greater variation in the inflation rates across categories in comparison to the aggregate inflation. For example, in our sample the average annual category-level inflation rate varies from -25.7% for analgesics to 21.9% for cookies. In contrast, the aggregate annual inflation rate during the sample period varied between 2% and 5.5%, on average.

[11] The minus sign indicates a reverse asymmetry. The categories with 0 or reverse asymmetries are analgesics, bath soap, shampoo, and toothbrush. For the remaining 23 categories, the asymmetry thresholds are positive. The average asymmetry threshold across the 27 categories is positive in all five analyses (all t_{26}'s >7.11, all p-values $<.001$).

As an additional analysis, we run a linear cross-section regression of the category-level asymmetry thresholds on the category-level inflation using each of the five category-level inflation measures. The results suggest that there is no statistically significant relationship between asymmetry and inflation at the category-level.[12]

4. Robustness

To check the robustness of this conclusion, five different tests of robustness were conducted. All confirm the conclusion that inflation at best offers a partial explanation for the asymmetry. These tests and the resulting findings are briefly discussed below. For more details, see the supplementary appendix.

4.1. Lagged price adjustment

The analysis so far assumed instantaneous price adjustment. To allow lagged adjustment, the analysis was repeated with 4-, 8-, 12-, and 16-week lags (Dutta et al., 2002; Bils and Klenow, 2004). The results suggest that the asymmetry holds for 25 of the 27 categories. In 99 of the 108 cases, i.e., in 92% of the cases, the thresholds are positive, averaging 6.6¢.

4.2. Alternative measures of inflation

The above analysis used the PPI. The analysis was repeated using CPI and CPI-Chicago. The latter is useful as it covers the area where most Dominick's stores operate. The findings of these analyses suggest that there is asymmetry in all but two categories, with the average threshold of 6.9¢.

4.3. Alternative measures of inflation with lagged price adjustment

The analysis of 4.2 was repeated with 4-, 8-, 12-, and 16-week adjustment lags. The findings of these analyses indicate that in 185 of the 216 cases, i.e., in 86% of the cases, the asymmetry remains, with the average threshold of 4.5¢.

4.4. Products for which prices have not increased

As another test, only the products for which prices have not increased during the sample period were considered.[13] The findings indicate that in 23 of the 27 categories, i.e., in over 85% of the cases, asymmetry is observed.

4.5. First year vs. the last year of the sample period

The 1989–97 period is characterized by a downward inflation trend. If inflation is causing the asymmetry, then the asymmetry should be stronger in the beginning of the sample period in comparison to the end of the sample period. Six product categories lack observations during the first year of the sample period. In 19 of the remaining 21 categories, i.e., in over 90% of the categories, a greater asymmetry is found in the last 12 months of the sample, averaging 9.0¢ in comparison to 0.6¢ in the first 12 months. A paired *t*-test comparing the asymmetry thresholds across the categories indicates statistical significance ($t_{20} = 4.799$, $p < .01$).

5. Possible explanations

The analyses in Sections 3 and 4 suggest that inflation cannot fully account for the observed asymmetry. Next, the paper explores whether or not the existing theories of asymmetric price adjustment can explain it. Although these theories can explain asymmetric price adjustment in general, it appears that they are unable to explain the specific form of asymmetry the paper documents. For example, the theory of capacity constraints (Peltzman, 2000) emphasizes the asymmetry in the sellers' ability to adjust inventory to price fluctuations. The theory, however, predicts that asymmetry should be observed for large price changes because small price changes are less likely to make capacity constraints binding. This is the opposite of what is observed in our data. Similarly, theories of vertical channels and imperfect competition cannot explain asymmetry in the small because it is hard to see how market or the channel structure can vary between small and large price changes. Another possible explanation is menu cost under trend inflation. However, if the asymmetry were due to

[12] For example, using MI2 to measure the category-level inflation, the estimates of the intercept and the slope are 11.3 and −137.3 with *t*-values 6.8 and −0.7, respectively. Thus the estimated slope is negative but statistically insignificant.

[13] The average prices during the first and the last 4 weeks of the sample were compared. An 8-week window yielded similar results. In this comparison, the list prices are used in order to avoid any effect of sales on the results. In the asymmetry analysis, however, the actual prices are used to make the current results comparable with the previous results.

inflation and menu cost (Tsiddon, 1993; Ellingsen et al., 2005), then one should not have seen asymmetry in periods of low-inflation, and even more so in periods of deflation. The asymmetry, therefore, is unlikely to be driven entirely by inflation.[14]

The robustness of our findings and the possible challenges to explain their patterns make them particularly intriguing. As a possible explanation, we hypothesize that that time-constrained consumers may be inattentive to small price changes.[15,16] If – for example – the cost of processing information on a price change exceeds the benefit, then shoppers might choose to ignore—and not react to—small price changes.[17] The inattention creates along the demand curve around the current price a region where consumer sensitivity is low for both small price increases and decreases. This makes small price decreases less valuable to the retailer because the lower price does not trigger the consumer's response. A small price increase, however, is valuable to the retailer as the consumer will not reduce her purchases. Thus, the retailer has incentive to make more frequent small price increases than decreases. Large price changes, however, trigger consumer reaction, and therefore the retailer has no incentive to make asymmetric large price changes.[18,19]

The idea that there exists a region of inattention around the current price along the demand curve is consistent with the findings of Fibich et al. (2007) and Kalwani and Yim (1992), who show that promotional price changes must exceed a certain threshold to produce any effect. It is consistent also with the literature on "just noticeable difference" (Monroe, 2003) and "price indifference bands" (Kalyanaram and Little, 1994). For example, according to McKinsey, the price indifference band is 17% for health-and-beauty products and 10% for engineered industrial components. Consistent with this, the common managerial intuition is that price reductions of less than 15% do not attract enough customers to a sale (Della et al., 1981; Gupta and Cooper, 1992).[20]

6. Conclusion

The paper finds asymmetry for price changes of up to about 10¢. In other words, the paper finds downward price rigidity "in the small." This type of asymmetry has not been reported in the literature, often flying under the radar screen. For example, the data plots presented by Álvarez and Hernando (2004) and Baudry et al. (2004) clearly indicate asymmetry "in the small" although the authors do not discuss it. These suggest that asymmetry in the small might be more prevalent than people think.[21]

Our findings suggest that inflation can explain some of the asymmetry the paper documents, which is interesting because a long-standing question in the New-Keynesian macroeconomic theory is whether or not individual price setters respond to monetary policy or more generally to macro variables. The finding that some of the asymmetry in the small that the paper documents using product- and store-level individual transaction price data is explained by inflation, provides evidence that price-setters may be paying attention and reacting to monetary/macro-developments.

There still remains a substantial portion of the asymmetry unexplained, even after accounting for inflation. While the existing theories of asymmetric pricing adjustment cannot explain the remaining asymmetry, it seems consistent with consumer inattention. To the extent that consumers' information processing costs depend on their opportunity costs, their ability to carry out the necessary calculations, their experience with doing this type of calculations and the amount of the

[14] If one considers a broader notion of price adjustment costs including managerial costs, then price adjustment costs could lead to asymmetry: the cost of price increase could be higher than the cost of price decrease. The reason might be consumer anger or fairness (Rotemberg, 1982, 2005; Kahneman et al., 1986), consumer goodwill loss (Okun, 1981; Kackmeister, 2007; Levy and Young, 2004), or search triggered by a price increase. This – however – predicts more price decreases than increases. Rotemberg's (1982) cost of price adjustment model implicitly assumes that consumers may prefer a series of small price changes to a single large price change. This idea could be consistent with our findings. However, that would depend on the size of menu costs: if the menu cost is too large, then a single large price change may be chosen over a series of several small price changes (Sheshinski and Weiss, 1977, 1992; Mankiw, 1985; Blinder et al., 1998).

[15] See, for example, Ball et al. (2005); Adam (2007); Mankiw and Reis (2002); Sims (2003); Reis (2006a, b); Woodford (2003) and Shugan (1980).

[16] Another explanation might be asymmetry in small shocks (Ball and Mankiw, 1994, 1995). Prices may be reacting differently to shocks of different magnitudes, and in a world without inflation, asymmetric distribution of small shocks could lead to asymmetric price adjustment in the small. We thank the anonymous referee for pointing this out.

[17] A recent news report offers anecdotal evidence: "The cost of General Mills cereals such as Wheaties, Cheerios, and Total is increasing an average of 2%. The price jump averages out to roughly 6 or 7¢ a box for cereals such as Chex, Total Raisin Bran…which typically cost around $3 in the Minneapolis area,…John French, 30, *doubted he would even notice* the higher prices for cereal on his next grocery trip. 'A few cents? Naw, that's no big deal', said French, of Plymouth, MN" (our emphasis). *Source*: Associated Press, June 2, 2001, "General Mills Hikes Prices".

[18] In a world inhabited by inattentive consumers, small price decreases are still possible. First, small price changes may be induced by competitive factors, such as price guarantees and price matches (Levy et al., 1997, 1998), as well as by changes in supply conditions (Dutta et al., 1999, 2002; Levy et al., 2002) and demand conditions (Okun, 1981; Warner and Barsky, 1995; Chevalier et al., 2003). Second, many food items have expiration date, and they may go on sale as the expiration date approaches. And third, managers may be following simple pricing rules, such as "reduce all prices in a given category by 2%", which could lead to small price reductions. See also Coenen, et al. (2007), Lach and Tsiddon (1992, 1996, 2007), Danziger (1999, 2001) and Rotemberg (2008).

[19] There is a limit on the surplus a retailer can extract from consumers. For example, if information-processing is costly, the customer may rely on the price for which she has last optimized. The retailer then can raise its price only to the upper bound of the region of inattention. Any additional increase beyond that will push the price far enough from the last optimization price to trigger a re-optimization. Thus, indefinite continuous small price increases are not feasible.

[20] The possibility that consumers may be inattentive to small price changes is consistent with the observation that retailers alert the public about promotions by posting sale signs, to ensure that shoppers *notice* the price discounts.

[21] Indeed, in his discussants' comments on this study, Cecchetti (2004) demonstrated that in Europe the phenomenon of asymmetric price adjustment in the small is widespread and is not limited to food store prices. See also Hoffmann and Kurz-Kim (2008).

calculations required, the asymmetry could vary with the level of customer attentiveness over shopping intensity (e.g., holiday vs. non-holiday periods) and across products and product categories. Therefore, studying settings in which the extent of inattention may vary will offer a more direct test of the empirical plausibility of the rational inattention explanation. Future research can incorporate models of reference point shift (e.g., Chen and Rao, 2002; Eichenbaum et al., 2008) to study the dynamics of information processing costs and their impact on firms' pricing behavior.

Our findings suggest that markets might respond differently to small and large changes, a notion consistent with the finding that prices react differently to small and large cost shocks (Ball and Mankiw, 1994; Dutta et al., 2002), and with recent field work that studies firms' conduct when they face decisions about small versus large price changes.[22]

Based on our findings, we speculate that asymmetry in the small will be present in settings where low-priced consumer goods are sold (Target, Wal-Mart, etc.). It is unclear, however, how generalizable our findings are to other setting. It is known that in some markets, such as in financial and in business-to-business markets, attention is critical because transactions often involve large quantities of the same asset. Similarly, in markets for big-ticket items people might be more attentive because of the large expenditures (Bell et al., 1998). Even then, however, buyers might ignore some rightmost digits (Lee et al., 2006). Thus, a car buyer may focus on "fourteen thousand eight hundred" dollars when the actual price is $14,889, creating some room for asymmetric price adjustment in the small. In future work – therefore – it will be valuable to study other data sets, products, and markets.

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[22] See, for example, Zbaracki et al. (2004, 2006). See also Cecchetti (1986); Rotemberg (1987); Basu (1995); Danziger (1999); Ball and Romer (2003); Konieczny and Skrzypacz (2005); Fisher and Konieczny (2006) and Barsky et al. (2007).

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