

**MAKING SENSE OF IGNORING CENTS:
PRICE POINTS AND PRICE RIGIDITY UNDER RATIONAL INATTENTION**

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ABSTRACT

We explore the relationship between price points and price rigidity using two datasets. One is a large weekly transaction price data set, covering 29 product categories over an eight-year period from a large Midwestern United States supermarket chain. The other comes from the Internet and includes daily prices over a two-year period for a variety of consumer electronic products with a wide range of prices, such as music CDs, digital cameras, DVD players, notebook PCs, etc. Across the two datasets, we find that overall “9” is the most frequently used for the penny, dime, dollar and the ten-dollar digits, and that the most common price changes are those that keep the terminal digits at 9 (e.g., multiples of dimes, dollars, etc). More importantly, when we econometrically estimate the contribution of price points to price rigidity, we find that overall 9-ending prices are at least 24% less likely to change in comparison to the prices ending with other digits. This level of *price point rigidity* is robust across the wide variety of price levels, product categories, retail formats and retailers examined in this study. To explain the phenomenon of 9-ending prices and their link to price rigidity, we extend the implications of the theory of rational inattention to individual price dynamics. We argue that the practice of 9-ending pricing may be an equilibrium outcome of firms’ reaction to their customers’ rational inattention to the rightmost digits of a price. An additional implication of rational inattention is that the popularity of 9-endings might vary across different channels depending on the degree of rational inattention by consumers in a particular channel. For example, it predicts that 9-ending should be more popular among bricks-and-clicks stores and less so among pure Internet retailers, as the Internet affords customers the opportunity to be rationally more attentive about prices because of lower search costs. We find that our Internet data are consistent with this prediction. We conclude by discussing the macroeconomic, business, and information systems (IS) implications of our findings.

“Because individuals have many things to think about and limited time, they can devote only limited intellectual resources to the tasks of data-gathering and analysis. We know from personal experience that many data that we could look up daily, and that are in principle relevant to our optimal economic decision-making, do not in fact influence our behavior, except when they change dramatically, or perhaps when we occasionally set aside some time to re-assess our portfolio.” **Sims (1998, p. 320–321)**

“Buyers may use rules of thumb when searching for items and comparing prices... If firms are aware of this tendency by consumers, they may set prices so as to exploit the use of the rules.” **Kashyap (1995, p. 266)**

“Why are so many items sold for \$2.99 and so few for \$3.00? There is an enormous temptation to attribute this phenomenon to a mild form of irrationality in which consumers notice only the first digit of the price and are lulled into thinking that \$2.99 is ‘about \$2.00’ instead of ‘about \$3.00.’ In fact, this explanation seems so self-evident that even many economists believe it. For all I know, they could be right. Perhaps someday a careful analysis of such behavior will form the basis for a modified economics in which people are assumed to depart from rationality in certain systematic ways.” **Landsburg (1995, p. 15)**

1. Introduction

The recent expansion in the popularity of new Keynesian ideas has led growing number of economists to recognize the importance of understanding the sources of nominal price rigidity.¹ One of the recent additions to the list of the existing theories of price rigidity is *psychological pricing point theory*, which Blinder, et al. (1998) list among the leading twelve-theories of price rigidity. According to Blinder, et al. (1998, p. 26), practitioners’ “...belief in pricing points is part of the folklore of pricing...” Consistent with this observation, they offer evidence from interviews on the importance of price points. For example, in their study of 200 large U.S. firms, they find that 88% of the firms that operate in the retail industry report substantial importance of psychological price points in their pricing decisions.² Similarly, Kashyap (1995) observes that catalog prices have the tendency to be “stuck” at certain ending prices.³ He concludes that the existing theories of price rigidity are unable to explain the specific form of price rigidity he finds. As an alternative explanation, which was suggested by the pricing managers of the mail order companies themselves, he offers the idea of psychological pricing points as a source of price rigidity.

As Blinder, et al. (1998, pp. 25–26) note, however, there are two difficulties with price point theory. First, not much is known about the actual practical importance of price points and their relationship to price rigidity. While the existing literature in economics and marketing offers growing evidence on the use of price points, there is a lack of direct evidence on the link between price points and price rigidity. Besides Kashyap (1995) and Blinder’s (1998) interview study, which although useful, does not offer direct evidence using actual price data, we are not aware of any other study that examines the effect of price points on price rigidity using the US data. Second, no satisfactory economic explanation has been offered for the notion of price

points. Indeed, as Kashyap (1995, p. 266) points out, “there is no tight theoretical justification for this [price point] story.”

We attempt to fill these gaps in the literature using two different datasets. One is a large weekly price data, covering 29 product categories over an eight-year period from a major Midwestern U.S. supermarket chain. The data comes from Dominick’s scanner database and includes actual transaction prices, as recorded by the stores’ cash register scanners. The second dataset comes from the Internet and includes daily prices over a two-year period for a variety of consumer electronic goods with a wide range of prices, such as music CDs, digital cameras, DVD players, notebook PCs, etc. from 293 different e-retailers. Taken together, the two datasets cover a diverse set of products, a wide range of prices, different retail formats, retailers and time periods.

We make two specific contributions to the literature and practice in economics and marketing. First, we explore practical importance of price points and their relationship to price rigidity. We begin by documenting the prevalence of price points in the retail setting. We then consider the size of price changes as a preliminary test of the link between price points and price rigidity. To test this link more directly, we econometrically estimate the probability of a price change in a situation where a product’s price ends with a price point in comparison to other price-endings.

Our main empirical findings can be summarized as follows: (i) We find that across the two datasets, “9” is the most popular for the penny, dime, dollar and the ten-dollar digits. We also find that (ii) the most common price changes are those that keep the terminal digits at 9 (e.g., multiples of dimes, dollars, tens of dollars, etc.). This result points to the significance of 9-endings as a barrier to price changes. And (iii) given the particular significance of 9-ending prices in our data, we quantify their effects on price rigidity, and find that across the two datasets, 9-ending prices are at least 24% less likely to change than prices with other endings.

Second, we develop a theoretical explanation for these empirical findings based on the emerging literature on *rational inattention* in economics. This is a departure from the explanations commonly offered by the existing marketing literature and by practitioners. They usually link the practice of using price points with various forms of what economists might call “money illusion.” In our theory, 9-ending prices are an equilibrium outcome of the firms’ optimal reactions to their consumers’ rational inattention to the rightmost digits of a price. This

theory predicts that the price setters take advantage of their consumers' inattention by setting the rightmost digits of their price to the highest possible number (i.e., 9) and keeping them at 9 if possible. This theory also predicts a variation in the use of 9 price-endings across different channels depending on the degree of rational inattention that prevails in a particular channel. For example, the increased ease of comparing prices due to lower search costs on the Internet may afford consumers the opportunity to be more attentive, thus reducing retailers' incentive to set those digits at 9. This variation in the degree of rational inattention implies that 9-ending prices should be more popular among bricks-and-clicks (B&C) stores and less so among the pure Internet (PI) retailers. We find that our Internet data are consistent with this prediction.

The paper is organized as follows. The two datasets are described in Section 2. In Section 3, we document the popularity of 9-endings by examining the frequency distribution of price-endings in the two datasets. In Section 4, we examine the frequency distribution of price changes by size and assess the extent to which they maintain the 9-endings. In Section 5, we explore econometrically the effect of 9-endings on the retail price rigidity. In Section 6, we offer a rational inattention explanation for the 9-ending pricing and price rigidity patterns that emerge from our analysis. In Section 7, we discuss the implications of our findings for the economics, marketing and information systems (IS) literatures.

2. Two Datasets

Blinder, et al. (1998, p. 177) suggest that the most obvious prediction of the price point theory is that price points should be most important in retailing, and more generally, to firms that sell mostly to consumers rather than to other businesses. Following this line of thought, we examine two different *retail* price datasets. One is Dominick's weekly transaction price data for 29 product categories over an eight-year period, and the other consists of daily prices from the Internet on hundreds of products varying from music CDs to notebook PCs. Taken together, the two datasets cover a variety of products, a wide price range, and different retail formats. In addition, although Dominick's is a retail grocery chain where prices are mostly set on a chain-wide basis at the corporate headquarters, our Internet data come from 293 different retailers employing different pricing-decision models. Our use of two datasets allows us to draw general conclusions that are not specific to a retail format, retailer, product, price range or time period.

Dominick's Finer Food (DFF) is one of the largest retail supermarket chains in the Chicago metropolitan area, operating about 100 stores with a market share of about 25%. The pricing practices of Dominick's are similar to those employed by large U.S. retail supermarket chains. The chain we study is representative of a major class of the retail grocery trade. The data consist of up to 400 weekly observations of retail prices in 29 different product categories, covering the period from September 14, 1989 to May 8, 1997. In Table 1, we provide descriptive statistics for weekly retail price observations by each product category contained in this data set. The retail prices are the actual transaction prices (i.e., the price customers paid at the cash register each week as recorded by the chain's scanners). If an item was on sale, then the price data we have reflects the sale price. Also, the retail prices reflect retailer's coupons or discounts, but not manufacturers' coupons. In the analysis described below, we have used all the data available from all stores, yielding a total of over 98 million weekly price observations. Dominick's data also contains a binary variable indicating whether a given product on a given week was on sale or on promotion. We use this information in the probabilistic model estimation in Section 5, to account for the effect of sales on the likelihood of a price change. See Chevalier, Kashyap, and Rossi (2003) for more details about Dominick's data.

The Internet price data were obtained through the use of a price information gathering agent. It was programmed to systematically mine price data from www.BizRate.com, a popular price comparison site, and ran daily from 3:00 a.m. to 5:00 a.m. From a list of products available at BizRate.com, we generated a large sample of product IDs using stratified proportionate random sampling (Wooldridge, 2002). The software agent then automatically built a panel of selling prices given the product ID's that cover different products and different online retailers over time.⁴ The Internet data consist of 743 daily price observations of 474 personal electronic products in ten product categories, from 293 different Internet-based retailers, over a period of more than two years from March 26, 2003 to April 15, 2005. The categories include music CDs, movie DVDs, video games, notebook PCs, personal digital assistants (PDAs), computer software, digital cameras and camcorders, DVD players, PC monitors, and hard drives.⁵ Table 2 presents descriptive statistics of the Internet price data.

3. Evidence on the Popularity of 9-Ending Prices

We next present results on the frequency distribution of price-endings in the two datasets. In the analysis of Dominick's data, our focus is on 9¢ and 99¢ price-endings because the overwhelming majority of the prices in retail grocery stores are well below \$10.00.⁶ In our Internet data, in contrast, the prices range from \$5.49 to \$6,478.00, with the average prices in different categories spanning \$12.90 to \$1,694.58. Given the wider price range of the Internet data, we focus not only on 9¢ and 99¢ price-endings, but also on other 9-ending prices in *both* the cents and the dollars digits, including \$9, \$9.99, \$99, and \$99.99.

In Figure 1, we report the frequency distribution of the last digit in the entire Dominick's data. If a digit's appearance as a price-ending was random, then with ten possible endings, we should see 10% of the prices ending with each. As the figure indicates, however, about 65% of the prices end with 9. The next most popular price-ending is 5, accounting for about 11% of all price endings. Only a small proportion of the prices ends with the other digits. The pattern is very similar at the category level, with 9 as the most popular price-ending for all categories except cigarettes.⁷

Next, we consider the frequency distribution of the last two digits (see Figure 2). With two digits, there are 100 possible endings, 00¢, 01¢, ..., 98¢, and 99¢. Thus, with a random distribution, the probability of each ending is only 1%. However, that is not what we find in the data. According to Figure 2, most prices end with either 09¢, 19¢, ..., or 99¢, which is not surprising given the finding that 9 is the dominant single-digit ending. But of these, more than 15% of the prices end with 99¢. In contrast, only 4% to 6% of the prices end with 09¢, 19¢, ..., and 89¢, each. We found a similar pattern for individual categories.⁸

Turning to the Internet data, Figure 3 displays the frequency distribution of the last digit in the Internet data. According to the figure, 9 is the most popular terminal digit (33.4%), followed by 0 (24.1%), and 5 (17.4%). The frequency distribution of the last two digits exhibits a similar pattern (see Figure 4), with 99¢ as the most popular price-ending (26.7%), followed by 00¢ (20.3%), 95¢ (13.8%), and 98¢ (4.8%).

Compared to the Dominick's dataset, the Internet dataset also includes some high-price product categories, which allows us to examine price-endings in dollars. In Figure 5, we present the frequency distribution of the last dollar digit in the Internet data. When all product categories are combined, 9 is the most popular ending for the dollar digit, with \$9 price-endings

over-represented with 36.1%, followed by \$4 price-endings with 9.9%, and \$5 price-endings with 9.2%. A similar pattern emerges for the last two dollar digits (see Figure 6). Not surprisingly, the last two dollar digits of most prices contain “9,” such as \$99, \$89, and \$09. But more prices end with \$99 than any other “9” price-endings. Moreover, almost 10% end with \$99 among the 100 possible dollar endings (i.e., 0 through 99).

We also examined the frequency distribution of the last three digits of prices in the Internet data.⁹ Overall, when all ten product categories are combined, as reported in the last column of Table 3, \$9.99 is the most popular ending for the last three digits (13.2%), followed by \$9.00 (10.0%), and \$9.95 (4.9%).¹⁰ Finally, when we examine the last four digits of the prices, for all ten product categories combined (see the last column of Table 4), \$99.99 is the most popular ending for the last four digits (3.47%), followed by \$99.00 (3.46%), and \$19.99 (2.16%).¹¹

Individual product categories in our Internet data exhibit large variations in the use of 9 as price-endings. For example, for the dollar-digit, \$3, \$4 and \$5 price-endings are the most common for the categories of CDs and DVDs because prices of CDs and DVDs are often between \$13 and \$16. And for last two digits the \$99-ending is not common at all in those two categories and the category of video games. Similarly, for these three categories, \$99.99 did not make it to the top 10 list with regard to the frequency distribution of the last four digits of prices (see Table 4). We note, however, that the average prices in these three product categories are far less than \$100 (i.e., \$13.46 for CDs, \$27.43 for DVDs, and \$30.83 for video games), and the maximum prices of CDs (i.e., \$26.98) and video games (i.e., \$57.99) are also well below \$100. So, it should not be surprising that we do not see a lot of 9-endings for the dollar and ten-dollar digits in those product categories.

To summarize, in both datasets, 9 is the most popular terminal digit overall, and the popularity of 9 is not limited to the penny-digit; it is present in the dime, dollar, and ten-dollar digits. Because our data include a variety of products with a wide range of prices and different retail formats, we conclude that the use of 9 as a terminal digit is prevalent in our data sets.¹²

4. Frequency Distribution of Price Changes by Size

Having documented the dominance of 9 as the terminal digit in both datasets, we next focus on the relationship between price points and price rigidity. As Kashyap (1995) points out, the frequency distributions of price points will be of particular interest to macroeconomists and monetary economists if they have dynamic consequences. Our goal, therefore, is to assess to what extent the specific price point we have identified in our data may be contributing to the retail price rigidity.

Since 9 is the most popular terminal digit, we suspect that the frequency distribution of price changes is not random. Prices should change in such a manner that the terminal digits are kept at 9. So, we will be more likely to observe price changes that are in multiples of dimes, dollars, ten-dollars, etc. First, we consider the frequency distribution of price changes in Dominick's data. Figure 7 displays the frequency distribution of price changes in cents. Notice that although the actual price changes occasionally go over \$1.00, there are very few of them. Therefore, we limit our analysis to the occurrence of price changes up to \$1.00. As expected, price changes that are multiples of dimes are most common among all possible price changes. In fact, a simple calculation shows that over 35% of the price changes are multiples of 10 cents.¹³

For our Internet data, the observed price range is much wider and we observe a much wider range for price changes as well. The price changes vary in magnitude from 1¢ to \$1,568, but as expected the most common changes are in multiples of dollars—and consequently, in multiples of dimes. As shown in Table 5, among the top ten most common changes in this dataset, eight are multiples of dollars, and nine are multiples of dimes. The only exception is 1¢, which is ranked at 10. The analysis of individual product categories yields similar results. Thus, similar to Dominick's dataset, the sizes of price changes are such that they preserve the 9-ending prices.

Because of the wider range of price changes found in the Internet data, the ten most common price changes only account for less than 30% of all price changes. To better identify the prevalence of price changes in multiples of dimes, dollars, and tens of dollars, we categorize price changes based on how many digits in a price are affected by a price change (i.e., whether it affects the penny digit only, the penny and dime digits, or the penny, dime and dollar digits, etc.). For example, if we focus on price changes affecting the penny digit only, we can group all possible price changes into ten categories: those that change a price by 0¢, 1¢, ..., 9¢. In the first

group will be price changes in multiples of dimes (excluding 0¢ where a price does not change); in the second group, 1¢, 11¢, ..., 91¢, \$1.01,, etc. Similarly, we can group price changes into 100 groups based on how they affect the penny and the dime digits, one of which will be the category into which all price changes in multiples of dollars fall (again, excluding 0¢ where price does not change). Finally, we can group price changes into 1,000 groups based on how they affect the penny, dime and dollar-digits, one of which will be the category into which all price changes in tens of dollars fall (again excluding 0¢, where price does not change).

When we categorize price changes in this manner, we find that when all product categories are combined, price changes in multiples of dimes are the most frequent among the ten possible changes to the penny digit, accounting for 55.12% of all price changes. In addition, we find that among the 100 possible changes to the penny and dime digits, the most popular ones are multiples of dollars, which account for more than 42.86% of all changes. Finally, among the 1,000 possible changes to the last three digits, multiples of ten dollars are the most common, accounting for 9.60% of all changes. Similar results are obtained for individual product categories. Changes in multiples of dimes and in multiples of dollars are the most common for all ten product categories in our dataset. Changes in multiples of ten dollars are the most common for seven product categories (hard drives, software, PDAs, DVD players, PC monitors, digital cameras, and notebook PCs).¹⁴ Based on the above results, we conclude that when prices change, they most likely change in multiples of dimes, multiples of dollars, or even in tens of dollars. Consequently, the terminal digits are kept at 9 even after a price change. This is an indication that terminal prices are stuck at 9 and 9-ending price points form barriers to price adjustment.

5. The Effect of Price Points on Price Rigidity

A firm's decision on whether to change its prices can be modeled with a binary choice model. To explore the contribution of 9-ending prices to price rigidity, we use a binomial logit model to estimate the price change probabilities. A logit model maintains logical consistency with the estimation of a 0/1 dependent variable, and provides an effective means to gauge the marginal effects via the odds ratio (Agresti, 2002, Hosmer and Lemeshow, 2000).¹⁵ As with the linear probability model, the disturbance terms in a logit model exhibit heteroskedasticity

(Greene, 2003). So instead of using ordinary least squares (OLS), we use maximum likelihood estimates (MLE) to correct this defect. The full form of the binomial logit model is:

$$\ln(q/(1-q)) = a + bD_{9-Ending} + cD_{OnSale} + e_t \quad (1)$$

where q is the probability of a price change, $D_{9-Ending}$ is a *9-Ending* dummy variable which equals 1 if the price ends with 9 (i.e., *9¢-Ending* or *99¢-Ending*) and 0 otherwise, and D_{OnSale} is an *OnSale* dummy variable which equals 1 if the product is on sale in a given week and 0 otherwise. The regression equation includes the *OnSale* dummy because, according to Schindler (2003) and Anderson and Simester (2003), prices ending with 9 may be related to sales, and sale prices are more likely to change than regular prices. Indeed, if we consider a sample series of Frozen Concentrate Orange Juice, Heritage House, 12oz (UPC = 3828190029 from Store No. 78), which is plotted in Figure 8, it is clear that sale prices are always reversed, unless there is a rare change in the list price. In the sample of 400 observations shown in this figure, there are only about fourteen to sixteen changes in the list price. By including the *OnSale* dummy, we account for any potential effect of sale when estimating price change probability.

The estimation results for Dominick's data are reported in Tables 6 and 7. In Table 6, we report the estimated coefficient of each dummy along with the odds ratio that the estimated coefficients imply. The coefficient estimate on the *9-Ending* dummy is negative, and the coefficient estimate on the *OnSale* dummy is positive for all 27 product categories as expected (all p -values < 0.0001). The odds ratios, which equal $e^{\text{coefficient}}$, are all smaller than 1 for the *9-Ending* dummy, indicating that prices that end with 9¢ are less likely to change than prices that do not end with 9¢. On average, prices that end with 9¢ are more than 40% less likely to change than prices that do not end with 9¢. As expected, sale prices are about 65 times more likely to change than regular prices.

When we examine the 99¢-ending prices, we obtain similar results. Specifically, all coefficient estimates on the *99¢-Ending* dummy are negative and significant (see Table 7), and therefore, the odds ratios are all smaller than 1 for the *99¢-Ending* dummy. This indicates that prices that end with 99¢ are less likely to change than prices that do not end with 99¢. In fact, on average, prices that end with 99¢ are 24% less likely to change than prices that do not end with 99¢. Also, all product categories showed positive and significant coefficients on the *OnSale* dummy, and sale prices are about 67 times more likely to change than regular prices.

Next, we estimate the same logit regression model for the Internet data, but now we use 9¢, 99¢, \$9, \$9.99, \$99, and \$99.99, in turn, as the independent variable. We did not include an *OnSale* dummy in these regressions as such information was not available in our data. The results of the logit regression for each independent variable are reported in Table 8. Similar to what we found with Dominick’s data, 9-ending prices are less likely to change than other prices. Overall, 9¢-ending prices are 31.90%, 99¢-ending prices 44.59%, \$9-ending prices 45.89%, \$99-ending prices 59.74%, \$9.99-ending prices 58.90%, and \$99.99-ending prices are 72.87%, less likely to change than other prices.¹⁶

6. An Explanation: Rational Inattention

What makes 9-ending prices so popular? Why are 9-ending prices more rigid? The phenomenon of 9-ending prices has received considerable attention in the marketing literature, where most studies explain the 9-ending pricing phenomena on psychological grounds.¹⁷ For example, according to Nagle and Holden (1995, p. 300), buyers perceive the 9-ending prices (which Nagle and Holden term “odd-number pricing”) “... as significantly lower than the slightly higher round numbers that they approximate.” They suggest that consumers may have learned to associate odd-ending prices with discount prices, and therefore, the 9-ending prices draw their attention. As another example, Schindler and Kirby (1997) propose two models to explain the popularity of 9-ending prices. Their first model, based on Kahneman and Tversky’s (1979) prospect theory, posits that consumers perceive a 9-ending price as a round-number price with a small amount given back, and that due to the prospect theory’s nonlinear value function, they perceive the 9-ending price to be more attractive than the round-price. In their second model, consumers underestimate a 9-ending price by encoding it as the first round number that comes to mind when they see the number 9 during left-to-right processing. Their data on retail price advertising lends support to their second model.¹⁸

All these explanations, however, assume some form of irrational behavior, as Shy (2000) argues. Could it be that 9-ending prices have a more rational explanation, as Landsburg’s opening quote in this paper suggests?¹⁹

6.1 *Customers’ Rational Inattention to the Terminal Digit of a Price*

We argue that frequent use of 9-ending prices and their link to price rigidity may be an

outcome of firms' optimal reactions to consumers' rational inattention to the rightmost digits of prices. The need for rational inattention by consumers arises for at least two reasons. First, consumers face huge amounts of information, which is costly to gather, absorb, and process. Second, consumers have time, resource, and cognitive information processing-capacity constraints. We know from personal experience that these constraints are common to most decision-makers, and especially to shoppers, in many settings.²⁰

The idea of rational inattention follows naturally from these information processing requirements, and the scarcity of the resources needed, as Sims' (1998) opening quote in this paper suggests.²¹ It also is consistent with suggestions by scholars already working in this area, such as Kashyap (1995, also quoted at the outset in this paper), who identified rules of thumb that buyers use, and firms' reactions to them as promising directions to explore. It also builds on emerging work in economics that assume departures from full rationality. Some of these papers are successful in explaining a wide range of phenomena, such as inflation (Akerlof, et al., 2000, Reis, 2005), monetary policy (Woodford, 2001, Ball, et al. 2005), macroeconomic prediction (Sims, 2003), consumption (Ameriks, et al., 2003, Reis, 2004), and customer antagonization (Rotemberg, 2003). We follow the above studies in assuming systematic departure from full rationality. We differ from those studies in that they focus on macroeconomic implications of rational inattention. We focus on the *implications of rational inattention for individual and firm price dynamics*.

Consumers with limited time and cognitive information processing-capacity constraints, who face a complex environment, such as an assessment and comparison of the prices of dozens and sometimes hundreds of products, will tend to use time-saving devices such as simplified rules, in gathering and processing price information. In other words, they will rationally choose to be selective in the nature and amount of the information they collect and use. Like any other choice, rational consumers will decide to devote time and resources to gathering and processing price information up to a point at which the marginal benefit equals the marginal cost.²² We, therefore, posit that it might be rational for consumers to ignore some price information.²³ Consistent with this logic, for example, Levy, et al. (2005) observed that the customer might ignore and not react to small price changes, because the costs of processing and reacting to small price changes might outweigh the benefits.

We argue that the benefit of paying attention to each additional digit of a price declines

as we move from left to right. On the other hand, since people usually process multi-digit numeric information (including prices) from left-to-right (Hinrichs, et al., 1982; Poltrock and Schwartz, 1984, and Lambert, 1975), the effort needed to recognize, process, and recall numeric information increases as the number of digits increases. In other words, the marginal cost of processing each additional digit increases as we move from left to right. Because the marginal benefit of the last digit is the lowest, and the marginal cost of processing and recalling it is the highest, the gap between the cost and benefit will be the greatest for the last digit, making it the least valuable among all digits. That is, the last digit will offer the consumer the lowest net marginal value. This will give the time-pressed consumer an incentive to ignore the last digit.²⁴

6.2 *The Firm's Reaction to Consumers' Rational Inattention and Price Rigidity*

Now, consider a price-setter, for example a supermarket price manager, who recognizes that her customers are rationally-inattentive to the last digit of her prices. How will such a price-setter price? Knowing that many of her customers ignore the last digit in the price figures, she will have an incentive to make the last digit as high as possible, and therefore, she will set it equal to 9. In other words, rational inattention to the last digit will lead to the popularity of 9¢-ending prices. Given the firm's reaction to its customers' inattention to the last digit of the price, rational consumers will expect that the firms will set it equal to 9. So, both firms and consumers will rationally expect that the ignored digit will be set equal to 9. Thus, 9¢ price-endings may be a rational expectations equilibrium outcome.

While many (perhaps even most) people will be rationally-inattentive to the price's last digit because of its low net marginal value, the net marginal value of each digit and the consumers' incentive to be rationally attentive will increase as we move from the rightmost digit to the left. As a result, the optimality of 9 diminishes. This implies that for the rightmost two digits we should still see more 99¢ endings than 89¢, 79¢, ..., 09¢ endings. But the dominance of 99¢ over 89¢, 79¢, etc. should be weaker than the dominance of 9¢ over 8¢, 7¢, and so on. This process will continue towards the dollar-digit as well as the ten-dollar digit. Indeed, this is what we observe in both Dominick's data (65% for 9¢ vs. 15% for 99¢) and our Internet data (31.9% for 9¢, 26.3% for 99¢, 13.5% for \$9.99, and 3.9% for \$99.99).²⁵

Now consider the implications of rational inattention for price rigidity. The idea of rational inattention as discussed above suggests that there will be a discontinuity in price

adjustment within the range of rational inattention. When changes in market conditions are not large enough to warrant a price change larger than the range of inattention based on the ignored digit, firms may be rational not respond to changes in these market conditions. For example, when the price-setter is facing a price change decision that requires a price increase from \$1.79 to \$1.80, the increase may not be optimal if the customers ignore the last digit and perceive the change to be bigger (i.e., as a 10¢ increase) than it actually is. Similarly, a price decrease from \$1.79 to \$1.78 may not have any effect on the demand if consumers ignore the last digit. Therefore, 9¢-ending prices will lead to more price rigidity when customers are rationally-inattentive to the last digit.

However, when a price change is justified, then in a world with rational inattention, the price-setter will have an incentive to make price changes in multiples of 10¢. For example, a firm that faces a series of 1¢ cost increases may not change its price for many periods, but when the firm does react, it may increase the price by 10¢, even though the cost increase in that particular period was only 1¢. In other words, the store could change the price from \$1.79 to \$1.89, instead of to \$1.80, without any additional cost, but with much higher benefit. That would be true even in a world with costs of price adjustment (Mankiw, 1985), because of the largely fixed nature of such costs in the U.S. retail supermarket and drugstore industries (Levy, et al. 1997, 1998; Dutta, et al. 1999).

6.3 *Variations in Rational Inattention and the Use of 9-ending Prices across Channels*

It is not unreasonable to expect variations in the level of rational inattention across consumers, categories and buying contexts. As a result, there might be variations in the popularity of 9-ending prices across different channels. For example, in channels where consumers have a limited opportunity to be attentive, we would expect to see more 9-ending prices. In contrast, in channels where consumers have a greater opportunity to be attentive, we would expect to see fewer 9-ending prices.

The world of Internet-based selling is a transformed environment of mercantile exchange. More than any other conclusion that observers have drawn about e-commerce, the common wisdom is that the technologies of the Internet have led to greater transparency, more widespread dissemination of information, and increasingly similar information about many elements of product, price and market competition that are readily available to rivals. This has

been to the great benefit of consumers, who are now better informed about the opportunities they have to make value-maximizing purchases in the marketplace than ever before (Kauffman and Lee, 2005). So, consumers on the Internet can easily compare prices and trace product information. In short, processing price information is much less costly on the Internet. With the use of Internet as a new channel, especially the existence of shopbots that allow consumers to see different prices side-by-side, consumers' search costs are tremendously reduced (Bakos, 1997, Varian, 2000). As a result, comparing prices across retailers on the Internet is much easier than in traditional non-e-commerce environments. Technologies, such as shopbots and search engines, provide a basis for consumers to be able to achieve a higher level of attention to price—if they choose to use them. In other words, consumers who shop on the Internet should have better opportunities to use all the digits of a price in making purchase decisions. Because of this increased incentive to be attentive to all digits in a price, we expect the use of 9 in price-endings to be less, and the prices to be less rigid on the Internet.

Although we do not have matching price data from Internet and bricks-and-mortar (B&M) stores, our Internet data can accommodate a test of the variation in 9-ending prices by comparing prices offered by bricks-and-clicks (B&C) retailers and pure Internet (PI) retailers. We argue that the prices of the B&C retailers should behave similarly to those of the traditional B&M retailers. This is because the Internet does not necessarily reduce the managerial costs for price changes due to the integration efforts of a firm's Internet channel with traditional channels by ensuring product, price and promotion consistency (Bergen, et al., 2005). In setting their prices, B&C retailers have the added constraint of keeping their prices consistent online and offline. And since offline consumers are (rationally) less attentive to the rightmost digits of a price, and given the constraint of consistent pricing, B&C retailers should use 9-endings frequently and their prices should be rigid, even for their online stores. On the other hand, PI retailers, who face online consumers only, should use 9-endings much less frequently because shopbots or search engines may actually flatten some of the potential behaviors that would be operative through the lens of rational inattention (Kauffman and Lee, 2005). So, PI retailers should be more flexible in their price adjustments, as online consumers are rationally more attentive to the right digits of a price.

To examine such variations in consumers' rational inattention and firms' choice of price-endings in different channels, we divided our Internet data into two categories of retailers (i.e.,

B&C and PI) in the following manner. First, retailers in our dataset that have an online presence only (e.g., Amazon.com) are classified in the PI category. For the remaining retailers, we checked whether they make pricing decisions independently of their respective B&M stores (e.g., in terms of price matching or promotion consistency). For example, although Barnes & Noble has an online presence (BN.com) as well as physical stores, its Internet store is a completely separate division, which has been spun off as a stand-alone company. So, BN.com has the capability to flexibly set or change its prices just as Amazon.com does. Similarly, Computer4Sure.com and TechDepot.com—two subsidiaries of the Office Depot Company—can also make decisions independently of their respective physical stores. We classified all those stores into the PI category.²⁶ Finally, there are 245 PI retailers among the 293 stores in our Internet data; the remaining 48 are B&C retailers (see Tables 9a and 9b).

When we split the retailers in our Internet data in the above manner, we see that B&C retailers use 9-endings much more frequently than PI retailers. Specifically, for the penny-digit, even though 9 is the most popular price-ending for all ten product categories and accounts for 67.4% of all prices for the B&C retailers, it is much less popular for the PI retailers. It is the most popular ending for only three product categories also, accounting for only 26.1% of all prices ($67.4\% > 26.1\%$, $p < .00001$). Similarly for the last two digits of a price, although 99¢ is the most popular price-ending for all but one product categories and accounts for 65.8% of all prices for B&C retailers, it is the most popular ending for only three product categories and accounts for only 23.1% of all prices for PI retailers ($65.8\% > 23.1\%$, $p < .00001$).

Similar results emerged for the dollar digit. While \$9 is the most popular price-ending for all but one product category for both types of retailers, it accounts for 50.5% of all prices among B&C retailers, but only 33.0% among PI retailers ($50.5\% > 33.0\%$, $p < .00001$). For the last two dollar digits, \$99 is the most popular price-ending for seven product categories and accounts for 12.4% of all prices among B&C retailers. But, it is the most popular price-ending for six product categories and accounts only for 8.9% of all prices among PI retailers ($12.4\% > 8.9\%$, $p < .00001$).

If we consider the last three digits of a price, we find that \$9.99 is the most popular ending for all but one product categories and accounts for 32.96% of all prices among the B&C retailers. However, it is the most popular for only three product categories and accounts only for 8.91% of all prices among PI retailers (Actually, overall, it is *not* the most popular price-ending

for PI retailers; it ranks behind \$9.00 as the second most popular ending; $32.96\% > 8.91\%$, $p < .00001$). Finally, for the last four digits, \$99.99 is the most popular ending for six product categories and accounts for 7.97% of all prices among B&C retailers. However, it is the most popular for only two product categories and accounts for a mere 2.50% of all prices among PI retailers (again, overall, it ranks behind \$99.00 as the second most popular ending for PI retailers; $7.97\% > 2.50\%$, $p < .00001$). Results at the individual category level show very similar differences across the two channels.

In addition, the two channels are also different in terms of the magnitude of the price changes as expected. Changes in multiples of dimes make up the top ten most common price changes for most of the product categories and for both channels. But, those changes are much more popular among the B&C retailers than among the PI retailers almost without exception (see Tables 10a and 10b). Overall, changes in multiples of dimes make up 79.0% of all price changes for B&C retailers, as compared to 52.1% for PI retailers ($79.0\% > 52.1\%$, $p < .00001$). The same difference is found between the two channels for the proportion of price changes in multiple of dollars ($72.7\% > 39.1\%$, $p < .00001$), tens of dollars ($17.4\% > 8.6\%$, $p < .00001$), and hundreds of dollars ($1.8\% > 0.7\%$, $p < .00001$). Therefore, it does seem that, for the B&C retailers, the rightmost digits of a price are more likely to be kept at 9 as there are more changes in multiples of dimes, dollars, tens of dollars, and even hundreds of dollars.

Finally, when we add a dummy for channels into the binary logit regression in Equation 1, we find that the 9-ending prices are still associated with more rigidity overall as well as at the individual product category level (i.e., 91% of the 9-dummies are still statistically smaller than zero). In addition, B&C retailers are indeed more rigid than the PI retailers. For the six types of 9-endings (i.e., 9¢, 99¢, \$9, \$99, \$9.99, and \$99.99), prices of B&C retailers are between 30% and 41% less likely to change compared to prices of PI retailers (see Table 11). Results at the individual product category level are similar: 41 (i.e., 76%) out of the 54 coefficients for the channel-dummy are statistically smaller than zero, 5 (9%) are statistically larger than zero, and 8 (i.e., 15%) are not different from zero.

Therefore, it does seem that the use of 9 as price-ending is more popular, and that prices are more rigid among the B&C retailers than among the PI retailers. These results are consistent with our rational-inattention-based explanation of 9-ending prices and our argument that the Internet may offer the opportunity for consumers to be more attentive to price-endings.²⁷

7. Discussion

The issue of price rigidity lies at the heart of New Keynesian macroeconomics (Blinder, et al., 1998) and industrial organization (Carlton, 1986). However, the sources of nominal price rigidity are not well understood. In this study, we explore one possible theory—*psychological price points theory*—which has been offered as a potential behavioral and cognitive explanation of price rigidity (Kashyap, 1995). Taken as a whole, our results begin to fill two major gaps in the literature on psychological price points: (i) still not much is known about the actual practical importance of price points and their relationship to price rigidity, and (ii) there is a concomitant lack of a satisfactory economic explanation.

Our results support the practical importance of price points, including their use and their relationship to price rigidity. We find that 9-ending prices are prevalent and lead to price rigidity across the product categories, price levels, retailers and even retail formats in our study. We also offer an economic explanation for the use and subsequent rigidity of price points developed from the emerging literature in economics on *rational inattention*. Moreover, we find evidence that the use of 9-ending prices varies across Internet selling formats in a way that is consistent with differences in the *rational attentiveness* that these channels engender with the consumers who use them.

In the next several subsections, we discuss the use of price points in our data, and the relationship to existing literature in economics and marketing. Then we evaluate our findings on the relationship between price points and price rigidity relative to the macroeconomy. In the third subsection, we discuss our rational inattention-based explanation of price points in more detail. We end with a consideration of the implications of these results for the e-commerce and IS research literatures.

7.1 Use of Price Points

In our supermarket and Internet datasets, 9 is the most popular terminal digit overall. The popularity of 9 is not limited to the penny digit. Its popularity occurs with the dime, dollar, and the ten-dollar digits, too. Moreover, our data include a variety of products with a wide range of prices and retailers and retail formats, suggesting that the use of 9-ending prices is a significant retail pricing phenomenon.

Our results are consistent with the findings reported by Friedman (1967) that 5 and 9-ending prices are particularly popular in the U.S. retail food industry. He refers to these two digits as “magic numbers.” Indeed, these two digits combined account for more than 80% of all price-endings in his retail price data. In addition, Friedman reports that 3 and 7-ending prices are next in popularity. These findings are in line with ours: we also find that 9-endings are the single most popular ending, followed by 5-endings, and then 3 and 7-endings. Unlike Friedman, however, we find that in our data a small proportion of prices end with 0 as well (see Figures 1 and 5).

As Kashyap (1995) has noted, however, there is no single definition of price points, and practitioners seem to use various kinds of price points. The existing empirical evidence is consistent with such a heterogeneous characterization of price point use. In Kashyap’s (1995) catalogue price data, for example, all prices ended with either 0 or 5 without exception. Further, what might constitute a price point appears to vary not only with industry, but also with country. For example, Ratfai (2003) reports that over 45% of the Hungarian retail prices in his data ended with 0, while less than 20% of the prices ended with 9. Similarly, Konieczny and Skrzypacz (2003, 2004) note that 9-ending prices are particularly popular in the U.S., Canada, Germany, Belgium, etc. But, they are scarce, for example, in Spain, Italy, Poland, and Hungary, where *round* prices are common. (See Fengler and Winter (2001) for similar results with German data, and Mostacci and Sabbatini (2003) for similar results with Italian data). In contrast, in Asian countries including Malaysia, Hong Kong, Singapore, Japan and China, Heeler and Nguyen (2001) find an unusual over-representation of 8-endings.²⁸ These and other pricing practices and their economic significance need to be explored further.

7.2 Price Points and Price Rigidity

The price point phenomenon, although of interest by itself (e.g., Landsburg, 1995), is particularly important for the macroeconomy if it contributes directly to retail price rigidity. In fact, the most consistent results emerging from our analysis are that once the terminal digits of a price are set at 9, it is at least 24% less likely for the price to change compared to when the terminal digits are not 9. Similarly, when the prices change, they tend to change in such a manner that keeps the terminal digits at 9, so they are made in amounts of dimes and dollars. While our analysis of the Dominick’s data is limited to the 9¢ and 99¢ price-endings and small

price changes (in multiples of dimes), the wider price range in our Internet dataset allowed us to examine 9-endings for the dollar digit and ten-dollar digit as well as the last three and four digits. Our findings go beyond the rightmost (penny) digit, and seem to hold for the dime, dollar, and ten-dollar digits as well. Moreover, our findings on 9 price-endings and price rigidity appear to be quite robust, occurring across two different datasets, with a wide range of prices, products, retail formats, retailers and even time periods. This suggests that 9-ending prices, and their contribution to retail price rigidity may be of substantial economic importance.

On the whole, this offers strong support for “price point” theories of price rigidity. Although there are studies indicating that prices set at price points tend to be more rigid (e.g., Álvarez and Hernando, 2004, Aucremanne and Dhyne, 2005, Baumgartner, *et al.*, 2005 and Lünemann and Mathä, 2005b), to our knowledge, this is the first study that directly examines the effect of retail price points on price rigidity across such a broad range of product categories, price levels, retailers and retail formats.

7.3 *Making Sense of Ignoring Cents: Rational Inattention*

Our explanation for these results develops the implications of rational inattention, and is in line with many recent studies that assume departures from full rationality to explain a wide range of phenomena. For example, Akerlof, et al. (2000), by assuming that people ignore low inflation in setting wages and prices, are able to trace out a range of equilibrium unemployment rates associated with different inflation rates. Rotemberg (2003), by assuming that consumers assess price change decisions based on their fairness, is able to reconcile two observations: (i) price increases antagonize consumers, but (ii) we don't see sharp decreases in purchases in response to price increases. Similarly, Sims (2003) assumes that agents have limited information-processing capacity, and finds that his model's predictions fit macro data quite well. Reis (2004, 2005), through the studies of consumption and inflation, reports improvements in the model fit by assuming that agents face costs of acquiring and processing information and thus update their information and re-compute their optimal plans only sporadically. In their studies of monetary policy, Woodford (2001) assumes that agents have limited information-processing capacity, and Ball, et al. (2005) assume that price setters are slow to incorporate macroeconomic information into their decisions, and both find good fit between their models and their data. Finally, Ameriks, et al. (2003) model absent-minded consumers who do not keep track of their

spending, and offer novel explanations for the link between spending and credit card use. We follow the above studies in assuming systematic departure from full rationality and exploring its implications for pricing.

As we mentioned earlier, our rational inattention-based explanation differs from most of the studies in marketing and economics on 9-endings (e.g., Nagle and Holden, 1995, Schindler and Kirby, 1997) in that it does not assume any irrational behavior. Interestingly, our main empirical results—that price points will be more rigid, and that price changes will be in units that support these price points (dimes and dollars in the U.S. retail context)—hold regardless of what theory is used to explain the use of price points. So long as price points have a behavioral or economic reason to exist, firms will find it in their best interest to stay with them, and to leverage that reason in their price adjustment decisions when prices have to change. While the results on the differential popularity of price points in different channels are consistent with rational inattention, they cannot be easily accommodated by any of existing behavioral or economic explanations for price points. Future research is needed to further disentangle the various explanations for the use of 9-ending prices.

Although the data we use, the empirical findings we report and the explanations we offer, are of a microeconomic nature, these ideas may have potential implications for broader macroeconomic and policy issues. In macroeconomics, we typically do not consider nominal magnitudes of quantities measured numerically to be as important as real magnitudes for optimal decision-making. Yet, these results imply decision rules by customers and firms that may affect both price points and price adjustments. In such situations, nominal magnitude of numeric information attached to economic quantities may matter. There are a variety of macroeconomic settings where these insights on price points, price rigidity and rational inattention may be particularly useful. For example, dropping the smallest currency unit has been a recent topic of debate in the United States and Europe.²⁹ The smallest currency unit defines the minimum regions of price points and possible customer inattention. This appears to be true in the case of products that are sold through automated devices such as soda and candy bar vending machines, parking meters, coin operated laundry machines, etc. (see Levy and Young (2004) and Bils and Klenow (2004)). In addition, the common use of 9-ending, and more generally the popularity of threshold pricing, has recently received a considerable attention in public discussions in several European Union Countries in the context of the conversion of prices from local currencies to the

Euro. (See the survey studies of the European Central Bank's IPN, summarized in Fabiani, et al. (2004).) The main concern in these countries has been the possibility that retailers may have acted opportunistically by asymmetrically upward rounding their prices after conversion to the Euro in their attempt to preserve the pricing points (See, for example, Folkertsma (2002), Folkertsma, et al. (2002), Ehrmann (2005), and the studies cited therein). We hope the results in our paper support continued research efforts in these directions.

7.4 *Implications for the IS literature*

As we have discussed so far, the Internet offers opportunities to inform our understanding of price points and price rigidity in many different ways. First, the Internet provides a unique technological context for the micro-level study of price setting behavior and strategies (Bergen, et al., 2005). The ability to access transaction data using software agents allows us to explore pricing and price adjustment patterns with lower costs, fewer strict assumptions, and more realism at a previously unimaginable level of microeconomic detail. So, such empirical research designs (what we call *massive quasi-experimental data mining methods*) can take advantage of natural experiments in the real world and enable a researcher to distinguish between outcomes associated with different levels of impacts, access or use of information technologies (IT) (Kauffman and Lee, 2005).

Second, with the new retailing activities on the Internet, we expect to see changes that reflect different technological underpinnings of the firm's *production process for prices* (Dutta, et al., 2003). Not only do the new technologies far surpass the capabilities that are available in traditional bricks-and-mortar stores to adjust their own prices (Kauffman and Lee, 2005) and track competitors' prices (Kauffman and Wood, 2006), they provide the basis for consumers to make to-the-cent price comparisons (Bakos, 1997). The reduction in search costs for attractive prices and bargains is accompanied by opportunities for sellers to implement algorithmic price discrimination approaches, to segment customers based on customer relationship management systems information and new data mining techniques. It is natural, then, that Internet-based sellers will create new ways to set prices in e-commerce. However, we found evidence that Internet-based retailers (including both B&C and PI retailers) also employ 9-ending prices for almost every conceivable product, and that they change their prices with 9-endings less frequently than those with other price-endings similar to traditional retailers—price points (i.e.,

9-endings) lead to price rigidity as we discussed in the previous sections. This is a very interesting finding in that firms today are able to flexibly manage and optimize prices by reducing physical price adjustment costs through the intensive use of technologies.

Yet, we also found some variations in the use of 9-endings and price adjustment patterns between the two different online channels (i.e., B&C and PI). The Internet apparently does not necessarily reduce the related managerial costs for price changes. This may be due to integration efforts that firms make to get their operations in the Internet channel in sync with their efforts to sell in traditional channels.³⁰ Although the Internet and information technologies have changed the process by which strategic pricing decisions are made and implemented in business operations, they may not affect other factors that are central to pricing decisions by firms. We believe that there is a need to develop substantial managerial understanding of these new firm pricing technologies.

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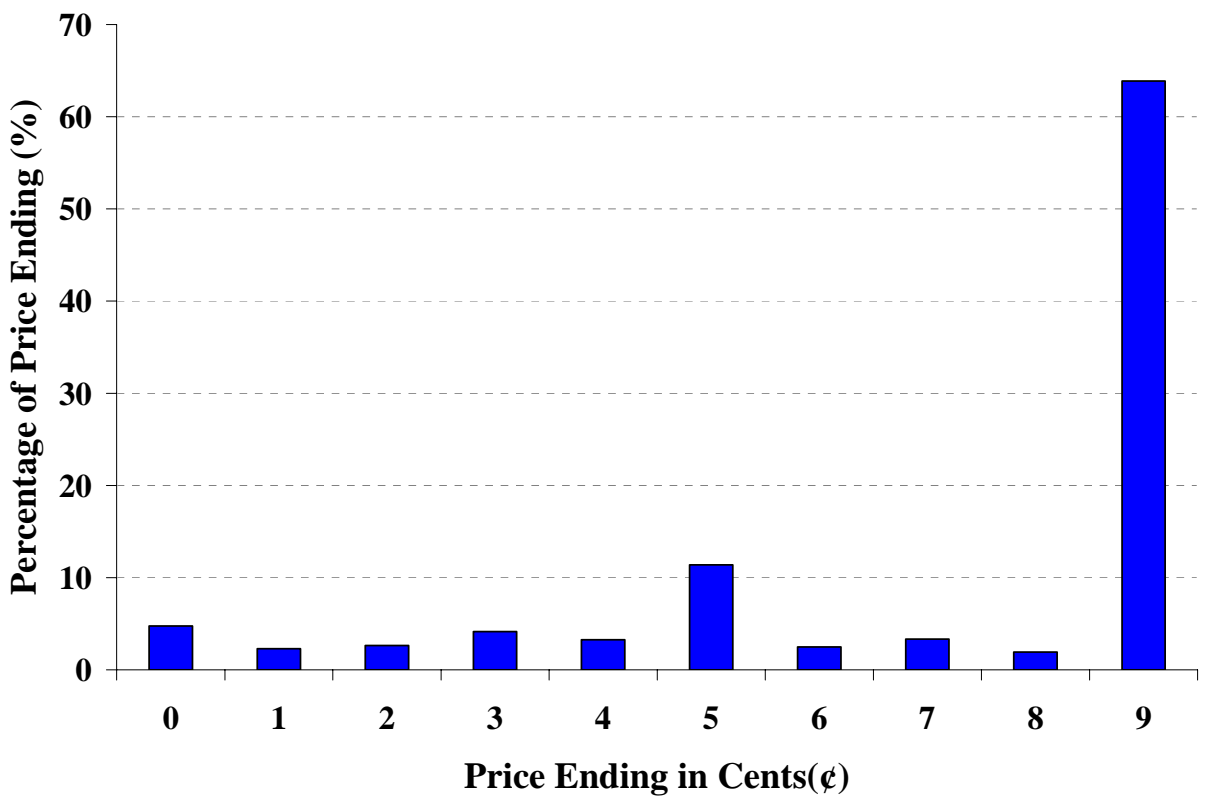
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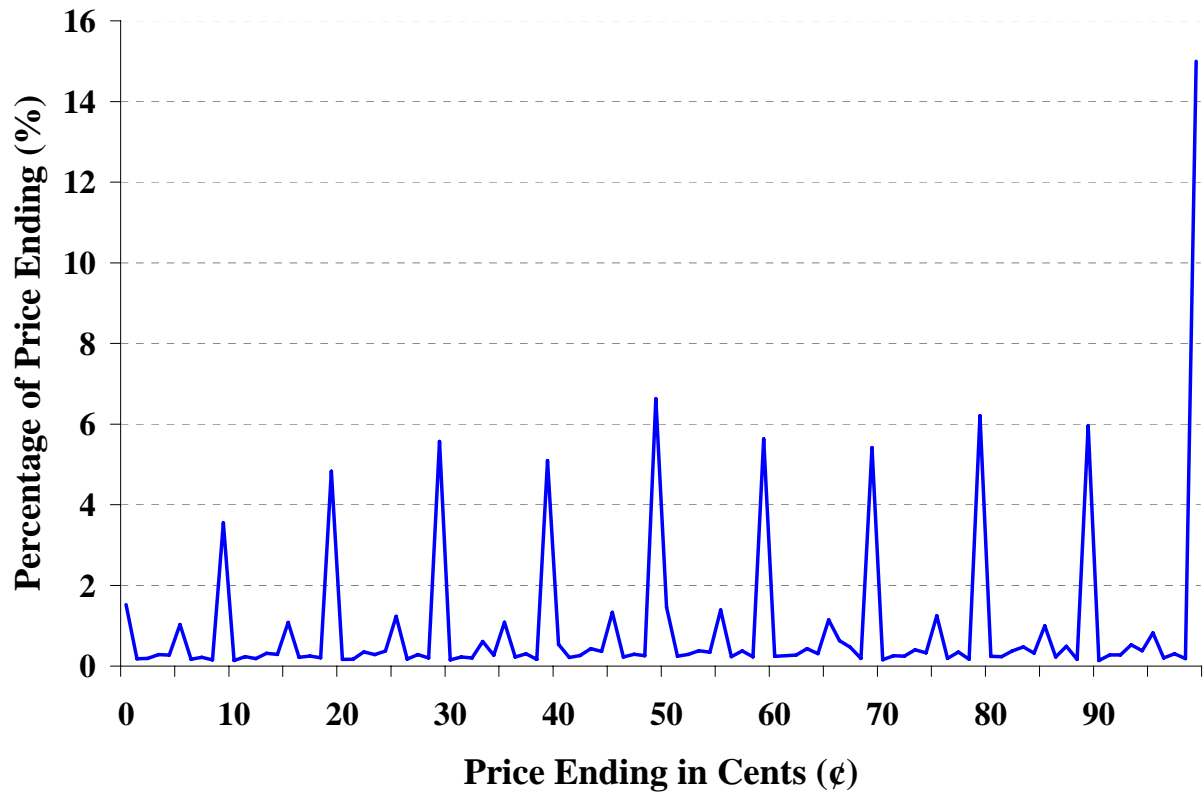
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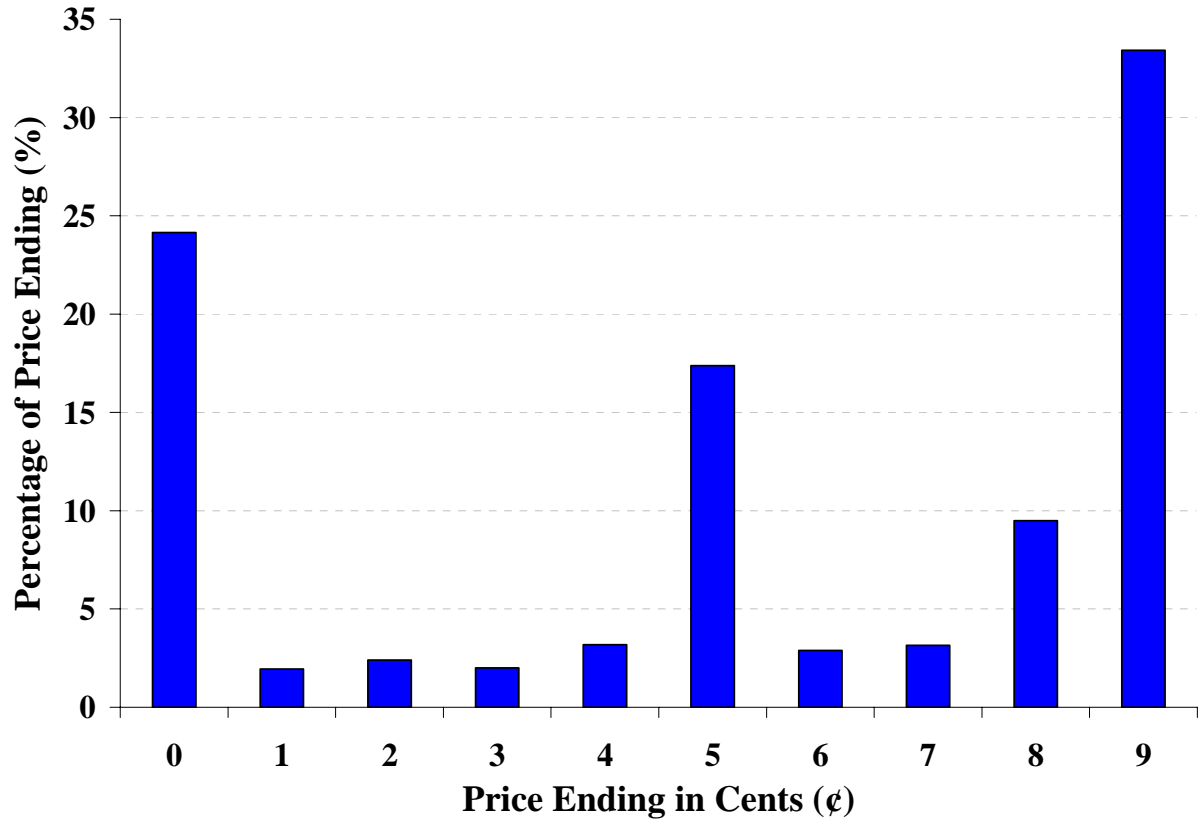
**Figure 1. Frequency Distribution of the Last Digit in the Dominick's Data:
All Categories**



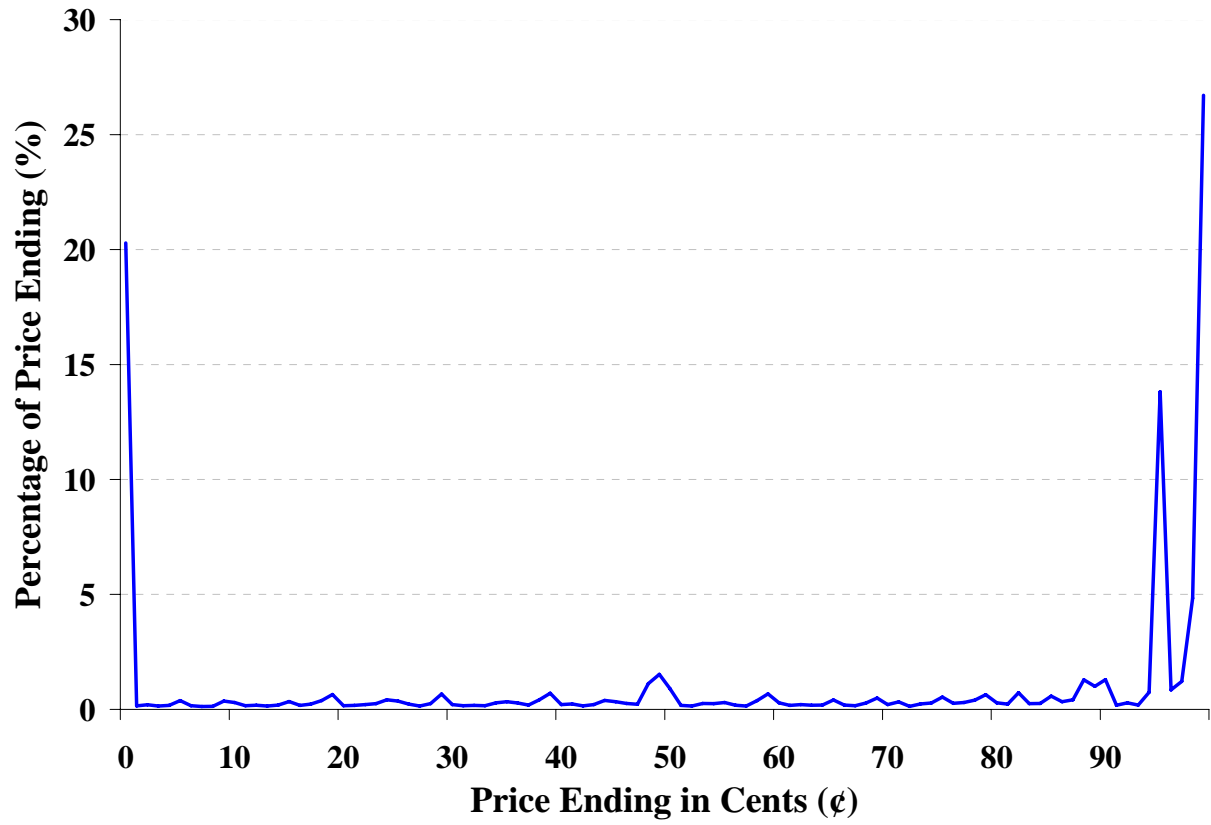
**Figure 2. Frequency Distribution of the Last Two Digits in the Dominick's Data:
All Categories**



**Figure 3. Frequency Distribution of the Last Digit in the Internet Data:
All Categories**



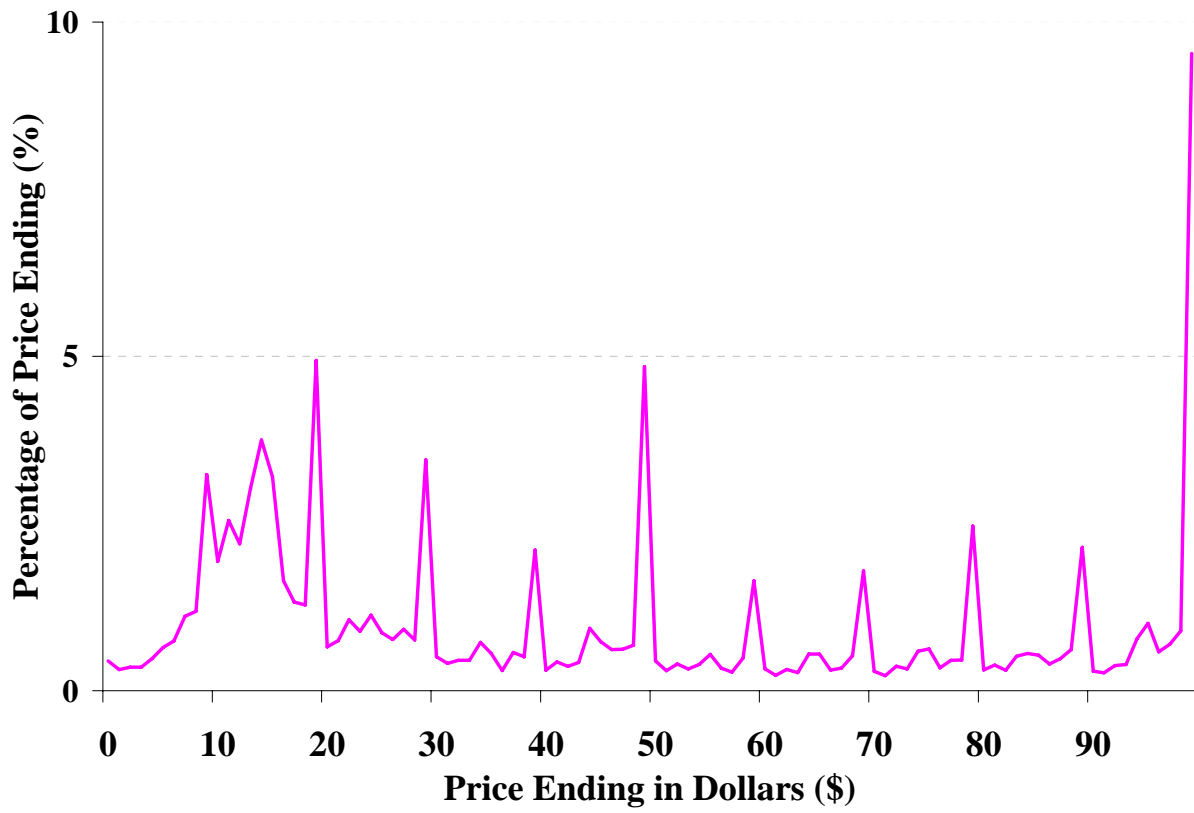
**Figure 4. Frequency Distribution of the Last Two Digits in the Internet Data
: All Categories**



**Figure 5. Frequency Distribution of the Last Dollar Digit in the Internet Data:
All Categories**



**Figure 6. Frequency Distribution of the Last Two Dollar Digits in the Internet Data:
All Categories**



**Figure 7. Frequency Distribution of the Price Changes in the Dominick's Data:
All Categories**

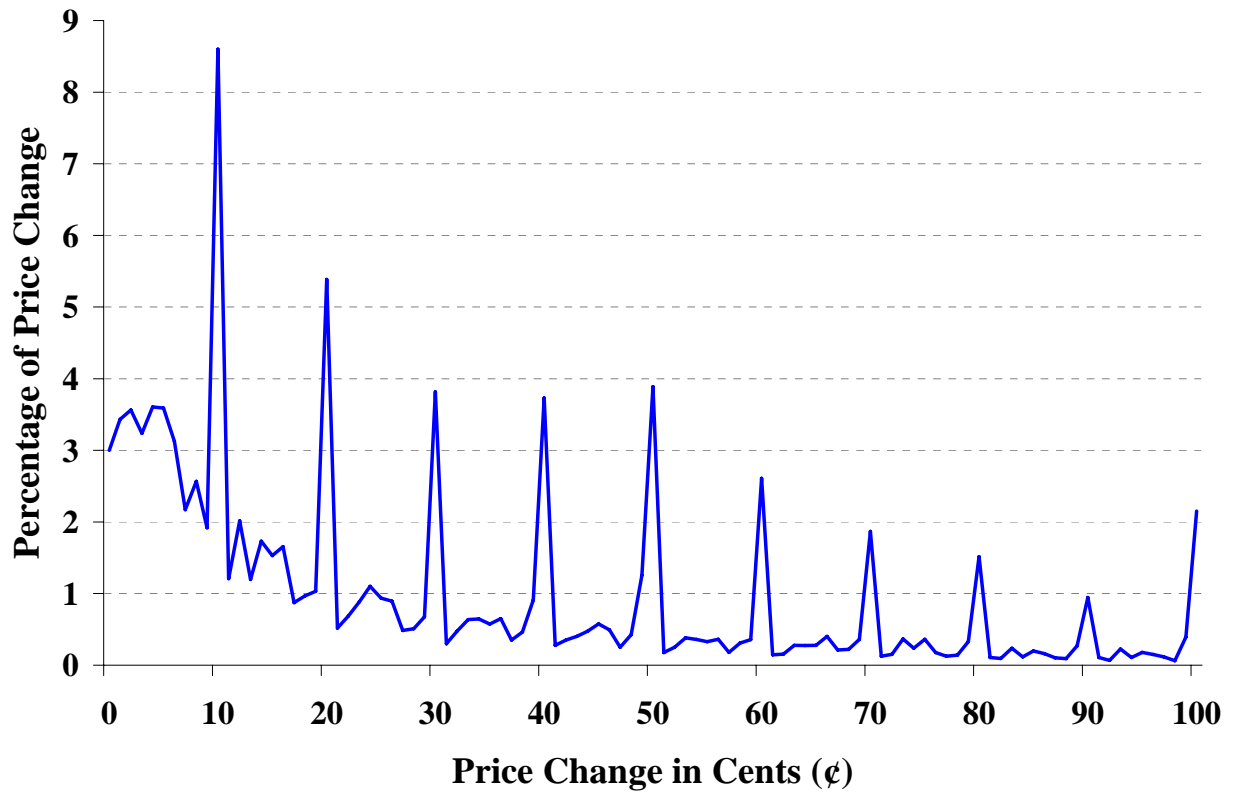
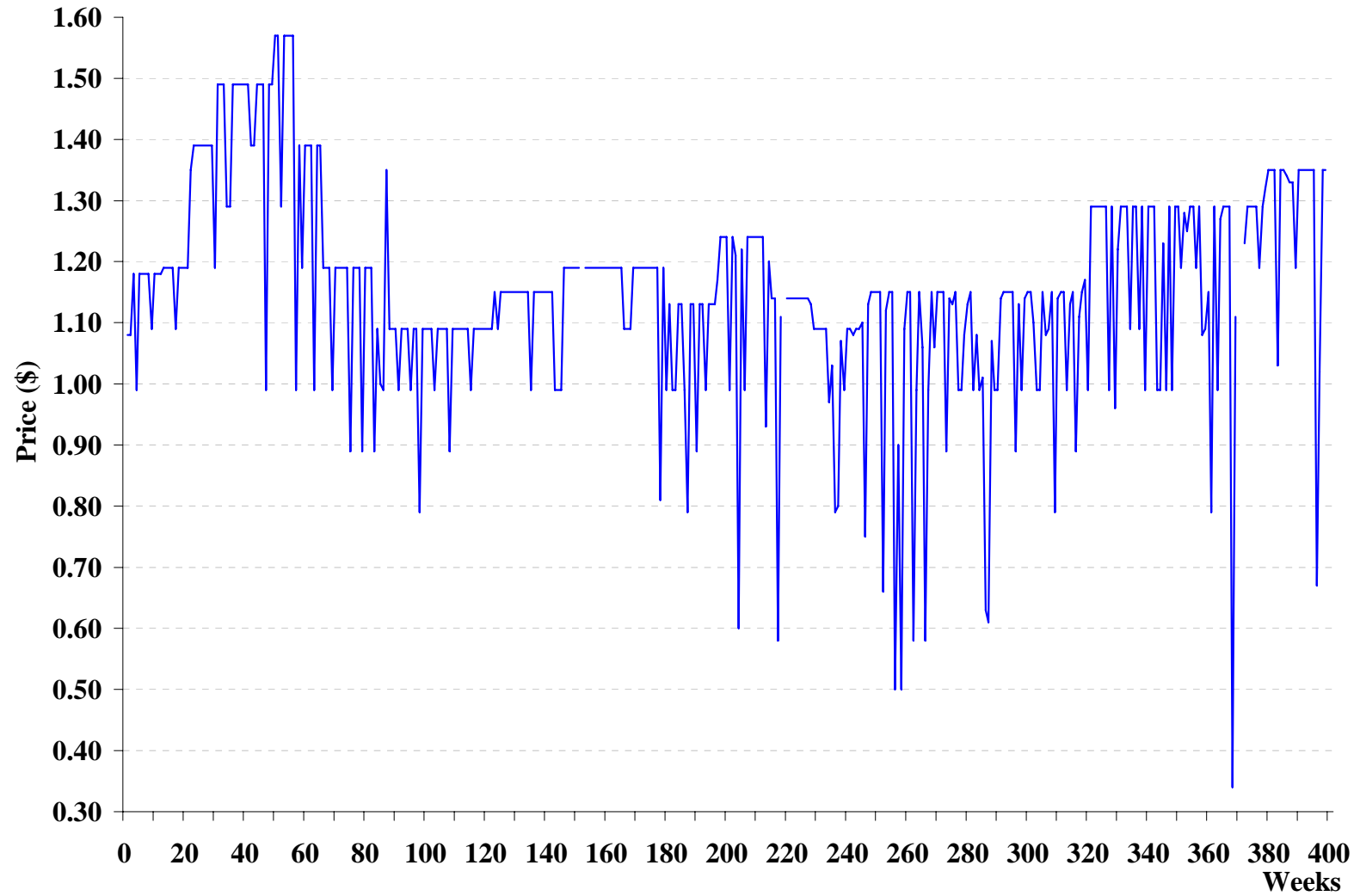


Figure 8. Price of Frozen Concentrate Orange Juice, Heritage House, 12oz
(UPC = 3828190029, Store No. 78), September 14, 1989 – May 8 1997
(Source: Dutta, et. al. 2002)



**Table 1. Descriptive Statistics for Weekly Retail Price Observations
by Category in Dominick's Data**

Category	Number of Observations	Number of Products	Number of Stores	Mean Price	Std. Dev.	Min. Price	Max. Price
Analgesics	3,040,172	638	93	\$5.18	\$2.36	\$0.02	\$23.69
Bath Soap	418,097	579	93	\$3.16	\$1.60	\$0.01	\$28.00
Bathroom Tissue	1,149,973	127	93	\$2.11	\$1.85	\$0.19	\$838.16
Beer	1,966,148	787	89	\$5.69	\$2.70	\$0.01	\$29.64
Bottled Juice	4,294,969	506	93	\$2.24	\$0.97	\$0.19	\$9.41
Canned Soup	5,504,494	445	93	\$1.13	\$0.52	\$0.19	\$324.80
Canned Tuna	2,382,983	278	93	\$1.80	\$1.07	\$0.11	\$12.89
Cereals	4,707,776	489	93	\$3.12	\$0.76	\$0.05	\$26.02
Cheeses	6,752,328	657	93	\$2.42	\$1.12	\$0.05	\$111.33
Cigarettes	1,801,470	793	93	\$7.69	\$7.95	\$0.01	\$250.00
Cookies	7,568,429	1,124	93	\$2.10	\$0.72	\$0.02	\$958.68
Crackers	2,228,269	330	93	\$2.01	\$0.57	\$0.10	\$7.29
Dish Detergent	2,164,793	287	93	\$2.34	\$0.90	\$0.25	\$15.89
Fabric Softeners	2,278,995	318	93	\$2.82	\$1.45	\$0.01	\$9.99
Front-End-Candies	4,437,054	503	93	\$0.61	\$0.24	\$0.01	\$6.99
Frozen Dinners	1,654,053	266	93	\$2.37	\$0.89	\$0.12	\$72.47
Frozen Entrees	7,172,075	898	93	\$2.33	\$1.06	\$0.10	\$15.99
Frozen Juices	2,368,157	175	93	\$1.39	\$0.45	\$0.10	\$6.57
Grooming Products	4,065,694	1,381	93	\$2.94	\$1.44	\$0.01	\$450.36
Laundry Detergents	3,277,445	581	93	\$5.61	\$3.22	\$0.04	\$254.18
Oatmeal	981,037	96	93	\$2.65	\$0.66	\$0.25	\$5.00
Paper Towels	940,757	163	93	\$1.50	\$1.41	\$0.23	\$13.99
Refrigerated Juices	2,166,755	225	93	\$2.24	\$0.91	\$0.10	\$7.05
Shampoos	4,676,790	2,930	93	\$2.95	\$1.86	\$0.02	\$54.99
Snack Crackers	3,487,565	420	93	\$2.18	\$0.59	\$0.02	\$281.40
Soaps	1,835,196	334	93	\$2.51	\$1.48	\$0.10	\$10.99
Soft Drinks	10,741,743	1,608	93	\$2.34	\$1.90	\$0.01	\$118.88
Toothbrushes	1,839,536	491	93	\$2.18	\$0.85	\$0.20	\$27.52
Toothpastes	2,981,532	608	93	\$2.43	\$0.89	\$0.10	\$19.95
Total	98,884,285	18,037	93	\$2.59	\$2.16	\$0.01	\$958.68

Note: The table reports on all price data from Dominick's Finer Food in its 93 stores for 400 weeks from September 14, 1989 to May 8, 1997. The data is available at : <http://gsbwww.uchicago.edu/kilts/research/db/dominicks/>

Table 2. Descriptive Statistics for the Internet-Based Sellers' Price-Endings Data Set

Category	Number of Observations	Number of Products	Number of Retailers	Mean Price	Std. Dev.	Min. Price	Max. Price
Music CDs	302,914	46	15	\$13.46	\$3.50	\$3.99	\$26.98
Movie DVDs	447,519	49	22	\$27.42	\$26.70	\$4.95	\$144.99
Video Games	244,625	49	38	\$30.83	\$12.57	\$4.90	\$57.99
Software	382,297	48	83	\$294.07	\$417.60	\$4.95	\$5,695.00
Hard Drives	263,244	46	73	\$330.67	\$556.29	\$39.00	\$3,670.98
PDAs	148,731	45	92	\$346.60	\$193.24	\$32.99	\$956.95
DVD Players	220,236	49	104	\$369.51	\$247.75	\$57.99	\$1,489.00
PC Monitors	319,369	51	87	\$682.89	\$659.13	\$85.78	\$3,010.41
Digital Cameras	247,917	46	143	\$760.12	\$688.76	\$175.95	\$6,000.00
Notebook PCs	79,386	45	45	\$1,666.68	\$475.80	\$699.00	\$3,199.00
Total	2,656,238	474	293	\$337.06	\$536.13	\$3.99	\$6,000.00

Note: Internet retailers have many different categories of products (e.g., Amazon.com sells books, CDs, DVDs, computer products and electronics). Consequently, the sum of the number of retailers in each product category is not consistent with the total number of stores in all product categories. In addition, some retailers do not have all products (e.g., Amazon has 15 music CDs while Barnes & Noble has 20). Also, the length of individual product's price time series varies due to different life cycle of products. Thus, the number of observations, for example, 302,914, is less than total available combinations, i.e., $46 \times 15 \times 743 = 512,670$.

Table 3. Top 10 Highest Frequencies of Last Three Digits of Prices in the Internet Data

Rank	CDs	DVDs	Video Games	SW	PDA's	Hard Drives	DVD Players	PC Monitors	Digital Cameras	Notebook PCs	Total
1	\$4.99 7.76%	\$9.99 5.13%	\$9.99 37.78%	\$9.00 11.55%	\$9.00 23.43%	\$9.99 8.97%	\$9.99 23.13%	\$9.00 16.60%	\$9.99 23.58%	\$9.00 48.43%	\$9.99 13.17%
2	\$2.99 5.20%	\$4.99 4.89%	\$9.82 4.51%	\$9.95 11.49%	\$9.99 15.21%	\$9.00 6.18%	\$9.00 10.74%	\$9.99 8.99%	\$9.00 21.60%	\$9.99 16.62%	\$9.00 9.98%
3	\$3.99 4.35%	\$3.99 2.78%	\$8.95 3.62%	\$9.99 7.72%	\$9.95 5.26%	\$9.95 4.41%	\$9.95 5.77%	\$9.95 4.03%	\$9.95 8.76%	\$9.95 5.01%	\$9.95 4.86%
4	\$1.99 4.22%	\$0.99 2.72%	\$7.99 3.35%	\$5.00 4.53%	\$8.00 3.09%	\$5.00 3.44%	\$9.97 5.39%	\$5.00 3.42%	\$5.00 5.19%	\$9.98 3.28%	\$4.99 3.24%
5	\$3.98 3.26%	\$5.99 2.65%	\$4.99 3.20%	\$0.00 3.40%	\$5.00 2.74%	\$4.99 2.57%	\$9.90 4.85%	\$0.00 2.80%	\$8.00 2.80%	\$5.00 2.49%	\$5.00 2.48%
6	\$5.99 2.96%	\$2.99 2.57%	\$9.95 2.85%	\$8.00 2.84%	\$4.99 2.48%	\$2.00 2.26%	\$5.00 4.13%	\$5.95 2.41%	\$4.99 2.37%	\$7.00 1.73%	\$2.99 1.46%
7	\$9.99 2.43%	\$6.99 2.37%	\$9.88 2.76%	\$4.95 2.73%	\$0.00 1.85%	\$7.00 2.16%	\$4.99 3.24%	\$0.95 2.33%	\$7.00 2.26%	\$4.00 1.64%	\$8.95 1.45%
8	\$4.98 2.40%	\$5.98 2.34%	\$8.99 2.72%	\$8.95 2.53%	\$4.95 1.69%	\$6.00 2.14%	\$8.00 2.26%	\$2.95 2.26%	\$0.00 1.85%	\$4.95 1.00%	\$8.00 1.44%
9	\$7.99 2.26%	\$1.98 2.08%	\$6.99 2.04%	\$2.00 2.21%	\$8.95 1.68%	\$8.99 2.10%	\$9.96 2.21%	\$8.95 2.05%	\$9.98 1.56%	\$7.99 0.97%	\$7.99 1.43%
10	\$8.99 2.11%	\$7.99 2.07%	\$6.95 1.79%	\$7.00 2.15%	\$5.99 1.47%	\$3.00 2.02%	\$9.94 1.51%	\$6.95 1.98%	\$9.90 1.44%	\$5.99 0.95%	\$4.95 1.42%

Note: Each cell contains the last three digits of prices and their proportions in each product category. Bold-marked prices in the first three rows indicate that they are in the top three frequent price endings in each category. The rightmost column includes all categories.

Table 4. Top 10 Highest Frequencies of Last Four Digits of Prices in the Internet Data

Rank	CDs	DVDs	Video Games	SW	PDA's	Hard Drives	DVD Players	PC Monitors	Digital Cameras	Notebook PCs	Total
1	\$14.99 7.48%	\$09.99 2.66%	\$19.99 14.34%	\$99.00 3.54%	\$49.00 5.77%	\$29.99 1.30%	\$99.99 7.87%	\$99.00 5.98%	\$99.99 13.51%	\$99.00 27.47%	\$99.99 3.47%
2	\$12.99 4.90%	\$13.99 2.56%	\$29.99 10.47%	\$99.95 3.46%	\$99.00 5.76%	\$59.99 1.27%	\$49.99 3.72%	\$99.99 3.78%	\$99.00 9.02%	\$49.00 9.29%	\$99.00 3.46%
3	\$11.99 4.00%	\$14.99 2.31%	\$49.99 9.05%	\$99.99 3.33%	\$99.99 4.82%	\$09.99 1.09%	\$19.99 2.90%	\$49.00 1.89%	\$99.95 3.26%	\$99.99 8.00%	\$19.99 2.16%
4	\$13.99 3.57%	\$15.99 2.14%	\$39.99 3.21%	\$89.95 1.71%	\$59.00 2.44%	\$49.99 1.01%	\$99.00 2.35%	\$49.99 1.72%	\$49.99 3.18%	\$79.00 3.04%	\$49.99 2.00%
5	\$13.98 3.26%	\$15.98 2.03%	\$19.82 2.74%	\$49.95 1.50%	\$79.00 2.44%	\$59.00 0.91%	\$69.99 2.30%	\$29.00 1.62%	\$49.00 3.15%	\$99.98 2.84%	\$29.99 1.55%
6	\$15.99 2.43%	\$10.99 1.83%	\$18.95 2.11%	\$79.95 1.37%	\$49.99 2.41%	\$99.99 0.86%	\$49.00 1.87%	\$39.00 1.35%	\$29.00 1.99%	\$29.00 2.84%	\$49.00 1.43%
7	\$14.98 2.40%	\$11.98 1.44%	\$19.88 1.99%	\$19.00 1.35%	\$19.00 2.00%	\$79.99 0.86%	\$79.99 1.83%	\$59.00 1.27%	\$79.99 1.81%	\$29.99 2.17%	\$14.99 1.40%
8	\$10.99 1.89%	\$10.95 1.40%	\$17.99 1.33%	\$79.00 1.14%	\$19.99 1.59%	\$39.99 0.83%	\$39.99 1.65%	\$19.00 1.07%	\$79.00 1.62%	\$30.00 1.89%	\$99.95 1.09%
9	\$15.18 1.89%	\$16.99 1.39%	\$48.95 1.28%	\$89.00 1.1%	\$29.99 1.41%	\$79.00 0.73%	\$29.00 1.64%	\$69.00 1.04%	\$39.00 1.34%	\$19.99 1.55%	\$09.99 0.97%
10	\$7.99 1.85%	\$17.99 1.34%	\$49.95 1.24%	\$19.95 1.05%	\$39.00 1.34%	\$39.00 0.71%	\$79.00 1.62%	\$79.00 1.00%	\$69.00 1.32%	\$49.99 1.53%	\$79.00 0.87%

Note: Each cell contains the last four digits of prices and their proportions in each product category. Bold-marked prices in the first three rows indicate that they are in the top three frequent price endings in each category. The rightmost column includes all categories.

**Table 5. Top 10 Highest Frequencies of Price Changes
by Product Category in the Internet Data**

Rank	CDs	DVDs	Video Games	SW	PDA's	Hard Drives	DVD Players	PC Monitors	Digital Cameras	Notebook PCs	Total	3 Categories Removed
1	\$1.00 10.26%	\$1.00 7.73%	\$10.00 11.44%	\$1.00 6.78%	\$10.00 7.54%	\$1.00 10.03%	\$10.00 4.46%	\$1.00 3.29%	\$10.00 8.09%	\$50.00 11.30%	\$1.00 6.74%	\$1.00 5.63%
2	\$0.10 6.77%	\$0.20 3.42%	\$1.00 9.82%	\$2.00 5.15%	\$5.00 4.41%	\$2.00 7.54%	\$20.00 3.95%	\$2.00 3.29%	\$20.00 5.89%	\$100.00 7.63%	\$2.00 4.49%	\$2.00 4.66%
3	\$2.00 5.22%	\$2.00 3.40%	\$5.00 7.40%	\$5.00 4.11%	\$2.00 4.02%	\$3.00 5.55%	\$30.00 2.70%	\$10.00 3.27%	\$4.00 3.46%	\$200.00 3.97%	\$10.00 3.24%	\$10.00 4.31%
4	\$0.20 3.59%	\$0.01 2.34%	\$2.00 5.57%	\$10.00 3.76%	\$1.00 3.41%	\$4.00 4.00%	\$5.00 2.51%	\$3.00 3.02%	\$5.00 3.44%	\$20.00 3.05%	\$3.00 3.09%	\$3.00 3.60%
5	\$0.01 3.46%	\$0.09 2.30%	\$20.00 4.69%	\$3.00 3.56%	\$20.00 3.24%	\$5.00 3.98%	\$1.00 2.13%	\$5.00 2.23%	\$2.00 3.28%	\$10.00 2.44%	\$5.00 2.72%	\$5.00 3.38%
6	\$0.50 2.45%	\$0.10 2.29%	\$3.00 4.25%	\$4.00 3.04%	\$30.00 2.57%	\$10.00 2.83%	\$3.00 2.13%	\$4.00 1.91%	\$6.00 3.28%	\$60.00 2.14%	\$4.00 2.30%	\$4.00 2.90%
7	\$0.06 2.06%	\$3.00 2.21%	\$3.06 2.64%	\$20.00 2.44%	\$3.00 2.35%	\$6.00 2.10%	\$4.00 1.95%	\$6.00 1.83%	\$50.00 2.97%	\$30.00 1.98%	\$20.00 1.80%	\$20.00 2.56%
8	\$0.14 1.88%	\$0.30 1.79%	\$0.11 2.05%	\$6.00 2.19%	\$6.00 2.29%	\$7.00 1.84%	\$2.00 1.57%	\$20.00 1.61%	\$1.00 2.87%	\$40.00 1.83%	\$6.00 1.55%	\$6.00 2.18%
9	\$0.02 1.69%	\$0.08 1.31%	\$18.00 1.61%	\$0.01 2.03%	\$4.00 1.90%	\$8.00 1.08%	\$6.00 1.51%	\$30.00 1.54%	\$30.00 2.87%	\$150.00 1.83%	\$0.10 1.38%	\$30.00 1.50%
10	\$0.30 1.69%	\$0.50 1.26%	\$7.00 1.39%	\$8.00 1.54%	\$15.00 1.79%	\$20.00 1.06%	\$50.00 1.51%	\$7.00 1.44%	\$3.00 2.64%	\$70.00 1.68%	\$0.01 1.38%	\$7.00 1.47%

Note: The rightmost column shows the results after three product categories (CDs, DVDs, and video games) are left out. Bold-marked prices in the first three rows indicate that they are in the top three frequent price changes in each category.

Table 6. Logit Regression of Likelihood of Price Changes on 9-Ending and Sale in Dominick's Data

Category	D_9 (9-ending = 1)		D_{OnSale} (OnSale = 1)	
	Coefficient	Odds Ratio	Coefficient	Odds Ratio
Analgesics	-0.6781	0.51	3.9829	52.63
Bath Soap	-0.8155	0.44	4.6464	100.00
Bathroom Tissues	-0.5036	0.60	3.6723	40.00
Bottled Juices	-0.2891	0.75	4.1268	62.50
Canned Soup	-0.1112	0.89	4.6189	100.00
Canned Tuna	-0.5331	0.59	4.5788	100.00
Cereals	-0.2558	0.77	4.7368	111.11
Cheeses	-0.9142	0.40	3.8187	45.45
Cookies	-0.8173	0.44	4.1490	62.50
Crackers	-0.4412	0.64	4.0389	55.56
Dish Detergent	-0.6283	0.53	4.7074	111.11
Fabric Softeners	-0.3779	0.69	4.6161	100.00
Front-end-candies	-0.4477	0.64	4.8119	125.00
Frozen Dinners	-0.5808	0.56	3.5407	34.48
Frozen Entrees	-0.5642	0.57	3.2641	26.32
Frozen Juices	-0.2451	0.78	3.9482	52.63
Grooming Products	-0.9030	0.41	3.3588	28.57
Laundry Detergents	-0.5783	0.56	4.1731	66.67
Oatmeal	-0.5805	0.56	4.1839	66.67
Paper Towels	-0.5186	0.60	4.3241	76.92
Refrigerated Juices	-0.5042	0.60	3.6385	38.46
Shampoos	-0.7868	0.46	3.1548	23.26
Snack Crackers	-0.8517	0.43	3.8756	47.62
Soaps	-0.6709	0.51	4.2641	71.43
Soft Drinks	-0.6709	0.51	4.2641	71.43
Tooth Brushes	-0.3154	0.73	3.6447	38.46
Tooth Pastes	-0.2343	0.79	3.7560	43.48
Average		0.59		64.90

Note: D_9 is 9-ending dummy variable, which equals 1 if the price ends with 9 and 0 otherwise. D_{OnSale} is a sale dummy, which equals 1 if the product is on sale in the given week and 0 otherwise. All p -values are less than 0.0001. The average odds ratios reported in the last row of the table are the simple averages of the odds ratios for each product category.

Table 7. Logit Regression of Likelihood of Price Changes on 99-Ending and Sale in Dominick's Data

Category	D_{99} (99-ending = 1)		D_{OnSale} (On-Sale = 1)	
	Coefficient	Odds Ratio	Coefficient	Odds Ratio
Analgesics	-0.1847	0.83	3.9805	52.63
Bath Soap	-0.2273	0.80	4.7925	125.00
Bathroom Tissues	-0.3426	0.71	3.6795	40.00
Bottled Juices	-0.2042	0.81	4.1422	62.50
Canned Soup	-0.1629	0.85	4.6238	100.00
Canned Tuna	-0.4714	0.62	4.5281	90.91
Cereals	-0.1603	0.85	4.7239	111.11
Cheeses	-0.6098	0.54	3.8378	45.45
Cookies	-0.1876	0.83	4.2162	66.67
Crackers	-0.0441	0.96	4.1185	62.50
Dish Detergent	-0.6024	0.55	4.7350	111.11
Fabric Softeners	-0.1980	0.82	4.5797	100.00
Front-end-candies	-1.3781	0.25	4.8630	125.00
Frozen Dinners	-0.4377	0.65	3.7235	41.67
Frozen Entrees	-0.1291	0.88	3.4461	31.25
Frozen Juices	-0.1008	0.90	3.9182	50.00
Grooming Products	-0.2406	0.79	3.6612	38.46
Laundry Detergents	-0.1446	0.87	4.1543	62.50
Oatmeal	-0.2548	0.78	4.1707	66.67
Paper Towels	-0.1546	0.86	4.2669	71.43
Refrigerated Juices	-0.2908	0.75	3.6428	38.46
Shampoos	-0.2957	0.74	3.3005	27.03
Snack Crackers	-0.3930	0.68	4.1214	62.50
Soaps	-0.3583	0.70	4.2807	71.43
Soft Drinks	-0.3583	0.70	4.2807	71.43
Tooth Brushes	-0.0709	0.93	3.6285	37.04
Tooth Pastes	-0.2760	0.76	3.7405	41.67
Average		0.76		66.83

Note: D_9 is 9-ending dummy variable, which equals 1 if the price ends with 9 and 0 otherwise. D_{OnSale} is a sale dummy, which equals 1 if the product is on sale in the given week and 0 otherwise. All p -values are less than 0.0001. The average odds ratios reported in the last row of the table are the simple averages of the odds ratios for each product category.

Table 8. Logit Regression Results of Likelihood of Price Changes on *NineEnding* in the Internet Data

Category	9¢-Endings	99¢-Endings	\$9-Endings	\$99-Endings	\$9.99-Endings	\$99.99-Endings
Music CDs	-0.0958*** (0.9086)	-0.5360*** (0.5851)	<i>0.2944</i> *** (1.3424)		-0.4252*** (0.6536)	
Movie DVDs	-0.5105*** (0.6002)	-0.6309*** (0.5321)	-0.2788*** (0.7567)		-0.9083*** (0.4032)	
Video Games	<i>0.1087</i> * (1.1148)	<i>0.0558</i> (1.0573)	-0.2904*** (0.7480)		-0.2680*** (0.7649)	
Software	-0.3183*** (0.7274)	-0.5045*** (0.6038)	-0.6117*** (0.5424)	-1.0809*** (0.3393)	-0.9060*** (0.4041)	-1.6635*** (0.1895)
PDA's	-0.2553*** (0.7747)	-0.3586*** (0.6986)	-0.4654*** (0.6279)	-0.7405*** (0.4769)	-0.5418*** (0.5817)	-0.9699*** (0.3791)
Hard Drives	-0.3049*** (0.7372)	-0.4038*** (0.6678)	-0.4304*** (0.6503)	-0.4883*** (0.6136)	-0.5295*** (0.5889)	-0.7107*** (0.4913)
DVD Players	-0.4939*** (0.6102)	-0.5763*** (0.5620)	-0.6395*** (0.5275)	-0.6695*** (0.5120)	-0.6389*** (0.5279)	-0.8563*** (0.4247)
PC Monitors	-0.2790*** (0.7565)	-0.4714*** (0.6242)	-0.5590*** (0.5718)	-0.8355*** (0.4337)	-0.8467*** (0.4288)	-1.3082*** (0.2703)
Digital Cameras	-0.4870*** (0.6145)	-0.5395*** (0.5831)	-0.5683*** (0.5665)	-1.1666*** (0.3114)	-0.6394*** (0.5276)	-1.4953*** (0.2242)
Notebook PCs	-0.5566*** (0.5731)	-0.8885*** (0.4113)	-0.7654*** (0.4652)	-1.0680*** (0.3437)	-0.9528*** (0.3856)	-1.1891*** (0.3045)
Total	-0.3842*** (0.6810)	-0.5905*** (0.5541)	-0.6141*** (0.5411)	-0.9099*** (0.4026)	-0.8891*** (0.4110)	-1.3044*** (0.2713)

Note: 2,651,365 data points. Each cell contains a coefficient and odds ratio in parenthesis; significance levels: *** < 0.01, ** < 0.05, * < 0.10.; estimated coefficients in *italics* indicate unsupportive results.

Table 9a. Descriptive Statistics: Bricks-and-Clicks Channel in the Internet Data

Category	No. of Observations	No. of Products	No. of Stores	Mean Price	Std. Dev.	Min. Price	Max. Price
Music CDs	90,341	45	5	\$13.58	\$3.80	\$3.99	\$24.99
Movie DVDs	115,064	49	7	\$26.11	\$26.54	\$4.95	\$144.99
Video Games	117,088	49	14	\$29.79	\$12.76	\$4.90	\$54.99
Software	21,949	20	8	\$234.80	\$149.75	\$59.99	\$699.99
Hard Drives	6,526	9	5	\$144.49	\$79.03	\$54.99	\$328.99
PDA's	13,211	18	11	\$305.74	\$186.67	\$69.99	\$799.99
DVD Players	19,983	22	12	\$361.75	\$208.91	\$68.99	\$739.00
PC Monitors	15,950	16	9	\$1,021.08	\$806.46	\$159.50	\$2,999.99
Digital Cameras	46,859	26	28	\$802.03	\$794.24	\$199.00	\$6,000.00
Notebook PCs	23,426	31	7	\$1,485.93	\$416.46	\$899.00	\$2,799.00
Total	470,397	285	48	\$241.84	\$509.98	\$3.99	\$6,000.00

Note: Bricks-and-Clicks (B&C) channels include stores that have both online and offline channels. In addition, online pricing decisions are dependent on their respective offline channels.

Table 9b. Descriptive Statistics: Pure-Internet Channel in the Internet Data

Category	No. of Observations	No. of Products	No. of Stores	Mean Price	Std. Dev.	Min. Price	Max. Price
Music CDs	212,573	46	10	\$13.41	\$3.36	\$4.09	\$26.98
Movie DVDs	332,455	49	15	\$27.88	\$27.13	\$5.20	\$134.98
Video Games	127,537	45	24	\$31.78	\$12.31	\$6.29	\$57.99
Software	360,348	48	75	\$297.67	\$428.28	\$4.95	\$5,695.00
Hard Drives	256,718	46	68	\$335.38	\$562.30	\$39.00	\$3,670.98
PDA's	135,520	45	81	\$350.57	\$193.41	\$32.99	\$956.95
DVD Players	200,253	49	92	\$370.28	\$251.29	\$57.99	\$1,489.00
PC Monitors	303,419	51	78	\$665.11	\$645.58	\$85.78	\$3,010.41
Digital Cameras	201,058	46	115	\$751.20	\$661.85	\$175.95	\$4,699.95
Notebook PCs	55,960	39	38	\$1,742.32	\$478.69	\$699.00	\$3,199.00
Total	2,185,841	464	245	\$357.55	\$539.44	\$4.09	\$5,695.00

Note: Pure-Internet (PI) channels include stores that have online presence only. In addition, they include stores that have both online and offline channels and make pricing decisions independently of their respective offline channel. Barnes & Noble is an example of B&C channels since its online store (i.e., BN.com) is a completely separate division (i.e., BN.com has the capabilities to flexibly change its prices just like Amazon.com) although it has both channels.

Table 10a. Top 10 Price Changes by Product Category: Brick-and-Clicks Channel

Rank	CDs	DVDs	Video Games	SW	PDAs	Hard Drives	DVD Players	PC Monitors	Digital Cameras	Notebook PCs	Total
1	\$1.00 33.30%	\$1.00 33.50%	\$10.00 16.78%	\$20.00 24.74%	\$10.00 9.78%	\$5.00 19.72%	\$10.00 7.18%	\$50.00 17.33%	\$20.00 11.08%	\$100.00 13.58%	\$1.00 20.47%
2	\$2.00 19.92%	\$2.00 15.98%	\$5.00 13.98%	\$25.00 6.19%	\$1.00 8.70%	\$10.00 16.90%	\$1.00 6.63%	\$10.00 3.33%	\$10.00 8.31%	\$50.00 8.64%	\$2.00 11.68%
3	\$3.00 5.50%	\$3.00 8.38%	\$20.00 8.55%	\$30.00 6.19%	\$30.00 6.52%	\$40.00 7.04%	\$20.00 6.63%	\$100.00 2.67%	\$50.00 7.23%	\$60.00 8.64%	\$3.00 5.43%
4	\$4.00 4.46%	\$5.00 4.73%	\$2.00 8.06%	\$120.00 6.19%	\$50.00 6.52%	\$0.97 5.63%	\$39.00 6.63%	\$30.00 2.00%	\$100.00 6.77%	\$20.00 6.17%	\$10.00 5.12%
5	\$0.50 3.32%	\$4.00 4.67%	\$3.00 6.74%	\$40.00 5.15%	\$20.00 4.35%	\$2.00 5.63%	\$30.00 5.52%	\$80.00 2.00%	\$30.00 5.69%	\$80.00 6.17%	\$5.00 4.93%
6	\$0.75 3.32%	\$7.00 1.73%	\$0.11 4.44%	\$50.00 5.15%	\$6.00 3.26%	\$1.00 4.23%	\$70.00 4.97%	\$200.00 2.00%	\$5.00 2.77%	\$200.00 6.17%	\$20.00 3.80%
7	\$1.50 2.28%	\$10.00 1.47%	\$1.00 4.11%	\$0.01 4.12%	\$0.01 2.17%	\$3.00 4.23%	\$9.00 3.87%	\$150.00 1.33%	\$2.00 2.46%	\$10.00 2.47%	\$4.00 2.97%
8	\$5.00 2.18%	\$6.00 1.28%	\$12.00 1.64%	\$20.14 4.12%	\$5.00 2.17%	\$30.00 4.23%	\$3.00 2.76%	\$0.10 1.33%	\$15.00 1.85%	\$40.00 2.47%	\$50.00 2.02%
9	\$2.25 1.61%	\$2.50 1.21%	\$7.00 1.48%	\$1.00 3.09%	\$35.00 2.17%	\$20.00 2.82%	\$5.00 2.76%	\$40.00 1.33%	\$25.00 1.54%	\$46.00 2.47%	\$30.00 1.96%
10	\$1.40 1.42%	\$3.50 1.21%	\$0.02 1.32%	\$10.00 3.09%	\$100.00 2.17%	\$4.00 2.82%	\$17.00 2.21%	\$62.00 1.33%	\$11.00 1.38%	\$90.00 2.47%	\$100.00 1.41%

Note: Each cell contains the amount of price changes and its proportions in each product category. Bold-marked prices in the first three rows indicate that they are in the top three frequent price changes in each category.

Table 10b. Top 10 Price Changes by Product Category: Pure-Internet Channel

Rank	CDs	DVDs	Video Games	SW	PDAs	Hard Drives	DVD Players	PC Monitors	Digital Cameras	Notebook PCs	Total
1	\$0.10 8.78%	\$0.20 4.16%	\$1.00 4.83%	\$1.00 6.85%	\$10.00 7.42%	\$1.00 10.09%	\$10.00 4.11%	\$1.00 3.37%	\$10.00 8.04%	\$50.00 11.67%	\$1.00 5.03%
2	\$0.20 4.54%	\$0.01 2.82%	\$2.00 3.59%	\$2.00 5.25%	\$5.00 4.53%	\$2.00 7.56%	\$20.00 3.61%	\$2.00 3.37%	\$20.00 4.84%	\$100.00 6.79%	\$2.00 3.59%
3	\$0.01 4.40%	\$0.09 2.80%	\$10.00 2.92%	\$5.00 4.12%	\$2.00 4.24%	\$3.00 5.57%	\$5.00 2.48%	\$10.00 3.27%	\$4.00 4.04%	\$200.00 3.66%	\$10.00 3.01%
4	\$1.00 3.45%	\$0.10 2.77%	\$3.00 2.81%	\$10.00 3.77%	\$20.00 3.18%	\$4.00 4.01%	\$30.00 2.34%	\$3.00 3.08%	\$6.00 3.79%	\$20.00 2.61%	\$3.00 2.80%
5	\$0.06 2.66%	\$0.30 2.19%	\$5.00 2.46%	\$3.00 3.61%	\$1.00 3.12%	\$5.00 3.82%	\$3.00 2.05%	\$5.00 2.29%	\$5.00 3.57%	\$10.00 2.44%	\$5.00 2.45%
6	\$0.14 2.44%	\$1.00 2.09%	\$4.00 2.24%	\$4.00 3.09%	\$3.00 2.41%	\$10.00 2.69%	\$4.00 1.98%	\$4.00 1.96%	\$2.00 3.45%	\$30.00 2.09%	\$4.00 2.21%
7	\$0.02 2.19%	\$0.08 1.60%	\$6.00 1.66%	\$6.00 2.23%	\$30.00 2.35%	\$6.00 2.12%	\$2.00 1.63%	\$6.00 1.88%	\$1.00 3.32%	\$150.00 1.92%	\$6.00 1.63%
8	\$0.50 2.19%	\$0.14 1.51%	\$0.10 1.57%	\$20.00 2.04%	\$6.00 2.24%	\$7.00 1.85%	\$50.00 1.63%	\$20.00 1.65%	\$3.00 2.98%	\$40.00 1.74%	\$20.00 1.55%
9	\$0.30 2.16%	\$0.15 1.44%	\$20.00 1.55%	\$0.01 1.99%	\$4.00 1.94%	\$8.00 1.09%	\$1.00 1.56%	\$30.00 1.53%	\$30.00 2.30%	\$70.00 1.74%	\$0.10 1.55%
10	\$0.40 1.99%	\$0.07 1.43%	\$0.01 1.54%	\$8.00 1.56%	\$15.00 1.88%	\$9.00 1.05%	\$6.00 1.56%	\$7.00 1.48%	\$50.00 2.11%	\$1.00 1.57%	\$0.01 1.51%

Note: Each cell contains the amount of price changes and its proportions in each product category. Bold-marked prices in the first three rows indicate that they are in the top three frequent price changes in each category.

**Table 11. Logit Regression of Likelihood of Price Changes in the Internet Data
(with the Channel Dummy)**

Category	9¢-Endings		99¢-Endings		\$9-Endings		\$99-Endings		\$9.99-Endings		\$99.99-Endings	
	D ₉	D _{B&C}	D ₉	D _{B&C}	D ₉	D _{B&C}	D ₉	D _{B&C}	D ₉	D _{B&C}	D ₉	D _{B&C}
Music CDs	<i>0.104</i> ^{***} (1.110)	-0.425 ^{***} (0.654)	-0.512 ^{***} (0.599)	<i>0.005</i> (1.005)	<i>0.260</i> ^{***} (1.296)	-0.360 ^{***} (0.697)			-0.223 ^{**} (0.800)	-0.357 ^{***} (0.700)		
Movie DVDs	-0.445 ^{***} (0.641)	-0.367 ^{***} (0.693)	-0.518 ^{***} (0.596)	-0.278 ^{***} (0.758)	-0.247 ^{***} (0.781)	-0.445 ^{***} (0.641)			-0.741 ^{***} (0.477)	-0.407 ^{***} (0.666)		
Video Games	<i>0.137</i> ^{**} (1.147)	-0.158 ^{***} (0.854)	<i>0.099</i> [*] (1.104)	-0.160 ^{***} (0.852)	-0.283 ^{***} (0.754)	-0.018 ^{***} (0.982)			-0.248 ^{***} (0.780)	-0.063 ^{***} (0.939)		
Software	-0.158 ^{***} (0.854)	-1.157 ^{***} (0.314)	-0.323 ^{***} (0.724)	-1.069 ^{***} (0.343)	-0.521 ^{***} (0.594)	-0.935 ^{***} (0.393)	-0.942 ^{***} (0.390)	-0.908 ^{***} (0.403)	-0.578 ^{***} (0.561)	-0.950 ^{***} (0.387)	-1.139 ^{***} (0.320)	-0.937 ^{***} (0.392)
PDA's	-0.143 ^{**} (0.867)	-0.509 ^{***} (0.601)	-0.249 ^{***} (0.780)	-0.441 ^{***} (0.643)	-0.444 ^{***} (0.641)	-0.525 ^{***} (0.592)	-0.708 ^{***} (0.493)	-0.534 ^{***} (0.586)	-0.444 ^{***} (0.642)	-0.419 ^{***} (0.657)	-0.837 ^{***} (0.433)	-0.484 ^{***} (0.616)
Hard Drives	-0.253 ^{***} (0.776)	-0.826 ^{***} (0.438)	-0.335 ^{***} (0.715)	-0.783 ^{***} (0.457)	-0.439 ^{***} (0.645)	-0.721 ^{***} (0.486)	-0.321 ^{***} (0.725)	-0.873 ^{***} (0.418)	-0.627 ^{***} (0.534)	-0.749 ^{***} (0.473)	-0.439 ^{***} (0.645)	-0.901 ^{***} (0.406)
DVD Players	-0.540 ^{***} (0.583)	<i>0.393</i> ^{***} (1.481)	-0.634 ^{***} (0.531)	<i>0.429</i> ^{***} (1.536)	-0.723 ^{***} (0.485)	<i>0.473</i> ^{***} (1.605)	-0.675 ^{***} (0.509)	<i>0.331</i> ^{***} (1.393)	-0.729 ^{***} (0.482)	<i>0.475</i> ^{***} (1.608)	-0.940 ^{***} (0.391)	<i>0.372</i> ^{***} (1.450)
PC Monitors	-0.204 ^{***} (0.815)	-0.640 ^{***} (0.527)	-0.383 ^{***} (0.682)	-0.569 ^{***} (0.566)	-0.510 ^{***} (0.600)	-0.441 ^{***} (0.643)	-0.762 ^{***} (0.467)	-0.489 ^{***} (0.613)	-0.740 ^{***} (0.477)	-0.450 ^{***} (0.638)	-1.157 ^{***} (0.314)	-0.536 ^{***} (0.585)
Digital Cameras	-0.435 ^{***} (0.647)	-0.017 ^{***} (0.983)	-0.494 ^{***} (0.610)	<i>0.002</i> (1.002)	-0.524 ^{***} (0.592)	-0.073 [*] (0.930)	-1.122 ^{***} (0.326)	-0.012 ^{***} (0.988)	-0.595 ^{***} (0.552)	-0.013 ^{***} (0.987)	-1.442 ^{***} (0.236)	-0.034 ^{***} (0.966)
Notebook PCs	-0.140 ^{***} (0.869)	-1.043 ^{***} (0.352)	-0.464 ^{***} (0.629)	-0.928 ^{***} (0.395)	-0.933 ^{***} (0.393)	-0.895 ^{***} (0.408)	-0.799 ^{***} (0.450)	-1.127 ^{***} (0.324)	-0.512 ^{***} (0.599)	-0.944 ^{***} (0.389)	-0.686 ^{***} (0.504)	-0.996 ^{***} (0.369)
Total	-0.263 ^{***} (0.769)	-0.446 ^{***} (0.640)	-0.458 ^{***} (0.632)	-0.346 ^{***} (0.707)	-0.565 ^{***} (0.568)	-0.461 ^{***} (0.630)	-0.893 ^{***} (0.410)	-0.532 ^{***} (0.588)	-0.759 ^{***} (0.468)	-0.409 ^{***} (0.664)	-1.180 ^{***} (0.307)	-0.514 ^{***} (0.598)

Note: 2,651,365 data points; Each cell contains a coefficient and odds ration in parenthesis; D₉ is a 9-ending dummy variable, which equals 1 if the price ends with 9¢, 99¢, \$9, \$99, \$9.99, \$99.99, respectively and 0 otherwise; D_{B&C} is a channel dummy variable, which equals 1 if a store is in the bricks-and-clicks channel and 0 if it is in the pure Internet channel;; significance levels: ***=0.01, **=0.05, *=0.10; estimated coefficients in *italics* indicate unsupported results.

¹ See, for example, Blinder, et al. (1998), Caplin (1993), Warner and Barsky (1995), Lach and Tsiddon (1996), Slade (1998), Ball and Romer (1990, 2003), Golosov and Lucas (2003), Davis and Hamilton (2004), Basu (2005), Dotsey and King (2005), Rotemberg (1987, 2005), and the studies cited therein. For recent surveys, see Kackmeister (2002), Willis (2003), and Wolman (2005). See also the studies conducted recently by the European Central Bank's IPN, such as Angeloni, et al. (2004), Coenen and Levin (2004), de Walque, Smets, and Wouters (2004), Dhyne, et al. (2004), Fabiani, et al. (2004), and Vermeulen, et al. (2004).

² See also the survey studies of the European Central Bank's IPN. These studies are summarized in Fabiani, et al. (2004). The phenomenon of pricing points has recently received considerable attention in public discussions in several European Union countries in the context of the conversion of prices from local currencies to the Euro. The main concern in these countries has been the possibility that retailers may have acted opportunistically by asymmetrically upward rounding their prices after conversion to the Euro in their attempt to preserve the pricing points. See, for example, Folkertsma (2002), Folkertsma, et al. (2002), Ehrmann (2005), and the studies cited therein.

³ For three mail-order companies, L.L. Bean, the Orvis Company, and Recreational Equipment, Inc (REI)

⁴ Sometimes the Internet-based sellers' (especially small firms') Web sites were inaccessible or the required price information was not available. Some prices, therefore, are missing in our original data set. We used the following procedure to handle such missing data. If 10% or more observations were missing for a product in a store, then that series was excluded from the data altogether. If less than 10% of the data was missing, then we examined if the prices for the day before and the day after were the same. If they were the same, then the software agent automatically filled in for the missing data with that price. Otherwise, the agent filled in for the missing data with the price for the day after. While we recognize that this is an arbitrary procedure, since there are only 0.075% missing prices in the entire dataset, it is unlikely to affect our results significantly.

⁵ We selected these categories because they are the most popular categories in the Internet-based markets. In addition, the products in these categories are sold by a large number of stores. For example, in the digital cameras category, "Canon EOS Digital Rebel XT" is sold by 63 stores. The selection of the specific products was random. For example, in the category of DVDs, we chose products from multiple sub-categories (e.g., action, drama, comedy, children, etc.). Similarly, in the music CDs category, we chose from many different sub-categories (e.g., blues, jazz, country, heavy metal, etc.). However, in some categories (e.g., notebook PCs, hard drives, PDAs), we included all the products available. In other categories (e.g., DVD players, digital cameras, PC monitors, software, video games), we randomly chose products from all sub-categories. For example, in DVD players, we chose half of the products from standard DVD players while the other half came from the more expensive DVD/VCR combo players. In digital cameras and camcorders, we chose half from regular digital cameras while the other came half from digital camcorders. In PC monitors, we chose half from CRT and flat CRT models, with the other half from LCD and TFT. In the software category, we chose products from multiple genres of software (e.g., educational software, operating systems, programming software, utility software, etc.). Similarly, in video games, we included multiple genres (adventure, action, sports, etc.).

⁶ According to Dutta, et al. (1999) and Levy, et al. (1997, 1998), the average price of an item in large U.S. supermarket chains during 1991–92 was about \$1.70. According to Bergen, et al. (2003), the figure increased to \$2.08 by 2001.

⁷ For the sake of space, most of the voluminous figures and tables on individual product categories in both datasets are included in a reviewer appendix, available upon request from the corresponding author. Note that the result for products in the Beer and Cigarettes categories in the Dominick's data are subject to various tax rules and other government regulations that could potentially skew the results. Therefore, we do not report the results on those two product categories.

⁸ With the exception of five categories (i.e., canned tuna, cigarettes, front-end-candies, oatmeal, and paper towels), the 99¢ ending prices are the most common and substantially more than most other two-digit ending prices. Even in the five categories where 99¢ ending is not the most popular, it is still very common and ranks within the top five price-endings among the 100 possible endings.

⁹ While so far we have used visually appealing figures to present the results from both datasets, results on the use of 9 for the last three and four digits in the Internet data, and latter the results in Section 4 on price changes in the Internet data, are presented only in tables, as they are too numerous (i.e., 1,000 possible endings for the last three digits, 10,000 possible endings for the last four digits, and 156,800 possible price changes) to be plotted.

¹⁰ There are 1,000 different endings.

¹¹ There are 10,000 different endings.

¹² This is consistent with what we heard from Jurek Konieczny, a discussant of our paper in the 2003 Central European Union Conference: "I asked the best economist I know, at least for such things—my wife—if she recalled a price not ending in a 9 at our local grocery store. Not really, she said. Maybe sometimes there are prices ending in a 5, but not really."

¹³ Category level data indicate some cross-category variation, although in general they are consistent with the above finding. That is, in most categories, price changes in multiples of 10 cents are more common than other price changes.

¹⁴ For hard drives, changes in multiples of ten dollars are the fourth most popular category. For CDs and DVDs, they are *not* ranked within the top 20, which we believe is because the prices for both products are rather low and the price changes may not go up to \$10 or more.

¹⁵ Since binary logit regression is relatively well known in marketing and IS research, we do not provide a lot of details about the estimation process, the interpretation of the model, the appropriate diagnostics for the statistical significance of the results, or other issues that relate to functional form. For the interested reader who would like more information, we recommend the following sources: Agresti (2002), Greene (2003), and Hosmer and Lemeshow (2000).

¹⁶ Similar results are obtained for each individual product category. While the categories of music CDs and video games showed some unexpected results, in 53 out of 56, that is, in 95% of all possible cases for the category-level analysis, the effect of 9 price-endings on the probability of price changes is negative and significant.

¹⁷ See Shapiro (1968) and Monroe (1990) for reviews of earlier literature, and Anderson and Simester (2003) for a review of more recent literature in marketing.

¹⁸ Other theories try to explain 9-ending pricing based on image effect or level effect explanation. Still other theories argue that sellers like to give change or that buyers like to receive a change. It has been suggested also that 9-ending prices may be interpreted as discount prices and thus are indicative of good bargains. Finally some authors have suggested a cognitive accessibility of certain numbers to explain pricing points, especially pricing with numbers that end with either 0 or 5. See Shy (2000) and Ruffle and Shtudiner (2002) for a critical review of some of these theories.

¹⁹ Landsburg (1995) offers an interesting historical account of 9-ending prices. See also Ginzberg (1936) for a social customs theory, and more recent authors, such as Basu (1997), Shy (2000), Ruffle and Shtudiner (2002) and Andersen and Simester (2003), for economic explanations for 9-ending prices.

²⁰ Information processing requirements faced by decision-makers in many economic models have been critically discussed in economics for some time. For example, this issue was debated in late 1970s and early 1980s in the context of the rational expectations hypothesis, when people began questioning some of the strong assumptions required for the hypothesis to hold (Shiller, 1978; Levy, 1990).

²¹ Rotemberg (2003) focuses on price rigidity that might result from consumer inattention. In Rotemberg's (2003, 2005) model, a price change triggers re-evaluation of the firm's fairness.

²² These time, resource, and information processing-capacity constraints have been explored by many authors in economics and marketing, under the labels of thinking costs (Shugan, 1980), reoptimization costs (Roufalgas, 1994), information processing costs (Sims, 1998), information gathering costs (Ball and Mankiw, 1994; Ball, 2000; Zbaracki, et al., 2004), decision-making costs that result from either costs of acquiring information or costs of reoptimization (Mankiw and Reis, 2002; Ball, et al., 2005; Reis, 2003 and 2004; Zbaracki, et al., 2004), or limited channel capacity for absorbing information (Woodford, 2001; Adam, 2004; Sims, 1998 and 2003). See also, Akerlof, et al. (2000), Ameriks, et al. (2003, 2004), Gabaix, et al. (2005), and Rotemberg (2005).

²³ This kind of selective consumer inattention to price information is consistent with evidence from surveys of consumer behavior in this industry. See, *Progressive Grocer*, November 1974, p. 39; *Progressive Grocer*, February 1964, pp. C104–C106; and Gabor and Granger (1961). This behavior is consistent also with the marketing literature in consumer behavior on “just noticeable differences” (Monroe, 1970 and 2001), where consumers do not react to small changes in prices because they do not “notice” these changes, as documented by Kalyanaram and Little (1994) for sweetened and unsweetened drink products.

²⁴ Our argument holds even if the cost of noticing, processing, and memorizing one additional price digit remains constant.

²⁵ The idea of rational inattention and its implications as developed here should be robust to competition if firms are trying to draw the same customer segments. In situations where customers are rationally-inattentive to the rightmost digit, competitors will not be able to “steal” customers by lowering their last digit to less than 9. As such, all competitors would find it optimal to end prices in 9's, and customers would find it rational to expect them to end in 9's.

²⁶ Results are similar when those ambiguous retailers are removed from the analyses.

²⁷ As further evidence for the heterogeneity in rational inattention, a story in the *Miami Herald* (Sunday, Sept. 20, 2003, pp. 1E and 8E) reported 140 prices sampled for 20 grocery items from seven grocery stores, which included a Wal-Mart supercenter, two Publix stores, two Winn-Dixie stores, a Super Target, and a Sedano's. In this small dataset there were 20 prices from Wal-Mart, only one of which ended with 9¢ and none of which ended with 99¢. This is in comparison with 96 prices that end with 9¢ and 25 prices that end with 99¢ among the remaining 120 prices from the six relatively more upscale stores. This is consistent with our notion that rational inattention may play a role in how often we see 9 as the terminal price. At Wal-Mart where consumers are usually more attentive (i.e., price sensitive), the use of 9 as the price-ending may lose its value.

²⁸ According to Heeler and Nguyen (2001), in the Chinese mind, numbers have special significance and symbolism. Even the sounds of the numbers can suggest good or bad luck. Thus number 8 presents luck to the Cantonese Chinese because in

Cantonese it sounds like *multiply* or *get rich* (*Fa* in Cantonese). In Japan, 8 also has great symbolic significance because the Japanese writing of the number 8 looks like the shape of a mountain (*sue-hirogari* in Japanese), and thus the number 8 signifies *grow* or *prosper*. Consistent with this interpretation, Heeler and Nguyen (2001) find that close to 50% of restaurant menu prices sampled in Hong Kong had 8-endings, which they define as “happy endings.” Consistent with the above is also a recent *Time Magazine* article by Rawe (2004), in which she reports that at the casino of a recently built \$240 million hotel Sands Macao in Macao (a former Portuguese colony handed over to China in 1999), the slot machines’ winning trios of 7’s have been replaced with trios of 8’s. It turns out that the cultural importance of some roman numerals is not limited to “happy endings.” For example, according to Mirhadi (2000), when the Masquerade tower was added to Hotel Rio in Las Vegas in 1997, the hotel architects decided to skip the 40th–49th floors because the Arabic numeral “4” in Chinese sounds similar to the word “death.” Instead, they went directly from the 39th floor to the 50th floor.

²⁹ According to a July 19, 2001 report of Larry Copeland of the *USA Today*, “France, Spain and Britain, quit producing low-denomination coins in recent decades because production costs kept going up while the coins’ purchasing power went down.” More recently, it has been reported that in many European Union Countries that have adopted the Euro, the public—buyers as well as sellers—seems to exhibit resistance to the use of 1-cent and 2-cent denomination coins because of the inconvenience their use entails: “They’re small, nearly valueless—and a nuisance to millions of Europeans. The tiny denomination 1- and 2-cent Euro coins are annoying shoppers and disrupting business from Paris to Milan,” (Eric Pfanner, “Euro quandary: It’s no small change,” *International Herald Tribune*, Tel-Aviv Edition, Friday, March 22, 2002, p. 1). The argument here seems to resemble the arguments made in the context of the “1¢ nuisance” cost caused by the need to obtain one-cent stamp to be added to the standard first class mail stamp after each upward adjustment in the price of the US first class mail by 1¢ (Rubin, 1999). In July 2001, Rep. Jim Kolbe (R-Arizona) has introduced the “Legal Tender Modernization Act,” which would make the US penny obsolete. According to the proposed bill, checks would still be made to the exact amount, but the merchants would be required to round up or down to the nearest nickel on cash purchases. The bill was defeated. Previous attempts, which were made in 1990 and 1996, also died in Congress (Source: Larry Copeland, “Bill Would Make Pennies Obsolete,” *USA Today*, July 19, 2001, internet edition). Elimination of pennies in cash transactions and rounding up/down of the prices to the nearest nickel has been recently discussed also in the context of the price-setting policy of the US House of Representative Gift Shop. (See the July 18, 1995 Report No. 95-CAO-05, Office of the Inspector General, US House of Representatives).

³⁰ Zbaracki et al. (2004) uncovered evidence from industrial markets that shows the managerial costs are significantly greater (i.e., more than six times) than the menu costs associated with price changes.