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Asymmetric price adjustment in the small*

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Abstract: Analyses of a large retail scanner price dataset 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.

JEL Codes: E31; D11; D21; D80; L11; L16; M31

Keywords: Asymmetric price adjustment; Price rigidity; Inflation; Rational inattention; Monetary policy

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1 **1. Introduction**

2 A longstanding question in the price adjustment literature is whether or not prices adjust
3 asymmetrically (Ball and Mankiw 1994, Carlton 1986, and Mankiw and Romer 1991). Although
4 economists have devoted considerable attention to this issue (recent studies include Davis and Hamilton
5 2004, Rotemberg 2005, and Peltzman 2000), the link between asymmetry and the size of price changes has
6 not received much attention.¹

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

16 The paper is organized as follows. Next section describes the data. Section 3 discusses the
17 findings. Section 4 addresses robustness. Section 5 offers possible explanations. Section 6 concludes.
18

19 **2. Data**

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

26 The data set consists of up to 400 weekly observations of retail prices in 27 product categories
27 representing 30 percent of the chain's revenue, from September 14, 1989 to May 8, 1997, although the
28 length of individual series vary.² The data contain the actual transaction prices paid at the cash register.³
29 Table 1 displays the list of the product categories that are included in the dataset along with some general
30 descriptive statistics.
31

32 **3. Empirical Findings**

33 Before presenting the findings, consider a sample series from the data. Figure 1 displays the
34 weekly prices of Heritage House frozen concentrate orange juice, 12oz, from Dominick's Store No. 78.
35 The series contain the following “small” price changes:
36

- 37 (a) **1¢**: 9 positive (weeks 13, 237, 243, 245, 292, 300, 307, 311, and 359) and 6 negative (weeks 86, 228,
38 242, 275, 386, and 387);
39 (b) **2¢**: 7 positive (weeks 248, 276, 281, 285, 315, 319, and 365) and 1 negative (week 287);
40 (c) **3¢**: 3 positive (weeks 254, 379, and 380) and 2 negative (weeks 203 and 353);
41 (d) **4¢**: 4 positive (weeks 23, 197, 318, and 354) and 1 negative (week 229); and
42 (e) **5¢**: 1 positive (week 280) and 1 negative (week 302).
43

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

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.

1
2 **3.1 Findings for the Full Sample**

3 Figure 2 shows the cross-category average frequency of positive and negative price changes. A
4 robust regularity is immediately apparent: there are more “small” price increases than decreases which we
5 call *asymmetry “in the small.”* The asymmetry lasts for price changes of up to about 10-15 cents, which is
6 about 5 percent of the average retail supermarket price of about \$2.50 (Levy, et al., 1997; Bergen, et al.,
7 2008). Beyond that, the two lines crisscross each other and thus, the systematic asymmetry disappears.

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

15
16 **3.2 Findings for Low-Inflation and Deflation Periods**

17 The most immediate explanation for these findings might be inflation. During the sample period,
18 the US was experiencing a moderate inflation, with an annual rate of between 5 percent (the first year of
19 the sample) and 2.5 percent (last year of the sample).⁶ During inflation one expects to see more price
20 increases than decreases (Ball and Mankiw, 1994).⁷ Therefore, it will be useful to ask whether or not the
21 asymmetry holds when inflationary periods are excluded from the data. Given our large sample, such an
22 analysis is indeed feasible.

23 To answer this question, two specific analyses were conducted. The first analysis includes only
24 those observations during which the *monthly* PPI inflation does not exceed 0.1 percent, which is defined
25 here as a *low-inflation* period. The second analysis includes only those observations in which the *monthly*
26 PPI inflation rate is non-positive, which is defined here as a *deflation*-period.⁸

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

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

36
37 **3.3 Asymmetry and Aggregate Inflation**

38 In our data, deflation months are scattered throughout the sample period. To check further how
39 asymmetry varies with inflation, therefore, the asymmetry threshold for each product category for each year
40 was calculated (Table 3, columns A-G). This analysis revealed a negative relationship between asymmetry

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. Indeed, price changes of all sizes were calculated, and it was 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.

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.”

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

1 and inflation: over time, the asymmetry increased as inflation decreased (with PPI, $t = 1.87$, $d.f. = 171$, $p =$
2 $.03$; with CPI, $t = 3.15$, $d.f. = 171$, $p < .01$; with CPI-Chicago, $t = 2.04$, $d.f. = 171$, $p < .05$).

3.4 Asymmetry and Disaggregate Inflation

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

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

13 Using the five category-level price indices, the deflationary periods were identified, and the
14 asymmetry thresholds were calculated for each category.¹⁰ The five new analyses generated a total of 135
15 (5x27) asymmetry thresholds. The findings, shown in columns H-L of Table 3, confirm the presence of
16 asymmetry in the small: 92% (125/135) of the asymmetry thresholds are positive, while only 4% (5/135)
17 are 0, and 4% (5/135) are -1.¹¹ The asymmetry thresholds range between 7.11¢ and 8.15¢, with an average
18 of 7.72¢.

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

4. Robustness

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

4.1 Lagged Price Adjustment

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

4.2 Alternative Measures of Inflation

36 The above analysis used the PPI. The analysis was repeated using CPI and CPI-Chicago. The
37 latter is useful as it covers the area where most Dominick's stores operate. The findings of these analyses
38 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

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

4.4 Products for Which Prices Have Not Increased

46 As another test, only the products for which prices have not increased during the sample period

⁹ See, Chevalier, et al., section II-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 percent for analgesics to 21.9 percent for cookies. In contrast, the aggregate annual inflation rate during the sample period varied between 2 percent to 5.5 percent, 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 $< .001$).

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.

1 were considered.¹³ The findings indicate that in 23 of the 27 categories, i.e., in over 85 percent of the cases,
2 asymmetry is observed.

3 4 **4.5 First Year vs. the Last Year of the Sample Period**

5 The 1989-97 period is characterized by a downward inflation trend. If inflation is causing the
6 asymmetry, then the asymmetry should be stronger in the beginning of the sample period in comparison to
7 the end of the sample period. Six product categories lack observations during the first year of the sample
8 period. In 19 of the remaining 21 categories, i.e., in over 90 percent of the categories, a greater asymmetry
9 is found in the last 12 months of the sample, averaging 9.0¢ in comparison to 0.6¢ in the first 12 months. A
10 paired *t*-test comparing the asymmetry thresholds across the categories indicates statistical significance (t_{20}
11 = 4.799, $p < .01$).

12 13 **5. Possible Explanations**

14 The analyses in sections 3 and 4 suggest that inflation cannot fully account for the observed
15 asymmetry. Next, the paper explores whether or not the existing theories of asymmetric price adjustment
16 can explain it. Although these theories can explain asymmetric price adjustment in general, it appears that
17 they are unable to explain the specific form of asymmetry the paper documents. For example, the theory of
18 capacity constraints (Peltzman, 2000) emphasizes the asymmetry in the sellers' ability to adjust inventory
19 to price fluctuations. The theory, however, predicts that asymmetry should be observed for large price
20 changes because small price changes are less likely to make capacity constraints binding. This is the
21 opposite of what is observed in our data. Similarly, theories of vertical channels and imperfect competition
22 cannot explain asymmetry in the small because it is hard to see how market or the channel structure can
23 vary between small and large price changes. Another possible explanation is menu cost under trend
24 inflation. However, if the asymmetry were due to inflation and menu cost (Tsiddon, 1993; Ellingsen, et al.,
25 2005), then one should not have seen asymmetry in periods of low-inflation, and even more so in periods
26 of deflation. The asymmetry, therefore, is unlikely to be driven entirely by inflation.¹⁴

27 The robustness of our findings and the possible challenges to explain their patterns make them
28 particularly intriguing. As a possible explanation, we hypothesize that that time-constrained consumers
29 may be inattentive to small price changes.^{15, 16} If, for example, the cost of processing information on a price
30 change exceeds the benefit, then shoppers might choose to ignore—and not react to—small price
31 changes.¹⁷ The inattention creates along the demand curve around the current price a region where
32 consumer sensitivity is low for both small price increases and decreases. This makes small price decreases
33 less valuable to the retailer because the lower price does not trigger the consumer's response. A small price
34 increase, however, is valuable to the retailer as the consumer will not reduce her purchases. Thus, the
35 retailer has incentive to make more frequent small price increases than decreases. Large price changes,

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.

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 and 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 (Mankiw, 1985; Blinder, et al. 1998).

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

¹⁶ Another explanation might be asymmetry in small shocks (Ball and Mankiw, 1994). 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 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: c."

1 however, trigger consumer reaction, and therefore the retailer has no incentive to make asymmetric large
2 price changes.^{18, 19}

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

11 12 **6. Conclusion**

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

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

24 There still remains a substantial portion of the asymmetry unexplained, even after accounting for
25 inflation. While the existing theories of asymmetric pricing adjustment cannot explain the remaining
26 asymmetry, it seems consistent with consumer inattention. To the extent that consumers’ information
27 processing costs depend on their opportunity costs, their ability to carry out the necessary calculations, their
28 experience with doing this type of calculations and the amount of the calculations required, the asymmetry
29 could vary with the level of customer attentiveness over shopping intensity (e.g., holiday vs. non-holiday
30 periods) and across products and product categories. Therefore, studying settings in which the extent of
31 inattention may vary will offer a more direct test of the empirical plausibility of the rational inattention
32 explanation. Future research can incorporate models of reference point shift (e.g., Chen and Rao 2002;
33 Eichenbaum, Jaimovich, and Rebelo 2008) to study the dynamics of information processing costs and their
34 impact on firms’ pricing behavior.

35 Our findings suggest that markets might respond differently to small and large changes, a notion
36 consistent with the finding that prices react differently to small and large cost shocks (Ball and Mankiw
37 1994; Dutta, et al. 2002), and with recent field work that studies firms’ conduct when they face decisions
38 about small versus large price changes.²²

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 and 1998), as well as by changes in supply conditions (Dutta, et. al., 1999 and 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 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).

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).

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

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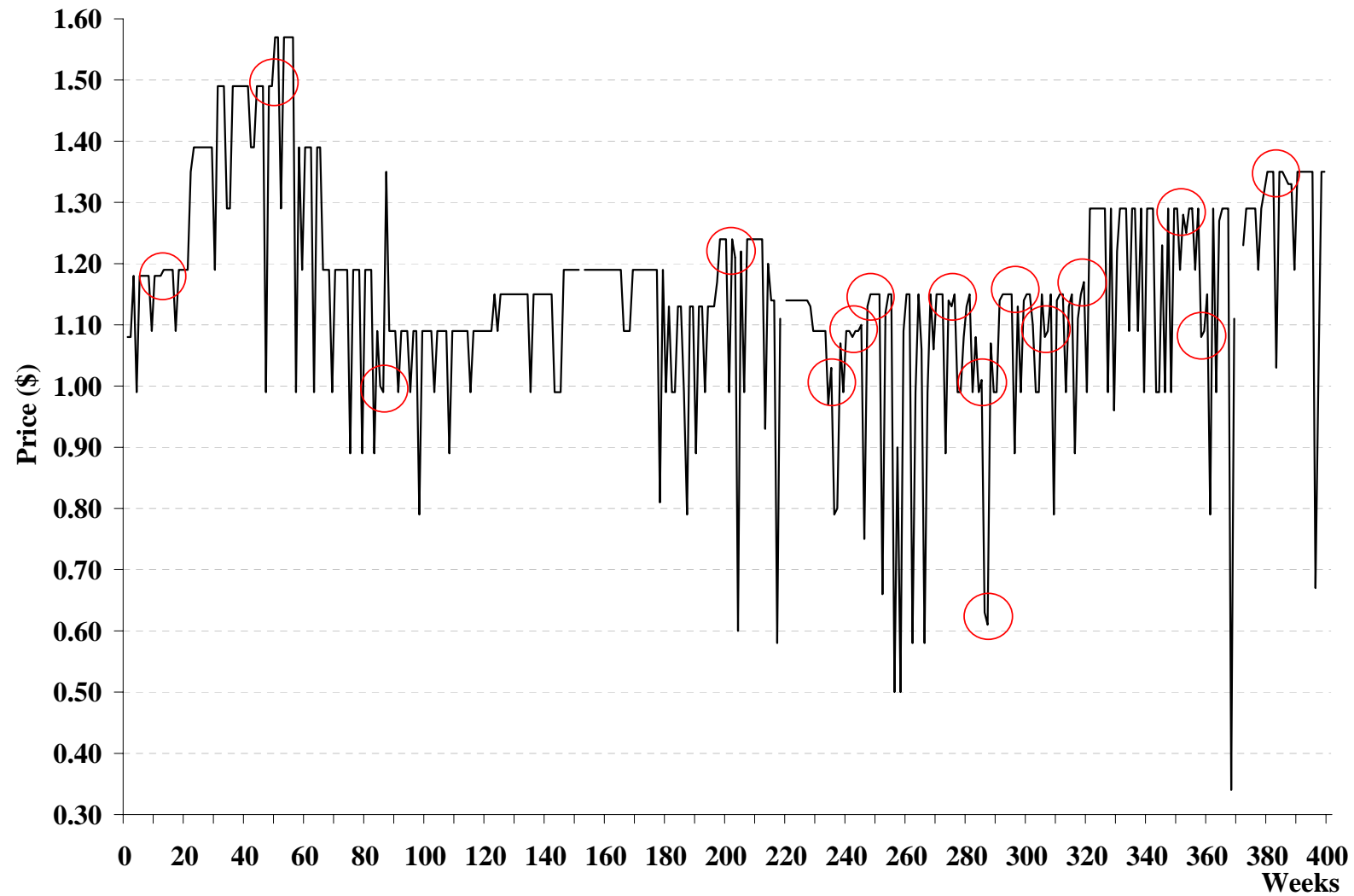


Figure 1. Price of frozen concentrate orange juice, Heritage House, 12oz (UPC = 3828190029, Store 78), September 14, 1989-May 8, 1997
(Source: Dutta, et al. 2002, and Levy, et al. 2002)

Notes:

1. Week 1 = the week of September 14, 1989, and Week 399 = the week of May 8, 1997
2. There are 6 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.

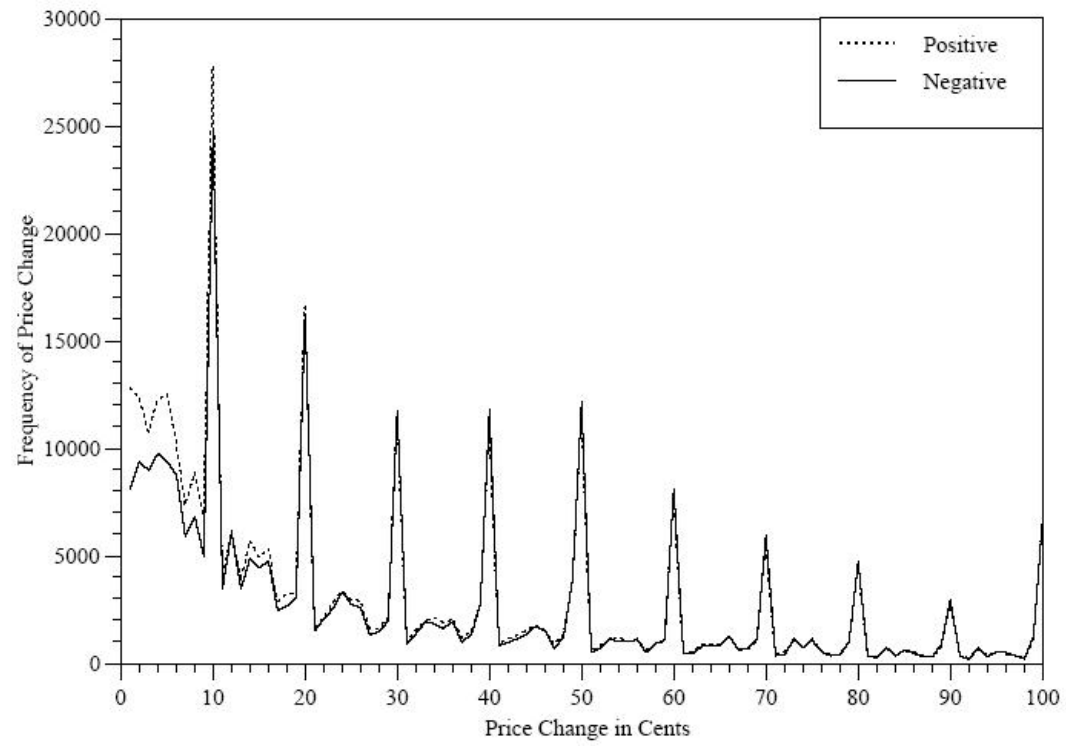


Figure 2. Average Frequency of Positive and Negative Price Changes, All 29 Categories

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	1,124	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	1,381	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	2,930	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	1,608	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. 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 percent.
3. Deflation sample includes the periods during which the monthly change in the PPI does not exceed 0 percent.
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.

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

Categories	Asymmetry and Aggregate Inflation							Asymmetry and Disaggregate Inflation				
	1990	1991	1992	1993	1994	1995	1996	WI	MI1	AI1	MI2	AI2
	A	B	C	D	E	F	G	H	I	J	K	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.

Supplementary Appendix

1. Table R1 reports the results of five robustness tests, as discussed in the paper, in section 4.
2. In Figure R1 we present the cross-category average frequency of positive and negative price changes in cents for the low/zero-inflation period sample.
3. In Figures R1.1a–R1.1c we present the frequency of positive and negative price changes in cents by categories for the low/zero-inflation period sample.
4. In Figure R2 we present the cross-category average frequency of positive and negative price changes in cents for the deflation period sample.
5. In Figures R2.1a–R2.1c we present the frequency of positive and negative price changes in cents by categories for the deflation period sample.

Table R1. Robustness tests

Categories	PPI					CPI					CPI-Chicago					F4W≥L4W	F12M	L12M
	No Lag	4W	8W	12W	16W	No Lag	4W	8W	12W	16W	No Lag	4W	8W	12W	16W	P	Q	R
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O			
Analgesics	30	12	5	10	0	10	1	0	(5)	0	7	(1)	(1)	5	14	3	0	16
Bath Soap	6	0	0	(1)	(1)	(1)	(3)	0	0	0	(1)	0	0	0	0	(1)	-	-
Bathroom Tissues	6	4	4	4	5	9	5	4	4	6	4	4	4	4	3	5	2	4
Bottled Juices	12	10	2	6	24	9	2	2	(7)	3	8	10	16	0	2	5	11	12
Canned Soup	12	11	10	12	18	10	11	2	2	8	14	12	13	11	12	0	0	24
Canned Tuna	1	2	2	1	2	1	1	1	1	1	1	1	2	1	1	1	3	2
Cereals	29	25	0	25	28	28	0	21	25	28	33	29	29	(1)	29	14	0	13
Cheeses	9	9	2	9	9	8	12	2	1	10	5	9	10	6	2	1	(1)	22
Cookies	11	11	10	11	10	11	3	5	5	10	4	11	11	12	10	2	1	10
Crackers	10	4	2	4	2	1	7	4	10	6	1	1	3	6	2	2	1	11
Dish Detergent	5	10	2	6	5	7	1	4	1	3	9	5	2	1	2	5	(4)	15
Fabric Softeners	5	13	2	1	5	3	5	0	1	2	8	2	1	1	1	1	0	1
Front-end-candies	5	4	6	2	9	9	9	6	6	1	7	6	5	2	1	(1)	(1)	1
Frozen Dinners	2	9	9	2	2	1	2	1	2	1	1	2	3	1	1	2	-	-
Frozen Entrees	20	4	20	10	19	10	10	12	0	9	11	3	0	(1)	4	14	1	20
Frozen Juices	9	9	1	6	1	7	1	1	5	4	5	1	9	14	2	9	1	13
Grooming Prod.	20	18	18	10	8	13	13	8	14	1	23	5	12	18	6	2	-	-
Laundry Detergent	16	13	11	5	2	9	0	3	12	13	20	3	1	1	3	12	1	6
Oatmeal	25	4	4	12	3	2	2	4	4	17	4	5	1	3	4	2	-	-
Paper Towels	2	2	2	2	1	2	2	2	2	2	2	1	2	2	1	2	1	4
Refrigerated Juices	15	6	18	11	5	6	6	2	9	5	9	3	3	6	9	7	0	10
Shampoos	0	5	5	(1)	0	(1)	(1)	(1)	8	0	5	5	2	(1)	(1)	0	-	-
Snack Crackers	11	2	2	2	2	3	2	5	1	2	6	2	2	2	2	2	(1)	3
Soaps	1	2	1	1	1	2	1	2	1	1	6	1	1	1	1	1	-	-
Soft Drinks	5	2	9	2	0	1	1	4	3	2	2	5	1	3	3	1	0	(1)
Tooth Brushes	20	1	10	8	2	8	(1)	0	(1)	2	1	1	8	2	2	3	(3)	1
Tooth Pastes	18	6	7	20	6	6	10	8	0	3	6	6	18	10	12	10	1	2
Average	11.3	7.3	6.1	6.7	6.2	6.4	3.8	3.8	3.9	5.2	7.4	4.9	5.9	4.0	4.7	3.9	0.6	9.0

Notes:

1. The figures in the table are asymmetry thresholds.
2. PPI – Producer Price Index, CPI – Consumer Price Index
3. A – PPI without lags; B – PPI 4 week lag; C – PPI 8 week lag; D – PPI 12 week lag; E – PPI 16 week lag;
4. F – CPI without lags; G – CPI 4 week lag; H – CPI 8 week lag; I – CPI 12 week lag; J – CPI 16 week lag;
5. K – CPI-Chicago without lags; L – CPI-Chicago 4 week lag; M- CPI-Chicago 8 week lag; N – CPI-Chicago 12 week lag; O – CPI-Chicago 16 week lag;
6. P – Products for which the first 4 week prices are greater than or equal to the last 4 week prices;
7. Q – First 12 months of the sample period; R – Last 12 months of the sample period.
8. The figures in parentheses indicate a reverse asymmetry. A zero-entry means that there is no asymmetry.

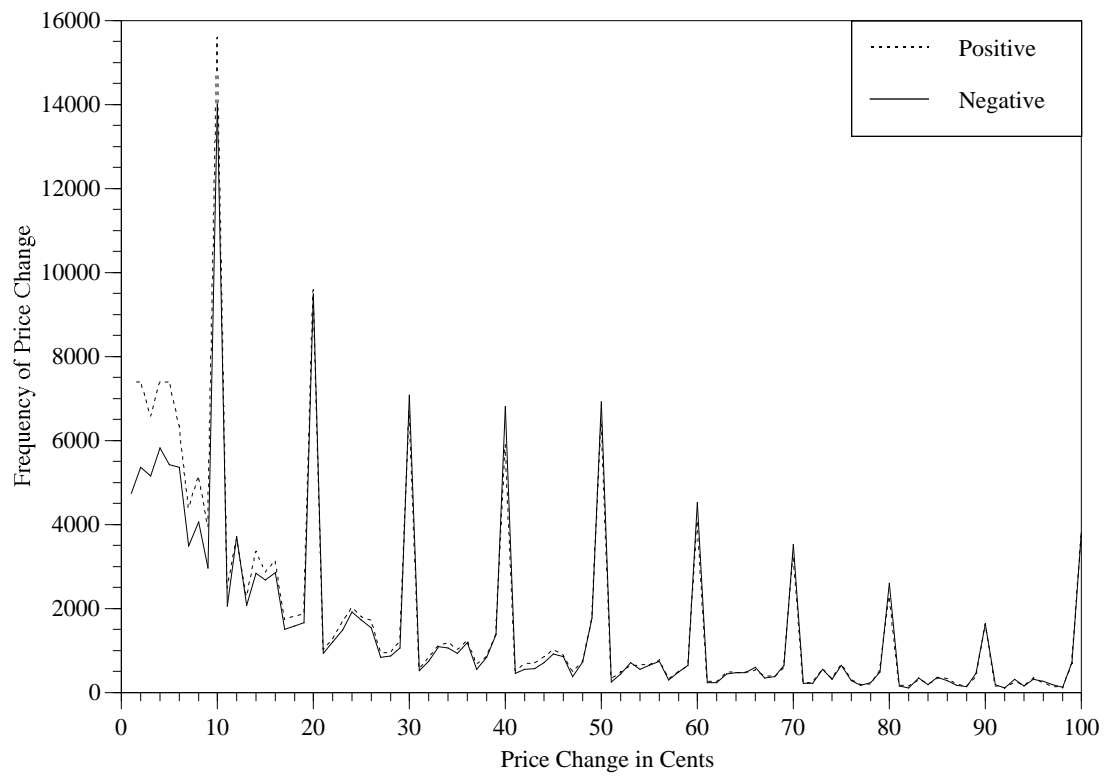


Figure R1. Average Frequency of Positive and Negative Price Changes
All 29 Categories, Low/Zero Inflation Period

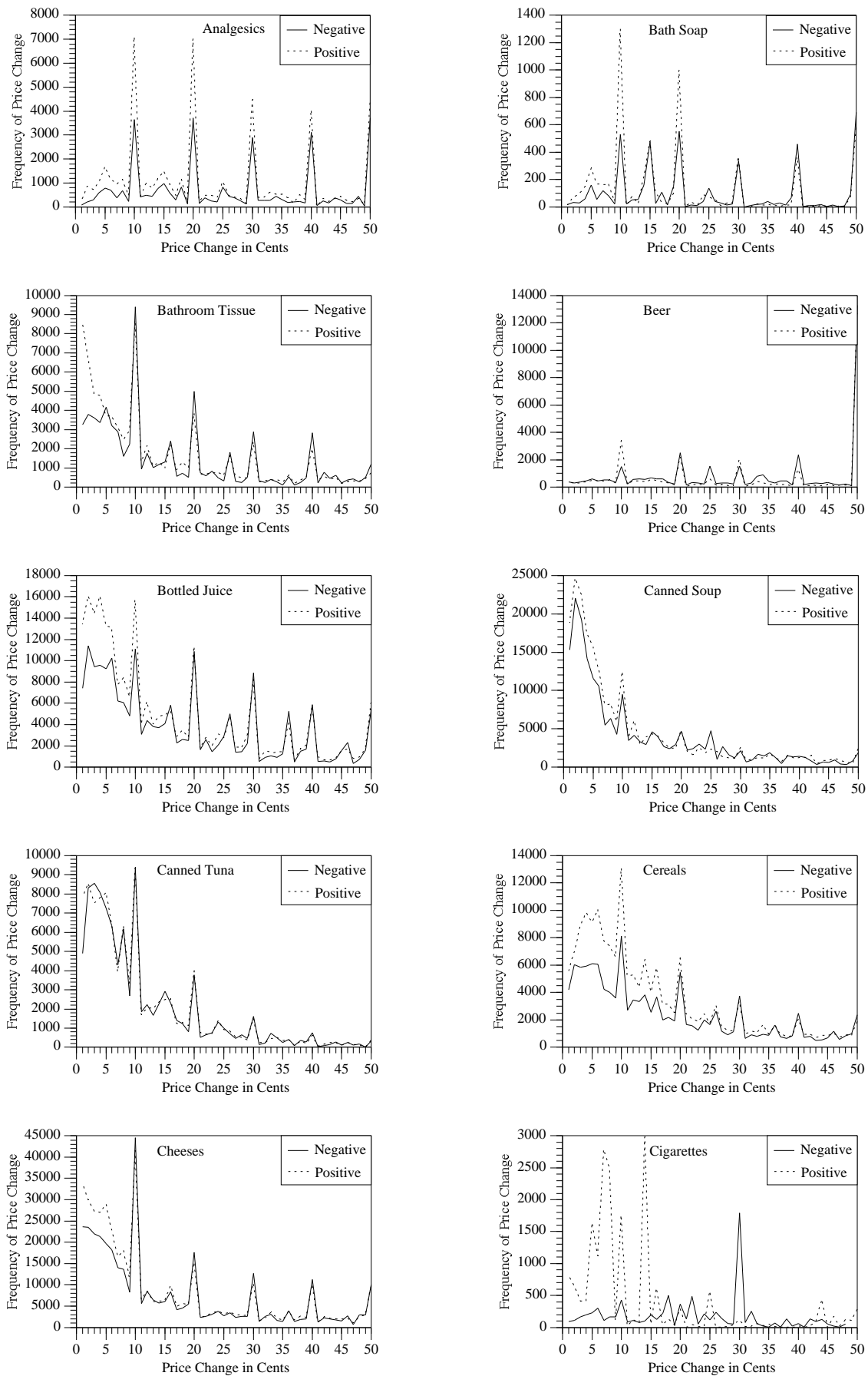


Figure R1.1a. Frequency of Positive and Negative Retail Price Changes in Cents by Category, Low/Zero Inflation Period

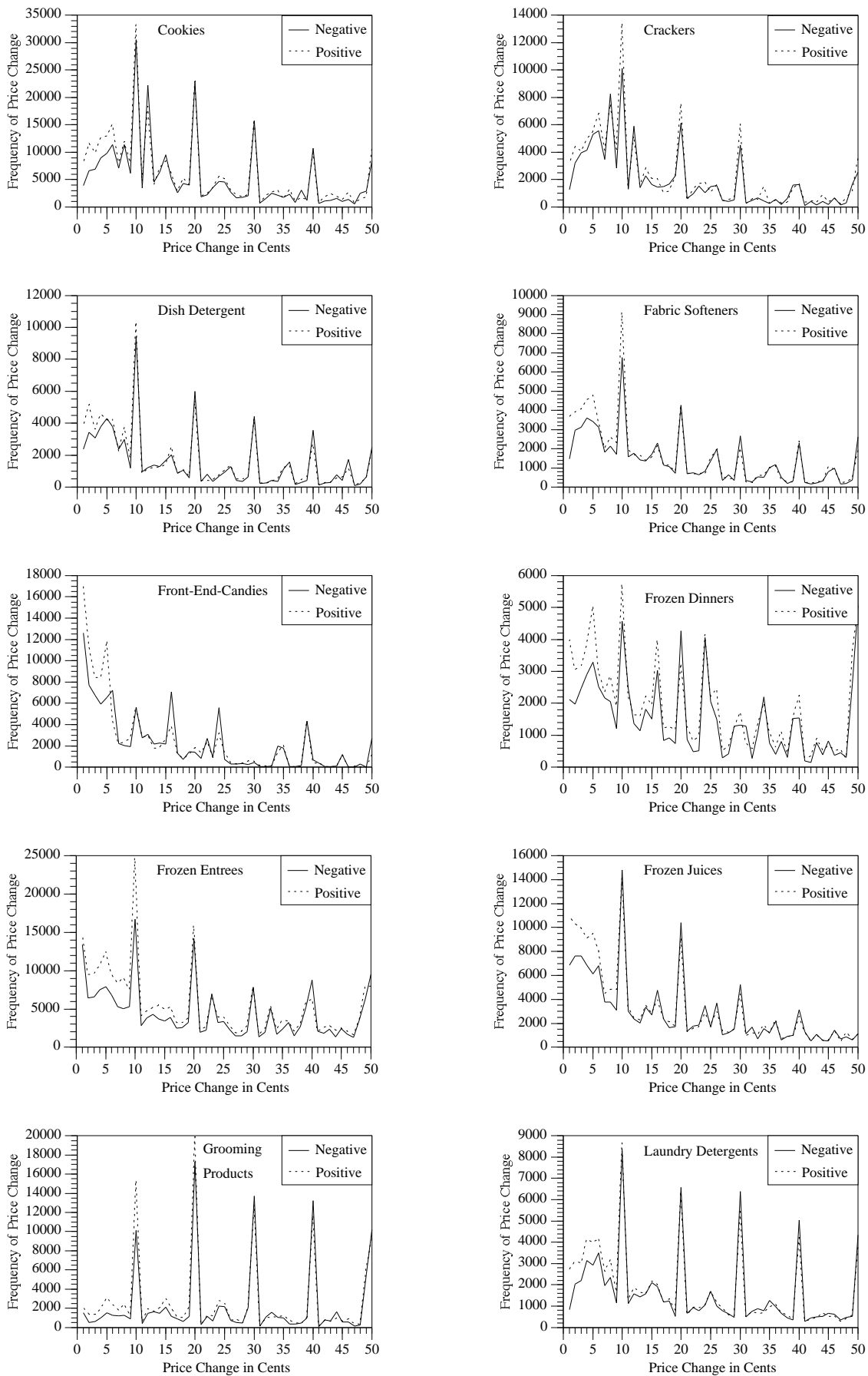


Figure R1.1b. Frequency of Positive and Negative Retail Price Changes in Cents by Category, Low/Zero Inflation Period

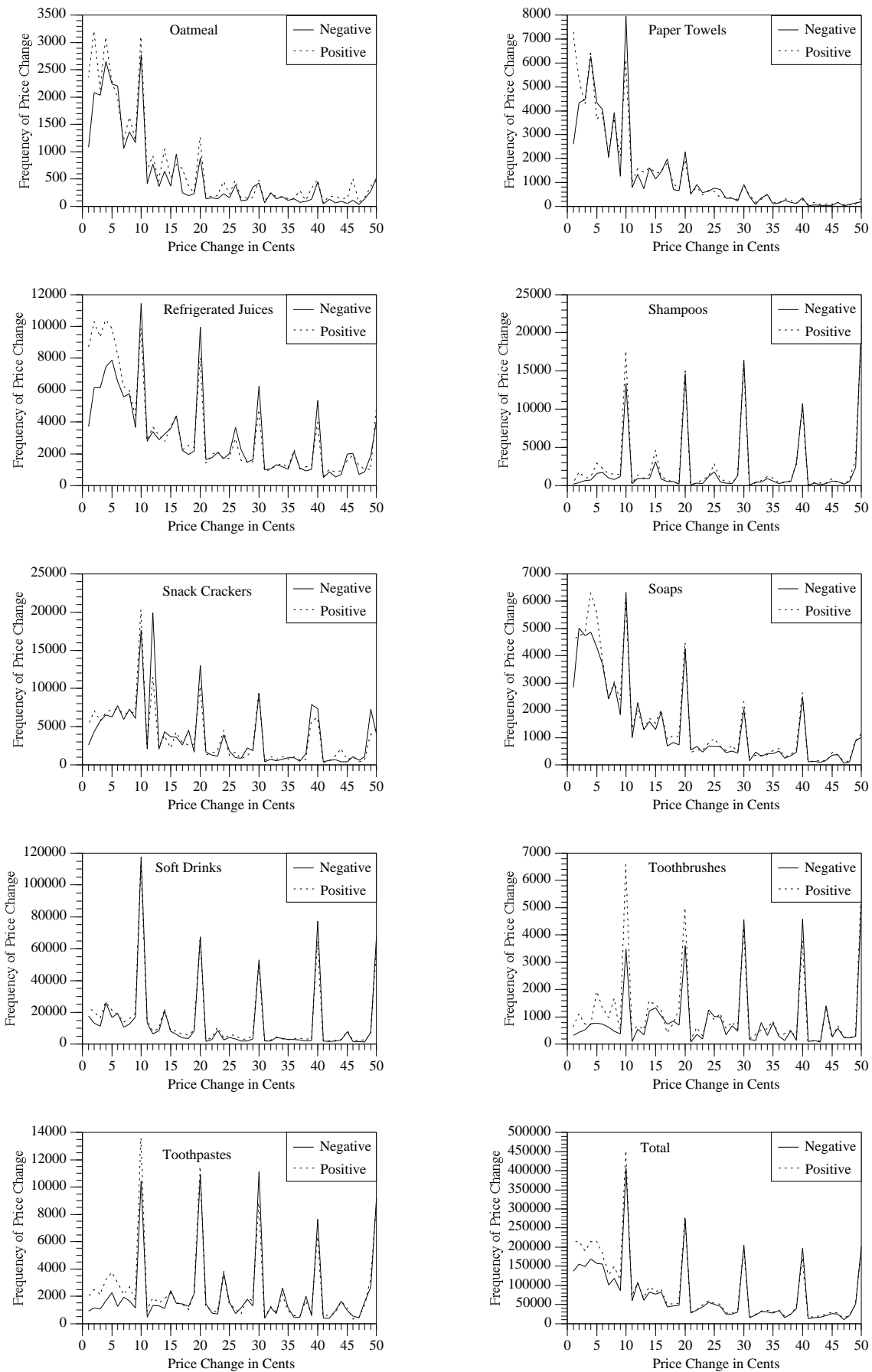


Figure R1.1c. Frequency of Positive and Negative Retail Price Changes in Cents by Category, Low/Zero Inflation Period

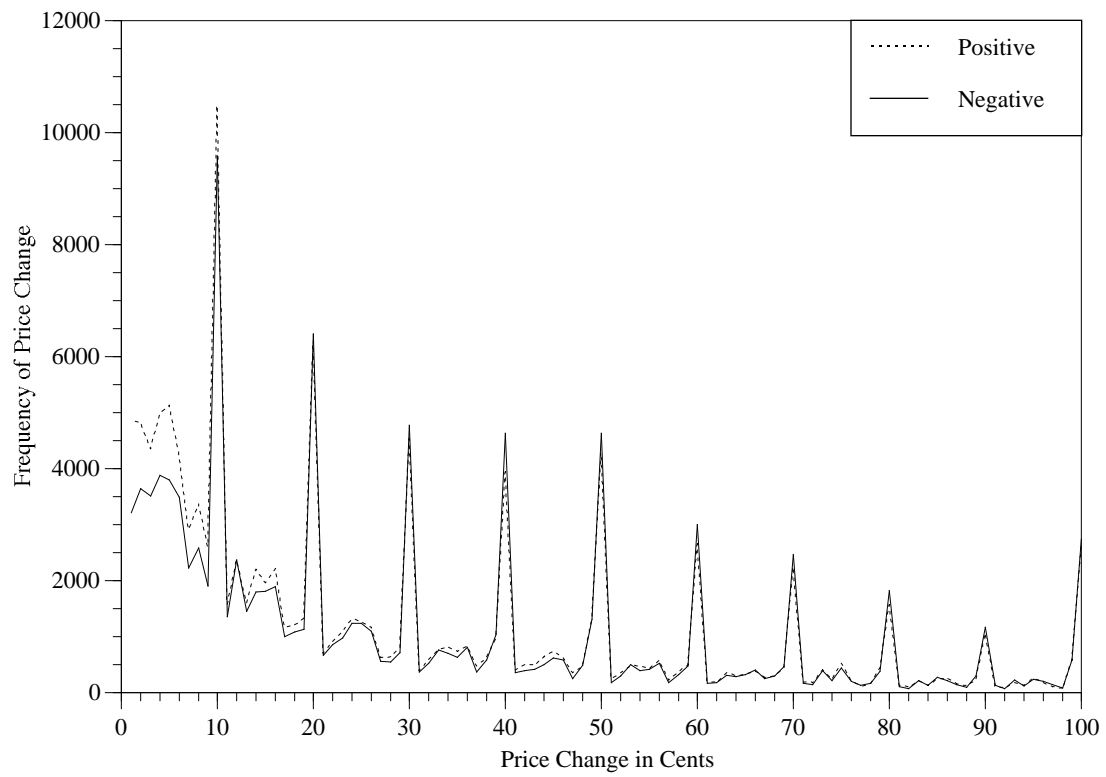


Figure R2. Average Frequency of Positive and Negative Price Changes
All 29 Categories, Deflation Period

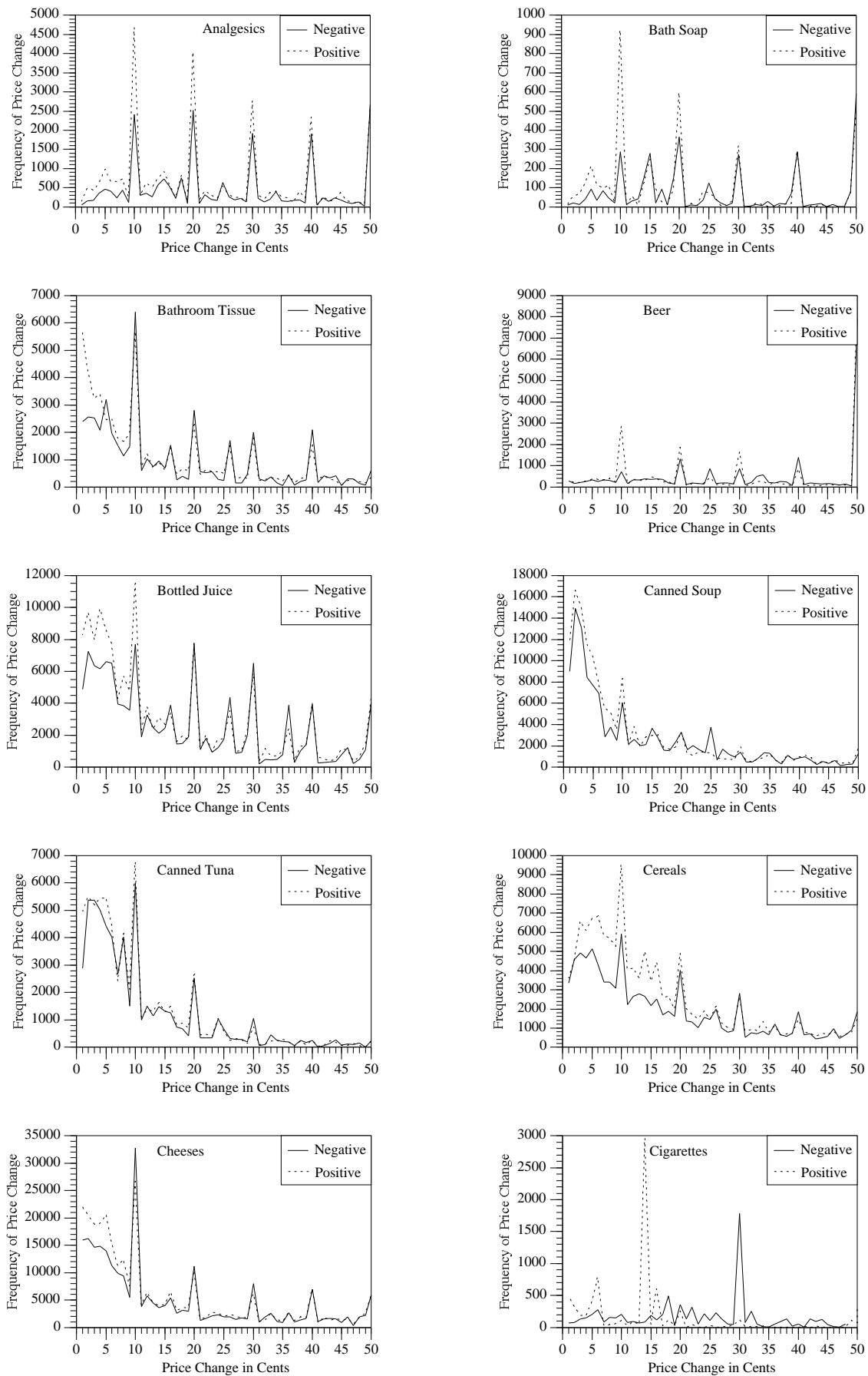


Figure R2.1a. Frequency of Positive and Negative Retail Price Changes in Cents by Category, Deflation Period

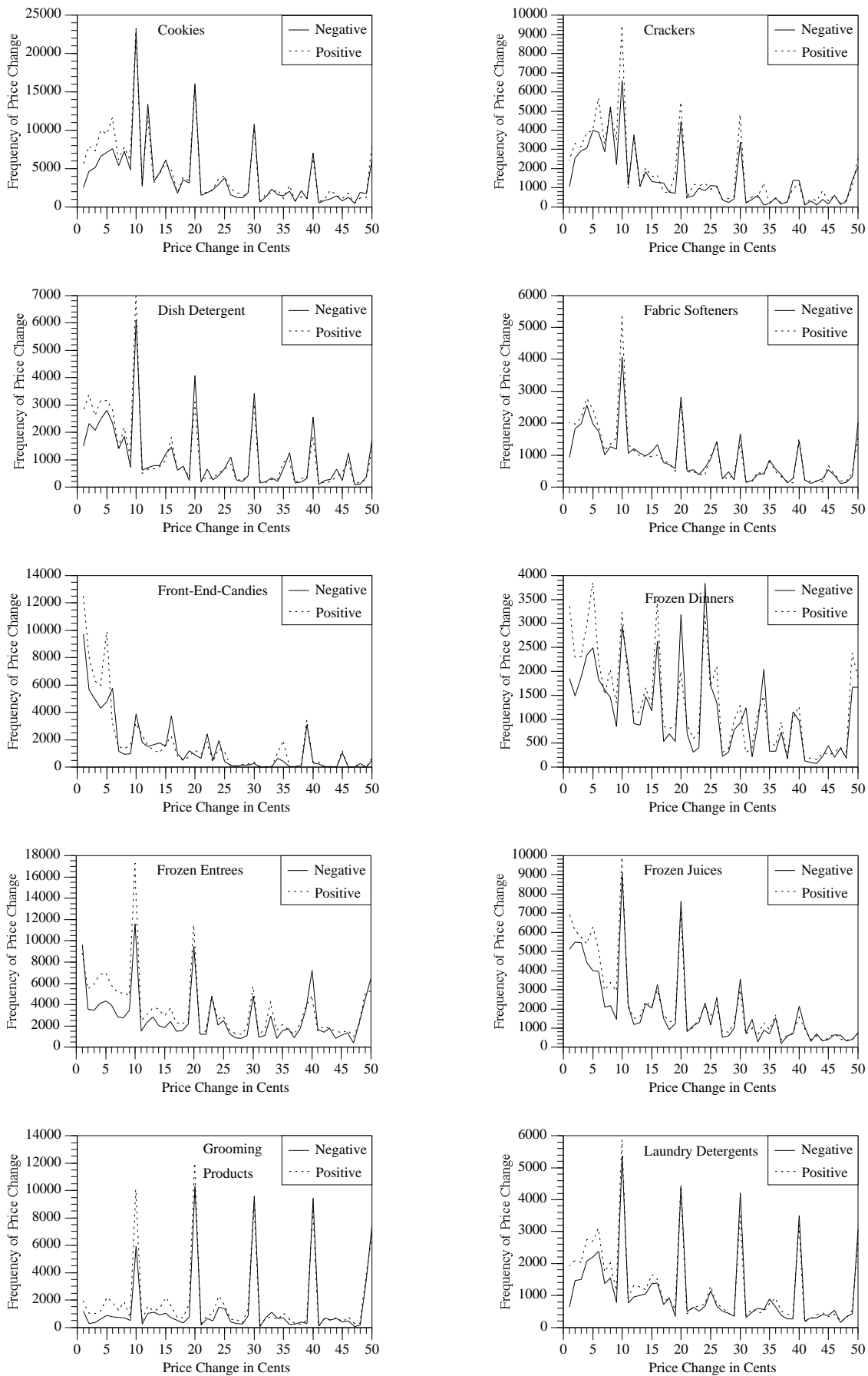


Figure R2.1b. Frequency of Positive and Negative Retail Price Changes in Cents by Category, Deflation Period

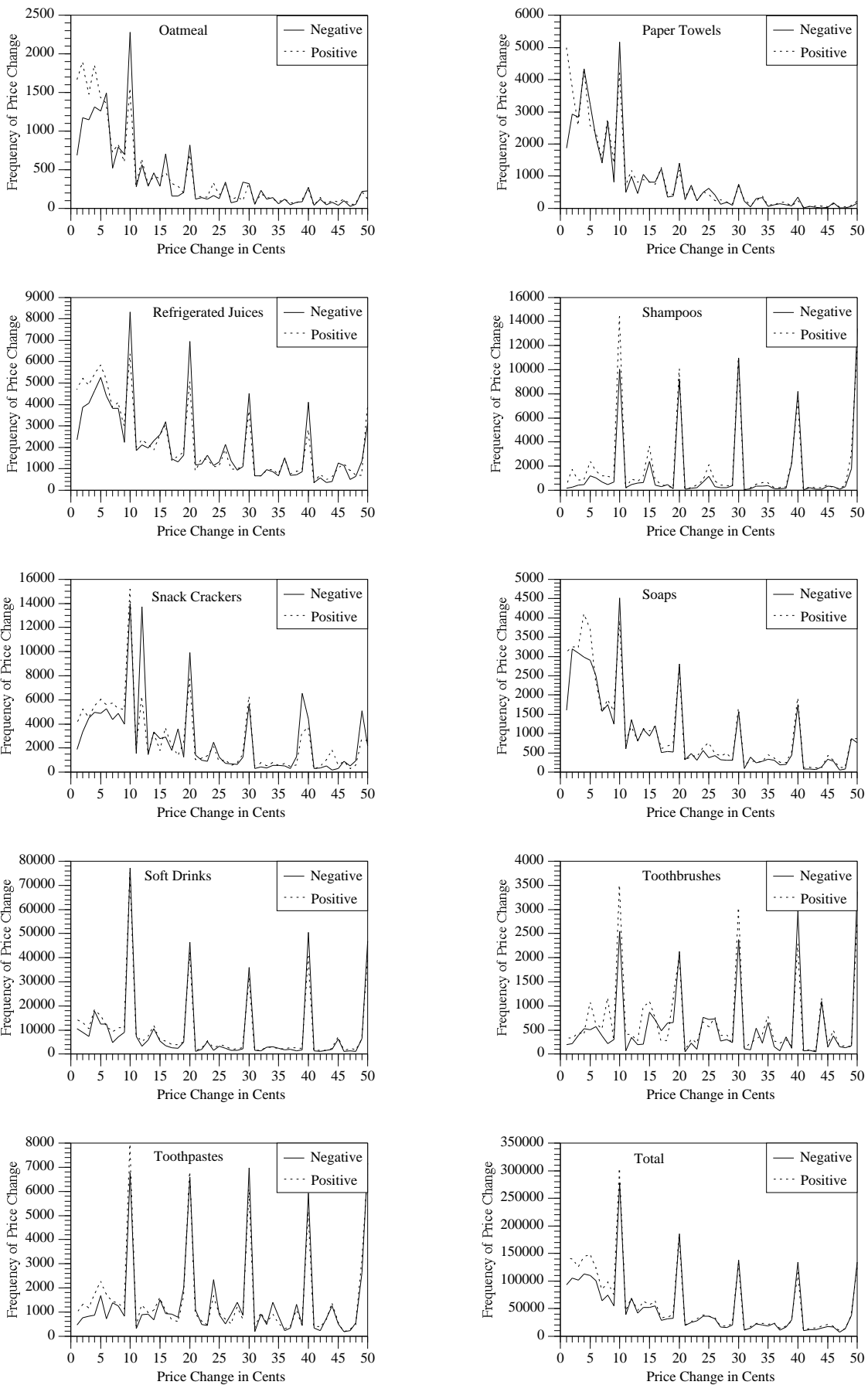


Figure R2.1c. Frequency of Positive and Negative Retail Price Changes in Cents by Category, Deflation Period