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Effects of $9 Price Endings on Retail Sales: Evidence from Field Experiments

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Abstract. Although the use of $9 price endings is widespread amongst US retailers there is little evidence of their effectiveness. In this paper, we present a series of three field-studies in which price endings were experimentally manipulated. The data yield two conclusions. First, use of a $9 price ending increased demand in all three experiments. Second, the increase in demand was stronger for new items than for items that the retailer had sold in previous years. There is also some evidence that $9 price endings are less effective when retailers use "Sale" cues. Together, these results suggest that $9-endings may be more effective when customers have limited information, which may in turn help to explain why retailers do not use $9 price endings on every item.

Key words. price ending, odd-pricing, pricing, catalogs

JEL Classification: C81, C93, D12, D8, L11, L15, M3

1. Introduction

Published studies report that 30% to 65% of all prices end in the digit 9 (Stiving and Winer, 1997; Schindler and Kirby, 1997; Daily Mail, 2000). Despite interest from economists reaching back over 65 years (Ginzberg, 1936) and the current widespread use of this practice amongst retailers, empirical evidence that price endings affect demand is limited. In this paper, we present a series of three field experiments in which we vary the price endings of many products. The three studies were conducted with two different national mail-order companies that sell moderately priced women's clothing.

The study was motivated in part by a pilot study in which one of the catalogs agreed to mail three versions of a catalog to separate randomly selected customer samples. The prices of four dresses were manipulated across catalog versions. The current policy of the catalog was to use a $9 ending and we refer to this as the Control version. In the two treatments, the price was either raised or lowered by $5,

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which removed the $9 ending from each dress. The prices and demand for the four dresses in each of the versions are summarized in the table below. A total of 66 dresses were sold in the $9 ending conditions, compared to 46 units in the $5 lower conditions and 45 units in the $5 higher conditions. The $9 ending yielded a demand increase of approximately 40% for these four dresses, while the $10 price difference between the two Treatment conditions resulted in effectively no difference in demand. This outcome persuaded catalog managers to conduct additional studies to replicate the findings on a larger sample of items. The findings also raise important questions about the contexts in which a $9 ending effect occurs. The three studies reported in this paper investigate whether the $9 ending effect varies depending upon how often an item has appeared in the catalog, and whether the $9 ending effect is moderated by "Sale" cues claiming that an item is discounted.

Pilot study: design and results.

	Prices			Number of units purchased		
Item	Control	Test A	Test B	Control	Test A	Test B
1	$39	$44	$34	21	17	16
2	$49	$44	$54	14	8	10
3	$59	$54	$64	7	7	6
4	$79	$84	$74	24	12	15

The marketing and economics literatures have long recognized the phenomenon of price endings but have produced few conclusive empirical studies. Prior research has focused on consumer-packaged goods or has involved very small price changes. Stiving and Winer (1997) offer a recent example of research conducted with consumer-packaged goods. They analyzed demand for canned tuna and yogurt and found conflicting evidence about the effect of 9-cent price endings (see also Blattberg and Neslin, 1990, p. 349). Examples of studies investigating very small price changes include Ginzberg (1936) and Schindler and Kibarian (1996). Ginzberg (1936) offers a brief description of a price-ending study conducted by a national mail-order catalog. In this study, round prices (i.e., 0-cent ending) were compared against "just under" prices of one to two cents less. Overall, the results were varied, with demand increasing for some items and decreasing for other items. Schindler and Kibarian (1996) conducted a study comparing 88-cent, 99-cent and 00-cent price endings in a clearance version of a mail-order catalog that sold women's clothing. Their findings regarding the impact on demand were also inconclusive.

Our studies offer new insights on the role and effectiveness of price endings. First, we present findings investigating $9 ending effects in three large-scale studies conducted in two different catalogs. The studies involved large price manipulations (generally $1 to $5) and revealed a consistent significant effect across all three studies, providing conclusive evidence that $9 price endings can increase demand. Second, we demonstrate that $9-endings are more effective on newer items. There is also some evidence that their effectiveness varies in the presence of "Sale" cues. The evidence that the effectiveness of price endings is moderated by the context in which they are used, may offer an explanation for the inconclusive findings in past studies.

The remainder of the paper is organized as follows. In Section 2, we present an overview of the studies and a brief description of the catalog companies. In Section 3, we present detailed descriptions and analyses of each study. In Section 4, we discuss the findings and conclude the paper.

2. Overview of studies

In this section, we provide an overview of the three studies. Because the details vary across studies, we provide a more precise description of each study in Section 3. The studies were conducted in two different mail-order catalog titles (companies). The titles, which we will call Grace's and Sandi's, are both owned by the same corporation. Although both catalogs sell moderately priced women's clothing, there is little overlap in their target markets. In both catalogs all of the items carry the catalog's own brand (private label) and have an average price of approximately $50. Over 52% of Grace's prices and 68% of Sandi's have $9 endings. The next most common price ending is $4, with 20% of Grace's prices and 28% of Sandi's prices ending in $4. Active customers typically purchase approximately twice a year, and may receive up to 20 catalogs per year.

In each study we simultaneously varied the use of $9 price endings on identical items in different catalog versions mailed to randomly selected customer samples. Each study had a Control version, in which the catalog's standard pricing policy was used. The Control version acted as a control for other unrelated tests, and so we were unable to vary the prices in this version. One or more Treatment versions were also created and prices were manipulated in these versions. As we explain in detail in the next section, the current pricing policy (i.e., Control version) for these catalogs was to use $9 endings on most items. Thus, most of the price changes in the Treatment versions resulted in the removal of a $9 ending. Customers were randomly designated to receive either the Control or one of the Treatment versions. Randomization was based on zip + 4 postal codes. Analysis of the frequency of orders by zip code revealed that over 99.7% of orders were from unique zip codes and that no more than two orders were received from the same zip + 4 postal code.

Measuring purchasing behavior of real customers offers greater external validity than laboratory experiments. The opportunity to charge different prices for the same products also overcomes potential endogeneity issues that arise when analyzing historical data. However, varying the content of catalogs is expensive and preserving the cooperation of a catalog retailer restricts discretion over the experimental design. In each study, catalog managers restricted the range of prices that we could vary. For example, in Study 1 we were only able to adjust prices on the first and last ten pages of the catalog. The catalog printer treated these twenty pages as a "block" and the cost of changing the prices on any of these pages was fixed. Changing prices on other pages would have resulted in additional costs. The managers also placed some restrictions on the price-levels. In Study 1, price changes were limited to $1 increments, while in Study 2 most of the price changes were limited to $5 increments.

The market for women's apparel is competitive and both Grace's and Sandi's compete with other retailers and mail-order firms. Although we have no information about competitor's activities, we would expect these activities to affect customers in the Control and Treatment versions similarly. More generally, the experimental design allows us to exclude alternative explanations arising from intervening events.

When customers call to place an order they are asked for a code printed on the back of the catalog that they are ordering from. This code allows the firm to identify which catalog the customer is purchasing from and, where appropriate, which catalog version. In each study, we received aggregate sales data for each version at the item-level. Items returned or cancelled by customers are netted out of the analysis.

The direct marketing industry has a long history of conducting "split-sample" experiments, in which randomly selected customer samples are mailed modified versions of otherwise identical catalogs. Wisdom in the industry suggests that profitability depends upon a firm's ability to design, implement and analyze split-sample studies and then appropriately disseminate the findings within the organization. Prices are a common focus of these studies; over 31% of catalog firms reported that they conducted split sample experiments of pricing strategies in 1999 (Direct Marketing Association, 2000). Other common experiments include testing the demand for new products, and the creative design of catalog covers, page layouts, and copy.

Testing of prices and other strategies is far more common among direct marketing firms than among traditional retailers. In part, this reflects the benefits of conducting split-sample tests in a catalog setting. The experimental versions of the catalogs can be distributed at the same time to an identical sample of customers. Tests conducted in retail stores generally require differences in strategies over time or differences across stores. This introduces the potential for alternative explanations due to intervening events or systematic differences between stores. Second, the number and identity of catalog customers who are exposed to the different experimental versions is known. In a retail store it is much more difficult to track the total number and identity of customers who visit a store. Third, stock-outs can distort measurement of demand in a traditional retail setting. For example, there is generally no record of customers who searched for an item and then departed when they could not find it, or customers who were never aware of an item but would have purchased it if it had been on display. In a catalog setting customers initiate orders in writing or via telephone before learning whether the item is available. The decision to cancel an order, substitute an alternative item or backorder an item is also explicit and therefore observable.

3. Results

In this section, we present a detailed description of each study. Study 1 involved the fewest items and the narrowest variation in prices. In Study 2, we were able to investigate whether the results from the first study generalize to a different catalog title. We were also offered more flexibility over the number of prices that we could change and the magnitude of the price changes. This increased flexibility enabled us to investigate whether the $9-ending effect depends on whether an item is new to the catalog or has appeared in previous seasons. Study 3 extends these results by considering the effect of a $9-ending when a "Sale" sign is present. We begin our discussion with Study 1.

Study 1

Study 1 was conducted with a Grace's catalog and involved a Control version and two Treatment versions that we label Version A and Version B. The three catalog versions were distributed to separate, randomly chosen customer samples, with 20,000 customers receiving each version. All of the customers had purchased from Grace's in the previous 18 months. The test involved varying the prices of items on the first and last ten pages of the catalog. There were a total of 73 items in these two ten page sections and 146 other items in the catalog.

We varied the prices of 27 items, all of which had $9 price-endings in the Control. On six items we increased the price in Version A and reduced the price in Version B. On ten items this manipulation was reversed; prices were decreased in Version A and increased in Version B. Finally, for a further eleven items we only varied the prices in Version B, increasing the price of four items and decreasing the price of seven items. All price changes were in $1 increments, so that price increases yielded price-endings of $0 and price decreases yielded price-endings of $8. A frequency distribution of price endings and summary statistics for all three versions are provided in Table 1.

Management of Grace's provided us with aggregate statistics for the three catalogs along with item-level demand data for the 73 items on the twenty test pages. Sales of each item (in a given version) ranged from zero to nineteen with an average demand of 2.6 units per item. This count of the number of units ordered could be expected to follow a Poisson distribution. In particular, we will assume that the number of units of item i ordered from version j is drawn from a Poisson distribution with parameter λ_{ij}:[1]

$$\text{Prob}(Q = q_{i,j}) = \frac{e^{-\lambda_{i,j}}\lambda_{i,j}^{q_{i,j}}}{q_{i,j}!}, \qquad q_{i,j} = 0, 1, 2, \ldots \tag{1}$$

1 For all three studies, we also modeled demand using a semi-log specification, $q_{i,j} = \sum_k \beta_k \ln(X_{k,i,j})$, and obtained similar results to those reported in the paper.

Table 1. Summary of price endings and prices offered in Study 1.

	Test items			
	Control	Version A	Version B	Other items
Price Endings				
\$0		6	14	
\$4	22	22	22	37
\$8		10	13	
\$9	50	34	23	103
Other	1	1	1	6
Total	73	73	73	146
Average price	\$54.44	\$54.38	\$54.45	\$56.01
Std deviation	\$21.11	\$21.10	\$21.05	\$19.93

where:

$$\ln(\lambda_{i,j}) = \alpha_0 + \sum_{j=1}^{J-1} \alpha_j Version_j + \sum_{i=1}^{I-1} \chi_i Item_i + \beta_1 \ln Price_{i,j} + \beta_2 Nine_{i,j}. \quad (2)$$

The $\alpha_j, \chi_i, \beta_1$ and β_2 terms are estimated parameters and the variables are defined as follows:

$q_{i,j}$	Number of units of item i purchased from version j.
$Version_j$	Dummy variables identifying the version.
$Item_i$	Dummy variables identifying the item.
$Price_{i,j}$	The price of item i in version j.
$Nine_{i,j}$	1 if the price of item i in version j ends in \$9; 0 otherwise.

The $Version_j$ terms control for version-specific effects (including any differences in the distribution of customers that received each version), the $Item_i$ terms control for item-specific effects, β_1 and β_2 measure the price and \$9 ending effects. We estimated this Poisson regression model through maximum likelihood using data describing the demand for the 73 test items in the three versions (219 observations). The findings are reported in Table 2 (for ease of exposition we omit the coefficients describing the version and item effects). As a benchmark we also report models in which we omit either the \$9 ending or the price variable.

The findings in Models 2 and 3 offer support for a \$9 ending effect. The coefficients for the \$9 ending variable are positive and statistically significant ($p < 0.05$). Expected demand is given by $\partial E[q_{ij}|x_{ij}] = \lambda_{i,j}$ and the marginal effect is $\partial E[q_{ij}|x_{ij}]/\partial x_{ij} = \beta\lambda_{ij}$. Thus, the percentage change in demand from using a \$9 ending is $\partial E[q_{ij}|x_{ij}]/\partial x_{ij}/E[q_{ij}|x_{ij}] = \beta$. We conclude that using a \$9 ending in Study 1 led to

Table 2. Nine ending model results for Study 1.

	Model 1	Model 2	Model 3
$9 ending		0.341*	0.351*
		(0.170)	(0.172)
Price (β_1)	−1.954		−3.182
	(6.406)		(6.383)
Sample size	219	219	219
Log likelihood	−210.9	−209.1	−208.9

Notes. Item and version-specific effects are omitted. Asymptotic standard errors are in parentheses.
*Significantly different from zero ($p < 0.05$).

an increase in demand of approximately 35%, which translates into 0.9 additional units per item.

While we find evidence of a positive $9 ending effect, the estimated price coefficient is not significant in either model. This is somewhat consistent with the findings from the pilot study where aggregate demand did not vary between the high and low price conditions. We might be tempted to conclude that customers are more sensitive to the $9 price cue than they are to actual price changes. However, the variance available to identify a price coefficient is small. The item-level effects account for variation in prices between items and so the price coefficient is identified by the price changes on the 27 test items. These same price variations are used to identify the $9-ending effect. In Study 2 we were able to mail catalogs to a larger sample of customers and introduce greater price variation. This enabled us to better separate the price and $9-ending coefficients and increased the statistical power of the study.

Study 2

Study 2 was conducted in a Sandi's catalog. The test was designed to investigate whether the results from Study 1 could be replicated in a different catalog title. We were also interested in whether the finding would survive greater variation in the prices and whether the effect varies depending on whether an item is new to the catalog.

Two versions of a catalog, which we label Treatment and Control, were each mailed to randomly selected samples of 31,250 customers. Between the two versions we manipulated the prices of 120 items, out of a total of 211 in each version. The prices of the 120 test items were all lower in the Treatment version, with the price decreases ranging from $3 to $5. The price changes resulted in the following distribution of price endings across the two versions:

Table 3. Summary of price endings and prices offered in Study 2.

	Test items		
	Control	Treatment	Other items
Price ending			
\$0	6	3	
\$2	6	8	
\$4	22	71	16
\$5	11	2	
\$6		4	5
\$7		8	1
\$8			1
\$9	75	24	68
Total	120	120	91
Average price	\$57.75	\$53.05	\$48.25
Std deviation	\$18.95	\$18.59	\$24.11

- Seventy-five test items had \$9 price endings in the Control version. Seventy-one of these items had \$4 price-endings in the Treatment, two had \$5 price endings, and two had \$6 price endings.
- Twenty-four test items had \$9 price endings in the Treatment. Twenty-two of these items had \$4 price-endings in the Control version, and 2 had \$2 price-endings.
- Twenty-one test items did not have a \$9 ending in either the Treatment or the Control.

The average prices across the two versions and the distribution of price endings are summarized in Table 3.

We used the same approach to analyze the findings as we employed in Study 1. In particular, we again assumed that the number of units of item i ordered from $Version_j$ follows the Poisson distribution described in equations (1) and (2). We estimated the model using data for all 211 items in the two versions (422 observations). Because the study only had two experimental versions, each item-specific effect is identified by just two observations. However, this is analogous to any study in which an outcome is compared across Treatment and Control samples. The Control sample provides the extra degree of freedom required to control for variance that is common to the two samples. The findings are reported in Table 4, where we also report the benchmark models in which the \$9 ending or price variable was omitted.

Additional data provided by this catalog allowed us to consider a modification to our model specification. The retailer classifies its items into three categories: footwear, "new" items and "established" items. The new and established items are all clothing items (not footwear). The new items were generally introduced in the most recent season, while established items were offered in previous seasons. The 211 items in this catalog included 55 established items, 128 new items and 28 footwear

Table 4. Summary of model results in Study 2.

	Model 1	Model 2	Model 3	Model 4
$9 ending		0.143**	0.152**	
		(0.039)	(0.041)	
$9 ending on footwear				− 0.397
				(0.247)
$9 ending on established items				0.098
				(0.069)
$9 ending on New items				0.218**
				(0.059)
Price (β_1)	− 0.304		− 0.592	− 0.480
	(0.450)		(0.486)	(0.509)
Sample size	422	422	422	422
Log likelihood	− 423	− 419	− 419	− 417

Notes. Item and version-specific effects are omitted. Asymptotic standard errors are in parentheses.
**Significantly different from zero ($p < 0.01$).

items. Of the 120 test items, 35 were established, 67 were new and 18 were footwear. This balance in the distribution of test items is also reflected in the distribution of $9 endings across the items. Amongst the established items, 55.5% of the established item prices ended in $9, compared to 55.9% of the new items and 55.4% of the footwear items. To investigate how the $9 ending effect varied across the product categories, we interacted the $Nine_{i,j}$ variable with dummy variables identifying each category. This led to the following model specification:

$$\ln(\lambda_{i,j}) = \alpha_0 + \sum_{j=1}^{J-1} \alpha_j Version_j + \sum_{i=1}^{I-1} \chi_i Item_i + \beta_1 \ln Price_{i,j} + \sum_{c} \beta_2^c Category_c * Nine_{i,j}, \tag{4}$$

where $Category_c$ refers to the category dummies. We label this last specification as Model 4 and the results of each model are shown in Table 4.

The findings replicate and strengthen many of the findings in Study 1. In Models 2 and 3 we see that $9 endings are again associated with a significant ($p < 0.01$) increase in demand. To aid interpretation we calculated the marginal increase in demand attributable to a $9 ending. On average each version sold 8.7 units of each item. This increased by approximately 1.3 units (15%) when an item had a $9 ending. The findings from Model 4 indicate that the $9 ending effect was stronger for new items than for established items. A $9 ending yielded an estimated increase of 1.8 units or 22% for new items compared to 10% for established items. For the footwear items the result was difficult to interpret; the coefficient was negative but not

Table 5. Summary of model results in Study 2.

	Control	Version A	Version B
Sale cue only	11	13	14
$9 ending only	176	91	90
$9 ending and sale cue	27	16	16
Neither	94	188	188
Total	308	308	308

significant. The relatively large standard error for this coefficient reflects the small number of footwear items sold.

Finally, the price coefficients are again all insignificant. This offers further evidence that customers are more sensitive to the $9 ending cues than to actual price differences.

Study 3

Study 3 had several goals. First we sought to replicate the $9 ending effect observed in the two previous studies. Second, we also hoped to replicate the findings in Study 2 revealing that the size of the effect is moderated by whether an item is an established or new item. Finally, we investigated whether the effect is also moderated by the presence or absence of a "Sale" cue claiming that a price is discounted.

In Study 3 three different versions of a Sandi's catalog containing 308 items were produced. The three catalog versions were distributed to separate, randomly chosen customer samples, with 90,000 customers receiving each version. The price descriptions for 38 of the items in the Control version included an explicit claim that the item was discounted. The prices of these items were presented as follows "Reg $X SALE $Y" compared to the standard description "$X". In addition a total of 203 items had $9 endings. In the two Treatment versions we varied prices and removed sale claims from some of these items. Removing a sale cue from an item results in an unadvertised discount, and catalog managers deemed this potentially costly but worthy of investigation. In contrast, adding a sale sign to an item without lowering the price was viewed as a risky strategy that may breach customer protection laws. For this reason we were unable to add sale cues to regularly priced items, so that the test contained less variance in the use of sale claims than we would have liked. The final distribution of sale claims and $9 endings is summarized in Table 5.

The prices in the Control version were the standard price for each item. In Version A the prices of 55 items were raised by $1 to $6 and the prices of 53 items were lowered by $0.50 to $4. In Version B the prices of 58 items were raised by $1 to $4.50 and the prices of 52 items were lowered by $0.50 to $10. The average prices across the versions and the distribution of price endings are summarized in Table 6. The manipulations involving $9.50 price endings were introduced by a catalog manager.

Table 6. Summary of price endings and prices offered in Study 3.

	Test items			
	Control	Version A	Version B	Other items
Price Endings				
$0		8	8	
$1		17	19	
$2	1	8	7	12
$4	3	1	1	63
$5	3			10
$6	2	7	7	6
$7		21	22	5
$8		27	27	
$9	139	43	42	64
$9.50		16	15	
Total	148	148	148	160
Average price	$58.39	$58.32	$58.44	$49.64
Std deviation	$32.94	$32.94	$32.90	$25.66

This manager reasoned that a $9 ending strategy would be even more profitable if it contributed an additional $0.50 of revenue per item.

To analyze the results of Study 3 we modified equation (2) to introduce explicit controls for the "Sale" cues.

$$\begin{aligned}\ln(\lambda_{i,j}) &= \alpha_0 + \sum_{j=1}^{J-1} \alpha_j Version_j + \sum_{i=1}^{I-1} \chi_i Item_i + \beta_1 \ln Price_{i,j} \\ &+ (1 - Sale_{i,j}) * Nine_{i,j} \sum_c \beta_2^c Category_c \\ &+ Sale_{i,j} * Nine_{i,j} \sum_c \beta_3^c Category_c + \beta_4 Sale_{i,j}(1 - Nine_{i,j}). \qquad (5)\end{aligned}$$

The $Sale_{i,j}$ variables was defined as: 1 if the price description of item i in version j included the word "Sale" and 0 otherwise. This specification allows us to identify three mutually exclusive effects. The coefficient β_2^c measures the effect of using a $9 ending with no "Sale" cue; β_3^c measures the effect of using a $9 ending with a "Sale" cue; and β_4 measures the effect of using a "Sale" cue alone. Preliminary analysis revealed that customers did not respond to $9.50 endings in the same way that they respond to $9 endings and so we did not incorporate these price endings into the *Nine* variable.

We estimated this model using data describing the demand for all 308 items in the three versions (924 observations). The findings are reported in Table 7 where we also report analogous benchmark models to those reported for the earlier studies. We did

Table 7. Summary of model results in Study 3.

	Model 1	Model 2	Model 3	Model 4
\$9 Ending × No Sale Cue		0.044	0.071*	
		(0.028)	(0.030)	
\$9 Ending on Footwear				0.077
× No Sale Cue				(0.059)
\$9 Ending on Established Items				− 0.024
× No Sale Cue				(0.112)
\$9 Ending on New Items				0.085*
× No Sale Cue				(0.035)
\$9 Ending × Sale Cue		0.078	0.117	
		(0.079)	(0.082)	
\$9 Ending on Established Items				− 0.109
× Sale Cue				(0.185)
\$9 Ending on New Items				0.217**
× Sale Cue				(0.084)
No \$9 Ending × Sale Cue		0.240**	0.215**	0.178*
		(0.069)	(0.071)	(0.073)
Price (β_1)	− 2.244**		− 2.312**	− 2.360**
	(0.464)		(0.492)	(0.503)
Sample size	924	924	924	924
Log likelihood	− 1519	− 1527	− 1515	− 1512

Notes. Item and version-specific effects are omitted. Asymptotic standard errors are in parentheses.
** Significantly different from zero ($p < 0.01$).

not include a variable measuring the joint effect of a "Sale" cue and a \$9 ending on footwear items as there were no footwear items that had both a "Sale" cue and a \$9 ending.

The coefficients estimated for the \$9 ending variables replicate and extend the findings from the two previous studies. In the absence of a sale sign, a \$9 ending is associated with a significant increase in demand (Model 3), although the significance of the coefficient depends upon the inclusion of the price variable (Model 2). On average the catalog sold 16.9 units of each item in each version and this increased by 1.2 units when an item had a \$9 ending (7%). The findings also replicate the evidence in Study 2 that the \$9 ending effect is stronger for new items than for established items or footwear (Model 4).

The "Sale" cue also led to a positive increase in demand. This is consistent with findings reported elsewhere (see, for example, Inman et al., 1990; Inman and McAlister, 1993; Anderson and Simester, 2001). The demand increase associated with the "Sale" cue is larger than that estimated for the \$9 ending (see Model 3), suggesting that customers are more sensitive to this cue than the price-ending cue. The comparison of the findings when using both a \$9 ending and a "Sale" cue on new items is particularly interesting. Adding a \$9 ending to a new item that already has a "Sale" cue led to a 3.9% demand increase (the difference between 21.7% and 17.8%). In contrast, adding a \$9-ending to a new item that does not have a "Sale" cue yielded an 8.5% increase in demand. One interpretation of this comparison is that $9 endings are less effective when an item already has a "Sale" cue. However, we caution that the joint effect of a "Sale" cue and a $9 ending on new items is estimated using relatively few items. This comparison is perhaps best interpreted as a tentative finding worthy of further investigation.

There is an important difference in the findings of Study 3 compared to the findings in the two previous studies. The coefficients estimated for the price variable in Study 3 are negative and consistently significant ($p < 0.01$). We offer two explanations for this difference. First, there was considerably more variation in the prices across catalog versions in Study 3 compared to the previous two studies. A total of 218 prices were varied in Study 3 (across the two treatment versions), compared to 43 prices in Study 1 and 120 prices in Study 2. This increased variation provided more information with which to identify the price coefficient. Second, 90,000 customers received each version of the catalog in this study, compared to 31,250 in Study 2 and 20,000 in Study 1. This resulted in average demand from each version of almost 17 units per item compared to less than 9 units per item in Study 2 and just over 2 units per item in Study 1. The increased demand for each item in Study 3 increased the statistical power of the study, reducing the standard errors.

4. Discussion

The three studies reveal that $9 price endings increase demand but that the effect is context dependent. In this section, we review different explanations for the $9 ending effect and evaluate the extent to which these explanations can be reconciled with the findings.

The literature contains a range of explanations for price ending effects. These explanations fall into two broad categories.[2] Explanations in the first category posit various reasons for why customers "drop-off" the right-most digits and therefore overweight the left-most digits. The most common of these explanations is that customers round prices down (Gabor and Granger, 1964; Lambert, 1975; Schindler and Kibarian, 1993) and essentially ignore the right-most digits. For example $59.99 might be coded as $59 or, in an extreme case, as $50. A limitation of these theories is that they do not explain why prices are rounded down rather than up. A related theory posits that customers engage in left-to-right processing of digits. Thus, when comparing $55 with $43 a customer that looked at only the left-most digit would process this as $50 vs. $40 or a $10 price difference (rather than $12). Raising the price from $55 to $59 would have no impact on this customer's perceptions of the price difference. However, lowering the price from $43 to $39 would create the perception of a $20 price difference (rather than $16). A third class of theories argues that because of the cognitive costs of processing price information, customers may

2 The authors thank Robert Schindler for his thoughtful suggestions on this taxonomy.

not encode some of the right-most digits (Schindler and Wiman, 1989; Schindler and Kirby, 1997). A common-theme in these theories is that customers imperfectly process price information, for either rational (cognitive cost) or irrational reasons.

A second class of theories posits that price endings provide information about relative price levels and/or product quality (Schindler, 1991). In these theories, customers pay more attention to the right-most digits because of the information that they convey. This contrasts with the customer's emphasis on the left-most digits in the "dropping off" theories. Researchers have suggested that one inference customers may draw from $9-endings is that a price is low, discounted, or on "Sale" (Schindler and Warren, 1988). For example, Salmon and Ortmeyer (1993) describe a department store that uses a 0-cent ending for regularly priced items and 98-cent endings for clearance items. Similarly, Randall's Department Store uses 95-cent endings on all "value" priced merchandize, which is "meant to indicate exceptional value to the customer" (Salmon and Ortmeyer, 1992).[3] Other researchers have suggested that customers may infer that $0-endings (and perhaps $5 endings) imply high quality and $9-endings imply low quality (Stiving, 2000). Stiving and Winer (1997) argued that the opposing implications of price and quality inferences might help to explain their contradictory empirical findings.

The dichotomy of "dropping off" effects and "information" explanations captures many theories of price-endings, but there are some notable exceptions. The "change making" theory suggests that odd-prices force employees to open the cash register to make change and this reduces employee theft. An alternative theory suggests that retailers use price endings to achieve even after-tax prices and reduce transaction costs. Neither of these explanations appears to apply in retail environments in which transactions are conducted using credit cards (such as catalog retailers).

The distinction between whether customers focus on the left or right hand digits offers an opportunity to discriminate between the "dropping off" and "information" explanations. This test was proposed by Stiving and Winer (1997) in their study of demand for yogurt and canned tuna. The prices of yogurt and canned tuna are all less than a dollar, and so they decomposed these prices into dimes and pennies. When limiting attention to the two largest brands in each category they find strong evidence that customers place less weight on the pennies digit relative to the dimes digit, which is consistent with rounding down theories. However, they find that the weight on the pennies digits increases when the dimes digits on the two brands are equal, which is consistent with left-to-right processing of digits. In sum, their evidence offers support for "dropping off" theories.

3 Inspection of prices at other retailers revealed many examples that were consistent with this pattern. For example, Eddie Bauer's September 1996 catalog used a $X price ending on regular prices and a $0.99 price ending on discounted items. Similarly, at www.jcrew.com on September 14 2000 all 548 clearance items in 55 categories had 99-cent endings and all regularly priced items had $X endings.

An equivalent decomposition to Stiving and Winer's in our setting is to decompose prices into tens of dollars and dollars. That is, \$54 is treated as \$50 (tens of dollars) and \$4 (dollars). Study 3, in which the variation in price endings was greatest, provides the richest test of this theory. We modified our Poisson model as follows:

$$\ln(\lambda_{i,j}) = \alpha_0 + \sum_{j=1}^{J-1} \alpha_j Version_j + \sum_{i=1}^{I-1} \chi_i Item_i + \beta_1 Tens_{i,j} + \beta_2 Dollars_{i,j} + \beta_3(1 - Sale_{i,j}) * Nine_{i,j} + \beta_4 Sale_{i,j} * Nine_{i,j} + \beta_5 Sale_{i,j}(1 - Nine_{i,j}). \quad (6)$$

The coefficient β_1 describes how variations in the left-hand digit affected demand, while the effect of the right-hand digit is measured by both β_1 and the coefficients for the *Nine* variable. If customers "round down" or place less weight on the dollars digits, then we would expect to observe $|\beta_2| < |\beta_1|$. This is a relatively weak test as the variation in demand explained by the right-hand digit is at least partially explained by the *Nine* variables. We find that $\beta_1 = -0.0631$ and $\beta_2 = -0.0651$. Both coefficients are significantly different from zero ($p < 0.01$) but the difference between them is not significant. After controlling for the effect of the \$9 price ending there is seemingly no difference in the weight that customers give to the left and right hand digits. We conclude that this analysis does not support the "dropping-off" explanations but it does provide support for an information explanation. The β_3 and β_5 coefficients remained positive and significant, which is consistent with customers forming favorable price inferences when observing a \$9 ending.

The evidence that the \$9 ending effect is stronger on new items is also consistent with an information explanation. The explanation requires that customers lack information about relative price levels, otherwise there is no need to use the price endings as a cue to infer this information. We would expect that on average customers would have more information about the relative price levels of items that they have seen more frequently in the past, suggesting that they will have less relative price information about new items compared to established items. A similar argument might also explain why customers appear to be more sensitive to the price-ending cue than to variations in the actual price. If customers are unsure about relative price levels, small price differences may not help customers evaluate whether an item is expensive or inexpensive. In the absence of other cues, the price ending may provide the only source of information that customers can use to help resolve their uncertainty.

Proponents of the information explanations may find further support for their arguments from the manipulations involving "Sale" cues. The claim that an item is discounted is more explicit in a "Sale" cue than in a \$9 price ending. This may explain both why "Sale" cues are more effective at increasing demand, and the tentative finding that price endings are less effective on items that already have sale signs. Having already informed customers that an item is discounted through a "Sale" cue, little additional information is revealed by the price ending.

We conclude that these context effects can be reconciled with an information explanation. However, it is difficult to reconcile them with a "dropping-off" explanation. It is not clear why the distinction between new and established items should affect the extent to which customers imperfectly process right-hand digits. Of perhaps even greater concern for the dropping off explanations is why the $9 ending effect does not also extend to $9.50 endings. The evidence suggests that, if anything, $9.50 endings lead to reduced demand in Study 3.

A criticism of the "information" explanations is that they focus on customer behavior but fail to consider the seller's perspective. In particular, the theoretical concern is that the signal may be equally costly for all sellers to implement. If so, this violates a necessary condition of information models, as it must be the case that the low price firm can signal at lower cost than the high price firm. In such a situation, an optimal response for every seller is to use $9 endings on each item. At least two explanations have been offered to suggest why this may not be an optimal strategy. First, Anderson and Simester (1998) provide an equilibrium explanation for how retailers may credibly convey information via "Sale" signs and a similar argument may apply to price endings. They argue that customers have expectations as to the frequency of a promotional cue prior to arriving at a store and believe these cues convey information about relative price. Upon arriving, customers observe how frequently the cues are used (the number of "Sale" signs) and use this to assess the likelihood that an item with a "Sale" sign is indeed low priced. If a retailer overuses a cue, it becomes less effective as customers are less likely to believe the item is indeed low priced. If this theory applies to price endings, retailers should selectively use $9 price endings. A second theory is that retailers have reputations. If a retailer uses a $9 price ending on a relatively high priced item then the retailer's reputation may be damaged. This may prompt retailers to restrict their use of $9 endings.

Both theories offer a rational explanation for customer reliance on price endings and retailers' (limited) use of price endings. However, even these two theories are incomplete. Neither theory explains why the favorable signal is associated with the digit 9. The information explanations could equally explain an $8 price ending effect. Similarly, the theories do not explain how customers learn to use this cue or whether the cue is specific to a product category or a store. The answers to both questions are important for retailers seeking to implement a price ending policy.

5. Conclusion

We have presented three field experiments demonstrating that $9 price endings increase demand but that the effect is context dependent. The effect is stronger for new items that customers have seen less frequently in the past. We evaluated two types of explanations for the findings. Under the information explanation customers use the price ending to infer whether the item is expensive or inexpensive relative to market price levels. The "dropping-off" explanations argue that customers imperfectly process price information. The findings appear to offer greater support for an information explanation than for a "dropping off" explanation.

What remains largely unexplained by our work is "Why 9?" The data and explanations are silent on how customers form beliefs that $9 endings convey favorable information that increases demand for an item. Future work may want to explore how these associations are formed, and this may help to explain the varied use of price endings across markets and geographies.

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