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Journal of Product & Brand Management

featuring Pricing Strategy & Practice

Behavioral pricing

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Behavioral pricing

Guest Editors: Hooman Estelami and Sarah Maxwell

Contents

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Abstracts & keywords

Reference prices in retail advertisements: moderating effects of market price dispersion and need for cognition on consumer value perception and shopping intention

Bidisha Burman and Abhijit Biswas

Keywords Advertisements, Prices, Cognition, Consumers, Values, Shopping

One main concern regarding the use of reference prices in advertisements relates to the possibility of deception due to consumers' positive response towards exaggerated or implausible claims. This paper examines the moderating roles of a contextual variable-market price dispersion for a product category, and that of an individual level variable-need for cognition, in influencing consumer evaluation of reference prices across two experiments. The results support the hypothesized effects of need for cognition and demonstrate that, for low need, for cognition individuals, increasing the level of reference price results in positive effects on value perception and shopping intention.

Consumer price knowledge in the German retail market

Heiner Evanschitzky, Peter Kenning and Verena Vogel

Keywords Prices, Consumer behaviour, Marketing, Retailing

Price knowledge as a construct has been one of the top behavioral pricing themes in the last four decades, especially in the Anglo-American literature. In Germany, scientists have paid relatively little attention to this topic during the last 15 years – with some notable exceptions. Therefore, this study analyzes German consumers' price knowledge and, by doing so, replicates and extends existing international work. After reviewing earlier attempts at assessing the construct, a measure is developed for the price estimation error "PEE", based on explicit price knowledge stored in long-term memory. Results, including data from about 1,000 consumers on 69 products from a German retail chain, indicate that price knowledge in Germany is relatively low. Based on that observation, implications for the management are discussed.

Price knowledge: effects of consumers' attitudes towards prices, demographics, and socio-cultural characteristics

Isabel María Rosa-Díaz

Keywords Prices, Consumer behaviour, Attitudes

The accuracy of consumer price knowledge is dependent on numerous factors. This study examined the effect of some variables related to consumers' attitudes towards prices and some demographic variables on price knowledge. Results showed that consumers were more knowledgeable about the relationships between the prices of competitor brands than about the actual prices in themselves. When certain error margins were allowed, the differences between absolute and relative price knowledge were not as evident. In addition, the accuracy of consumer knowledge of prices was found to be dependent on how much importance they placed on price, and it influenced subjects' perceptions of themselves as shoppers. In this study, women and people with low income level were more knowledgeable about prices. The statistical effects and relationships between these variables were analyzed taking into account the economic, social, and cultural setting in which the research was conducted.

Pricing dynamics in the online consumer electronics market

Xiaolin Xing, Fang-Fang Tang and Zhenlin Yang

Keywords Online operations, Retailing, Pricing, Electronic commerce

This paper investigates prices of consumer electronics sold on the Web by both online-only retailers (Dotcoms) and the online branches of multi-channel retailers (MCRs). Surprisingly, it finds that Dotcoms charge higher price than MCRs, a conclusion contradictory to the results of most of empirical studies. Also finds that the electronics prices decreased over the period of study in general, dropping about 0.6 percent per week, and the prices of MCRs and Dotcoms went down with time at a similar speed. Further, the prices across MCRs are 35.3 percent more dispersed than the prices across the Dotcoms based on full prices, and 33.1 percent more dispersed based on percentage prices. However, results show that price dispersion moved up with time

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in general, with no significant difference in the speeds between MCRs and Dotcoms.

Capturing the effects of coupon promotions in scanner panel choice models

Jorge M. Silva-Risso and Randolph E. Bucklin

Keywords Coupons, Brand awareness, Data handling

The authors develop a logit modeling approach, designed for application to UPC scanner panel data, to assess the effects of coupon promotions on consumer brand choice. The effects of coupon promotions are captured via two measures: the prevailing level of availability and the prevailing face value of coupons for each brand. Both of these measures are derived from coupon redemptions of a separate sample of households. The approach captures both the advertising effect and the price discount incentive of a coupon. It also avoids drawbacks of previous choice models which have incorporated coupon effects by subtracting the value of a redeemed coupon from the price of the brand purchased. The authors illustrate their modeling approach on data for two product categories: catsup (light coupon usage) and liquid laundry detergent (heavy coupon usage). Findings are reported for coupon users and non-users as well as across latent segments.

Iso-profit pricing for product lines

David J. Curry

Keywords Breakeven analysis, Profit, Pricing, Promotional methods, Pricing policy

When considering a price decrease in response to competitive pressures or stagnating demand, management may ask how much additional volume must be sold at the new price to match the current profit level. This "iso-profit" pricing problem has been studied extensively for single items manufactured using one resource. This paper solves three realistic extensions of the problem: when two or more items share a resource, when multiple items share multiple resources, and when resource vendors offer quantity discounts. Findings are summarized in 12 points, many of which are counterintuitive.

Introduction

Dedicated to the memory of Norma Monroe whose love and care for all students of pricing will forever be remembered.

Price management is one of the most central and sensitive elements of the process of managing a successful brand. Even a small change in price can have a disproportionate change in profitability, thereby increasing the importance of accurate and scientific ways of determining optimal prices. Moreover, beyond the monetary aspects of price, studies suggest that price often sends profoundly meaningful signals to the market, buyers, and competitors, and may therefore, trigger changes in other components of a marketing program, such as advertising and promotions. As a result, interest in studying consumer response to prices is growing among both practitioners and academics.

Owing to the interest in consumer response to prices, a new branch of pricing, referred to as *Behavioral Pricing*, has witnessed notable growth in recent years. Behavioral pricing focuses on how consumers perceive and respond to prices and how their perceptions and subsequent behavior may be explained by underlying psychological phenomena. As such, this branch of pricing research significantly contrasts and in many cases challenges decades of "traditional" neoclassical economic research on price. The challenge to the neoclassical economic view of price is based on its often questionable assumptions, which limit its managerial and practical use for developing pricing strategies. For example, in the traditional economic perspective of price, consumers are assumed to be fully knowledgeable about prices of competitors, fully aware of the product's underlying quality, and capable of storing and processing large amounts of product and non-product information. All these assumptions have been refuted by behavioral pricing research.

Behavioral pricing consequently provides a new perspective on how consumers respond to prices. This new perspective has received considerable interest not only among academics but also among brand managers and practitioners interested in improving the profitability and market attractiveness of products they manage. The growth of interest in the topic is clearly evident in the research output associated with behavioral pricing in both academic and non-academic journals and conferences over the past decade.

The purpose of this Special Issue of the *Journal of Product & Brand Management* is to further expand the research output channels for pricing research, particularly from the behavioral perspective. Submissions were first solicited through a call-for-papers which resulted in a large number of manuscripts. The submissions were then subjected to a rigorous and detailed review process by a large team of reviewers who specialize in pricing. The resulting set of papers published in this Special Issue has been hand-picked by the reviewers and the editors based on their incremental contribution to the field of pricing, and are therefore, pioneering studies in their own context.

The first paper deals with implausibly high advertised reference prices, which can deceive consumers into believing that the actual price is more of a "bargain" that it actually is. Burman and Biswas find that an implausible price has a greater effect than a plausible one when prices in the product category are widely dispersed. This effect, however, is moderated by the individual's need for cognition. Those with a high need for cognition are affected by a plausibly but not implausibly high advertised reference price, but those with a low need for cognition are affected by both.

The next two papers investigate the price knowledge of consumers across cultures. Evanschitsky, Kenning and Vogel studied some 1,000 German consumers. They find that less than 50 percent of German consumers have any idea of the price of grocery items. Consumers' estimates, however, are generally lower than the actual price, demonstrating the potential for retailers to implement price increases.

The study by Rosa-Diaz considers many potential factors that might influence the price knowledge of Spanish consumers. She finds that Spanish women and middle-aged consumers have the most accurate knowledge of prices. Whether consumers are married and have low income or education also has an indirect effect through their influence on gender and age.

Xing, Tang and Yang investigate the important new concern of Internet pricing. They show that, compared to multi-channel retailers, Internet-only retailers charge higher prices for electronics. Multi-channel retailers start with higher posted prices, but they then lower them with larger price promotions. Their data show that, contrary to

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common belief, price dispersion of electronics increased over time.

The final two papers present pricing models to aid managers in making optimal pricing decisions. The Silva-Risso and Bucklin model is designed to determine the effects of couponing activity on brand choice. They demonstrate that their model provides better results than previous ones. They also find that coupon users are more deal prone, less brand loyal, and more likely to have sufficient time to take advantage of coupon promotion.

The final paper addresses the difficult question of how much added volume is required to maintain profits after a price decrease. Curry develops a model to determine the supply side costs incurred by increased volume. He extends iso-pricing modeling by showing how increased volume can both require added capacity and also generate possible savings from higher volume purchases.

The production of this Special Issue would not have been possible without the support of many individuals. It is important, however, to recognize the particular impact and contribution of the former editor, Kent B. Monroe. He not only developed the pricing focus of the *Journal of Product & Brand Management* but also provided decades of service to pricing research and trained countless number of pricing researchers. Without his contributions, the field of pricing would not be as advanced as it is today. The editors of the Special Issue would also like to thank Richard Whitfield of MCB for his outstanding support. In addition, much gratitude is due to the reviewers who have provided cogent, positive feedback on both the papers that have been selected and those that were not. The support of the following reviewers is therefore, acknowledged:

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Hooman Estelami and Sarah Maxwell
Pricing Strategy & Practice Section Editors

Reference prices in retail advertisements: moderating effects of market price dispersion and need for cognition on consumer value perception and shopping intention

Bidisha Burman and Abhijit Biswas

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Keywords

Advertisements, Prices, Cognition, Consumers, Values, Shopping

Abstract

One main concern regarding the use of reference prices in advertisements relates to the possibility of deception due to consumers' positive response towards exaggerated or implausible claims. This paper examines the moderating roles of a contextual variable-market price dispersion for a product category, and that of an individual level variable-need for cognition, in influencing consumer evaluation of reference prices across two experiments. The results support the hypothesized effects of need for cognition and demonstrate that, for low need, for cognition individuals, increasing the level of reference price results in positive effects on value perception and shopping intention.

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Introduction

The use of reference prices in retail advertisements is a very common practice for increasing the attractiveness of an offer. Not surprisingly, such widespread use of reference prices has spurred enormous interest among academic researchers who have investigated buyer perceptions and evaluations of such claims over the last three decades (Bearden *et al.*, 1984; Berkowitz and Walton, 1981; Biswas *et al.*, 1999; Blair and Landon, 1981; Della Bitta *et al.*, 1981; Janiszewski and Lichtenstein, 1999; Lichtenstein and Bearden, 1989; Lichtenstein *et al.*, 1991; Liefield and Heslop, 1985; Urbany *et al.*, 1988).

Previous research has consistently found a strong positive effect of advertised reference prices on consumer evaluation, but the concern lies with the potentiality of reference prices to deceive consumers. Compeau and Grewal (1998) criticize the use of exaggerated reference prices, and state that "the potentiality for deception seems rife because external reference prices have a strong influence on consumers, even when they are exaggerated" (p. 263). Compeau and Grewal's concern has merit because, studies have found that exaggerated or implausible reference prices are perceived as implying better "deals" than plausible reference prices (Biswas *et al.*, 1999; Lichtenstein and Bearden, 1989; Lichtenstein *et al.*, 1991; Urbany *et al.*, 1988). Compeau and Grewal (1998) have called for stepped up federal enforcement efforts to complement the states' efforts in prosecuting retailers that make exaggerated saving claims.

As one of the main concerns regarding reference price advertisements is the possibility of consumer deception, researchers have attempted to identify market conditions which might mitigate the effects of exaggerated or implausible reference prices. For example, Biswas *et al.* (1999) examined the effects of reference prices in the presence and absence of "other" price information, namely price information for two other similar brands in the market. The authors argued that consumers are seldom limited to using one external reference price, and implausible reference prices may not be effective in the presence of "other" price information. Biswas *et al.* found that the positive effects of implausible reference prices are evident even in the presence of regular price information for similar brands. Clearly, this finding should be of concern to the consumers as well as the policy makers.

This paper is motivated by the concerns regarding the possibility of consumer deception by implausible reference price claims. The key research question is: are there conditions when implausible reference prices may not have the potential for deception? In this paper, we examine

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the role of a contextual variable – market price dispersion for a product category, and that of an individual level variable – need for cognition in influencing consumer evaluation of reference prices. While empirical and conceptual arguments suggest that implausible reference prices are likely to evoke more positive consumer responses than plausible reference prices, our study provides further understanding of the contexts in which such favorable responses may or may not be evoked.

Conceptual background

The assumption that consumers' value perceptions and shopping intentions rely on a comparison of sale price to an internal reference price is based on Helson's adaptation level theory (1964) which suggests that people adapt to three classes of cues: focal cues – to which the response is directed, organic cues – the physiological and psychological processes that affect behavior, and the contextual cues – the context within which the focal cues are operative. This theory implies that buyer's internal reference prices are influenced by the key focal cues in an advertisement, which are the advertised selling price and the advertised reference price (Della Bitta *et al.*, 1981).

Assimilation-contrast theory (Sherif *et al.*, 1958) predicts that an advertised reference price which is not far from the consumer's range of acceptable prices will be assimilated and therefore, it is considered to be a plausible reference price. On the other hand, an advertised reference price which is too far from this range will be considered as an implausible reference price and may have a contrast effect leading to a possibility of rejection of the advertised reference price. Based on assimilation-contrast theory, Sawyer and Dickson (1985) define latitude of acceptance as a region, and any price falling in this region is assimilated and any price outside this region is contrasted. Contrasts may lead to rejection or even negative reactions. However, Urbany *et al.* (1988) suggest the discounting hypothesis as an alternative explanation to consumer responses to implausible reference prices. Discounting is considered to be a natural response of consumers to reference price advertisement (Blair and Landon, 1981; Liefield and Heslop, 1985; Urbany *et al.*, 1988). The discounting hypothesis suggests that when ads make implausible claims, consumers may not reject them but discount them to a more reasonable level before making their judgments of the deal. In general, the major implication of adaptation-level theory and assimilation-contrast theory is that consumers' acceptable range of prices is likely to shift with the information acquired through external sources like reference prices (Biswas and Blair, 1991; Lichtenstein and Bearden, 1989; Lichtenstein *et al.*, 1991; Urbany *et al.*, 1988).

In the first study, we use adaptation-level theory, assimilation-contrast theory, and range theory (Volkmann, 1951) as the foundation of our research. We use these theories to understand the effects of plausible and implausible reference prices on consumer evaluations of reference prices in the context of market dispersion of price for the product category. In the second study, the characterization-correction model (Gilbert, 1989) is used to explain the moderating role of consumers' need for cognition in consumers' evaluation of reference prices.

Study one: moderating effects of market price dispersion

Consumers experience a considerable degree of price variation for standardized consumer products in the market. Duncan (1981) found large price variations of consumer products in local markets and prices of more expensive products tend to differ more from one store to another (Pratt *et al.*, 1979). Therefore, a relevant question is: can price dispersion in the market for a product category affect how reference prices for a brand within that category are evaluated by the consumers? Based on adaptation level, assimilation-contrast, and range theories, we argue that this is possible and that implausible reference prices are likely to be more effective compared to plausible reference prices when the market price dispersion is high compared to when it is low.

According to the adaptation level and assimilation contrast theories, consumers' judgments of plausibility of a reference price are affected by their expected marketplace prices. Emory (1970) observes that the anchor for judgment of other prices (e.g. advertised reference price) may be some average of prices of similar products. Nwokoye (1975) suggests that often the end prices (i.e. the highest and the lowest prices) are used as anchors to evaluate other prices. This suggestion is consistent with the recent findings of Janiszewski and Lichtenstein (1999) who, based on Volkmann's (1951) range theory, suggest that attractiveness of a market price depends on a comparison of the market price to the end points of the evoked price range. Overall, it seems that consumers are likely to use a range of expected market prices to evaluate plausibility of an advertised reference price (Lichtenstein and Bearden, 1989).

We posit that in situations where prices within a product category are widely dispersed in the market, consumers' expected price range becomes larger. Consequently, the highest/lowest expected

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price of the consumer is more likely to be displaced upward/downward, when the price dispersion in the market for the product category is wide. In other words, the range of expected prices for the advertised brand increases as the price dispersion for the product category in the marketplace increases. This may lead to relatively greater acceptance (or lesser discounting) of an implausible reference price. Kalyanaram and Little (1994) suggest that the latitude of price acceptance is not only influenced by variability in the prices in the marketplace, but also by the reference price. Specifically, these authors suggest that a higher reference price may lead to wider latitude of price acceptance. Therefore, consistent with assimilation-contrast theory and the findings of Kalyanaram and Little (1994), we posit that an implausible price is more likely to be assimilated (or less likely to be discounted) when market price dispersion is wide. Consequently, a large difference between the sale price and implausible reference price will imply high savings to the consumer and therefore, make the sale price more attractive.

On the other hand, when market price dispersion is narrow, an implausible reference price is likely to be contrasted since the displacement of consumers' expected range of price either does not occur in this situation or is minimal. Therefore, the large difference between the sale and reference prices may not seem believable to the consumer and the implausible reference price may be either rejected or discounted. Thus, when market price dispersion of a product category is narrow, an implausible price may not have any effect on consumer evaluations of an offer, but may have effects similar to that of a plausible reference price, or have a reduced effect due to negative consumer inferences associated with an implausible reference price. Overall, an implausible reference price is likely to have a greater effect on value perception and shopping intentions than a plausible reference price when the market price dispersion for a product category is large compared to when it is small. Thus, we hypothesize:

H1. Compared to plausible reference prices, implausible reference prices are likely to enhance (a) value perception and (b) shopping intention when price dispersion in the marketplace is wide compared to when it is narrow.

Methodology

Pretest for product selection and determining the reference prices and the sale price

A pretest was conducted to select the appropriate product, and determine the sale price, plausible reference price, and the implausible reference price for the experiment. Business undergraduate students of a state university were used as subjects for the pretest ($n = 32$). Pretest subjects were provided with hypothetical advertisements of five products (VCR, calculator, DVD player, student desk and bike) with descriptions of each. The descriptions consisted of four common features of each of the five products. DVD player was selected for use in the experiment because respondents indicated moderate familiarity with it as compared to the other products. Both highly familiar products as well as unfamiliar products were eliminated because the former would make manipulation of market price dispersion difficult, while the latter would affect the shopping intention of the respondents. Respondents were also asked to indicate the lowest price, fair price and the highest price at which they could find the product in town. The estimated mean lowest market price for the DVD player was $142.37. The mean fair price was $163.59 and the estimated mean highest price was $296.22.

Subjects and procedure

Sixty-five undergraduate students participated in the study. They were assigned randomly to one of the four cells in a 2 (wide vs narrow market price dispersion) × 2 (plausible vs implausible reference price) between-subjects experimental design. The subjects were provided with a booklet that consisted of instructions on the first page, followed by a consumer durable price survey report. This report stated the price range of DVD players in the market. Subjects in the wide market price dispersion condition were given a report stating a very large difference in the prices for DVD players in the marketplace, and similarly in the narrow price dispersion condition, the report stated a small difference in the prices for DVD players in the marketplace. The report was followed by a print ad of a DVD player. The ad showed a regular price of $499.99 for a DVD player in the implausible reference price condition and $249.99 in the plausible reference price condition. Based on the pretest estimates, the sale price in both conditions were set at $149.99.

Independent and dependent variables

The operationalization of the implausible reference price was similar to the method used by Biswas and Blair (1991). The implausible reference price was set at $499.99, a price considerably higher than the estimated highest market price. The plausible reference price was set at $249.99, within one standard deviation of the mean estimated fair market price. The sale price of

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\$149.99 was set at a price lower than the plausible reference price but higher than the mean estimated lowest market price.

The experiment required a manipulation of the market price dispersion. The manipulation method used was similar to that used by Urbany (1986). In the narrow market, price dispersion subjects were told that the price range for DVD players was within \$90 between the highest and lowest prices charged by the retailers in the market. Similarly, those in the wide market price dispersion condition were told that the price range was \$450 for DVD players in the marketplace. The prices were developed so that there was a significant difference in the perception of each price range.

The dependent variables were operationalized as follows:

Value perception. Four seven-point scales used to measure subject's value perception of the offer were adapted from previous studies. These items were: "The item offered by the merchant will be"...(A bad buy for the Money – An excellent buy for the money); "the advertised offer represents"...(No savings at all – An extremely large savings); "The price charged by the merchant for the item will be"...(An extremely unfair price – An extremely fair price); "The item offered by the merchant will be"...(Not a good value for money – An extremely good value for the money).

Shopping intention. Three items were used to assess subject's shopping intentions, adapted from previous studies. These items were: "If you were considering the purchase of this item, how willing would you be to shop at the store running this advertisement?"...(Definitely unwilling to shop – Definitely willing to shop); "If you were thinking of purchasing this item, would you go to the store that advertised the item?"...(Definitely would not go – Definitely would go); " What is the probability that you would shop at the store running the ad, if you were considering the purchase of this item?"...(Not probable at all – Very probable).

Results

Manipulation checks

The reference price manipulation was checked by asking the subjects to indicate plausibility and implausibility of the reference prices on a 7-point scale (1 = very implausible, 7 = very plausible). First, a 2 (reference price levels) × 2 (market price dispersion) ANOVA was run which indicated that there was no interaction effect of reference price level and market price dispersion on consumer perceptions reference price plausibility. As expected, there was a main effect of reference price level ($F = 4.488$; $p < 0.05$). Planned contrasts indicated that the plausible (mean = 4.19) and implausible (mean = 3.43) reference price were perceived as expected ($t = -2.151$; $p < 0.05$).

The manipulation of the market price dispersion was checked by asking the subjects to indicate the extent to which DVD player prices varied in the marketplace according to the consumer durable price survey report (1 = extremely small, 7 = extremely large). First, a 2 (reference price levels) × 2 (market price dispersion) ANOVA was run which indicated that there was no interaction effect of reference price level and market price dispersion on consumer perceptions of price variation. As expected, there was a main effect of market price dispersion ($F = 105.202$; $p < 0.001$). Planned contrasts supported the manipulation of market price dispersion (narrow dispersion mean = 6.00, wide dispersion mean = 3.34; $t = 10.224$; $p < 0.001$).

Hypothesis test

The results of the study indicate that there is a significant interaction effect of reference price and market price dispersion as predicted by *H1* (Wilks' Lambda = 0.830, $F = 6.242$, $p = 0.003$). The multivariate analysis of variance results are shown in Table I. The multivariate interaction effect is attributable to the dependent variables of value perception ($F = 10.683$, $p = 0.002$) and shopping intention ($F = 6.978$, $p = 0.01$). Multivariate main effect of market dispersion of prices was significant ($F = 5.31$, $p = 0.007$) and no main effect was found for reference price.

As predicted, the effects of plausible reference price (mean = 4.78) and implausible reference price (mean = 4.62) on value perception are not significantly different when the market price dispersion is narrow ($t = -0.761$, $p > 0.05$) but the difference in value perception between plausible reference price (mean = 4.77) and implausible reference prices (mean = 5.78) was significant when the market price dispersion is wide ($t = 3.49$, $p < 0.01$) (Figures 1 and 2 and Table II for means). Similarly, the shopping intention of consumers was not significantly different for plausible (mean = 5.42) and implausible reference prices (mean = 5.63) when the market dispersion of price is narrow, but the difference in their shopping intention was significantly higher when reference price was plausible (mean = 5.51) than when it is implausible (mean = 6.29) in the wide market price dispersion condition ($t = 2.83$, $p < 0.01$).

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Table I The effects of reference price and market price dispersion on value perception and shopping intention (Study 1)

	MANOVA					ANOVA	
Sources	**Wilks' Lambda**	**Effect size**	***F*-value**	**Sig.**	**d.f**	**Value perception**	**Shopping intention**
Main effects							
Reference price (RP)	0.912	0.088	2.932	0.061	1	5.576 (0.021)*	2.375 (0.128)
Price dispersion (PD)	0.852	0.148	5.310	0.007	1	10.240 (0.002)	4.021 (0.049)
Interaction effect							
RP * PD	0.830	0.170	6.242	0.003	1	10.680 (0.002)	6.978 (0.010)
Residual					62		

Note: *p-values are provided in parentheses

Figure 1 Moderating effects of market price dispersion

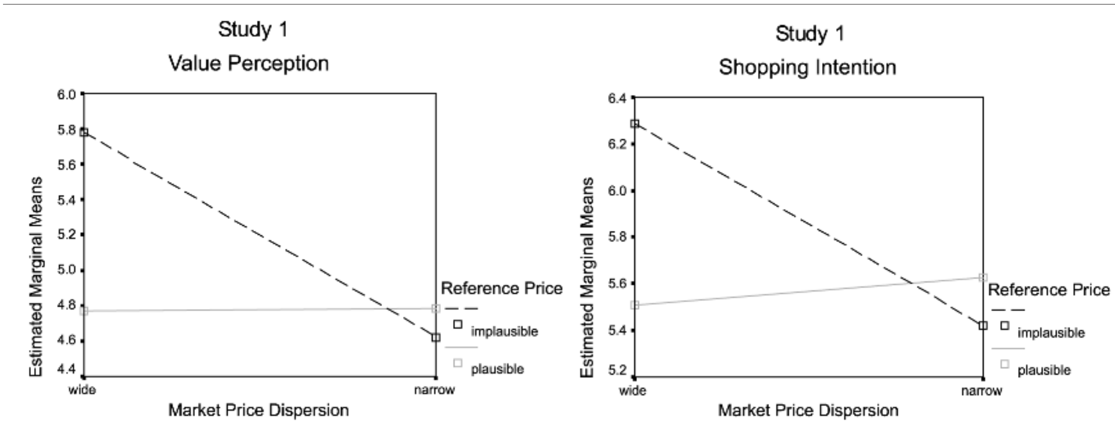

Figure 2 Moderating effects of need for cognition

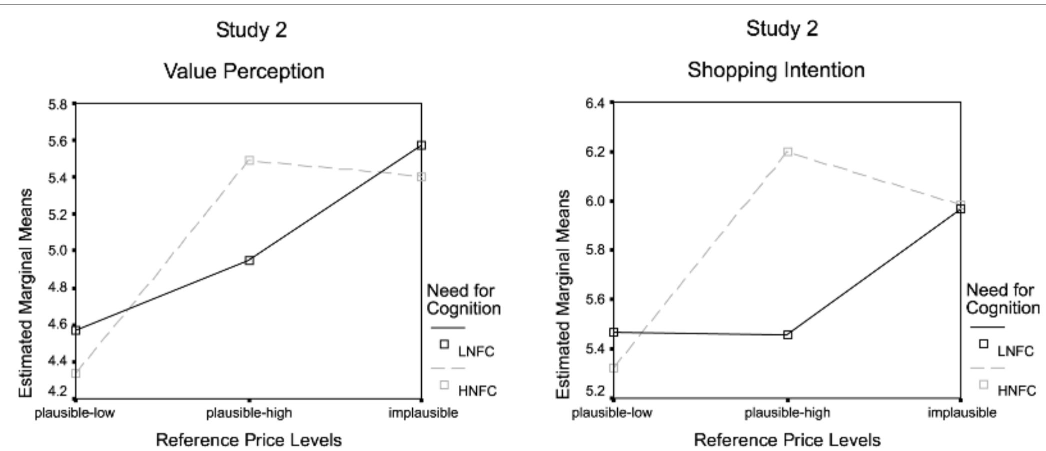

Table II Means and t-values (Study 1)

	Wide price dispersion			Narrow price dispersion		
Variables	**PL RP**	**IMPL RP**	***t*-value**	**PL RP**	**IMPL RP**	***t*-value**
Value perception	4.77 (0.762)*	5.78 (0.888)	3.489[a]	4.78 (0.676)	4.62 (0.502)	−0.761
Shopping intention	5.51 (0.939)	6.29 (0.665)	2.832[a]	5.63 (0.696)	5.42 (0.623)	−0.874

Notes: *Standard deviations are provided in parentheses; a = $p < 0.01$; PL RP: Plausible-low reference price; IMPL RP: Implausible reference price

These results provide strong support for *H1a* and *H1b*.

The results of the first study demonstrate that market dispersion of prices plays an important role in determining the effectiveness of reference pricing. When market dispersion of prices was wide, value perception and shopping intention were significantly higher for implausible reference price than for plausible reference price. In the wide market price dispersion situation, the assimilation of the implausible reference price seem to have occurred due to the shift in the internal price standards of the consumers towards the reference price. However, in the narrow market price dispersion situation, the impact of implausible reference price was not significantly different from that of plausible reference price possibly due to a discounting effect.

Study two: moderating effects of need for cognition

Need for cognition

Individuals differ in terms of their likelihood to engage in effortful, systematic thinking (Inman *et al.*, 1997). The construct "need for cognition", first introduced by Petty and Cacioppo in 1982, is defined as the tendency of an individual to engage in and enjoy thinking. Low need for cognition (LNFC) individuals are thought of as cognitive misers because they avoid effortful processing while the high need for cognition (HNFC) individuals are the concentrated cognizers who are the ones willing to engage in effortful processing. The HNFC individuals seek out and elaborate on relevant information when performing a task and engage in evaluative responding (Tidwell *et al.*, 2000). HNFC individuals pay more attention to not only the content of the message but also other relevant information as a basis for judgment. Therefore, individuals high in need for cognition are less likely to fall prey to judgment and decision biases than low need for cognition individuals (Mantel *et al.*, 1999).

Effects of reference prices and consumers' need for cognition

Reference price literature suggests that if the advertised reference price is higher than the consumer's highest perceived normal price but is still plausible, an assimilation effect occurs and the individual's internal price standards (i.e. the range of perceived normal prices, internal reference price range, the latitude of acceptable prices) are likely to be displaced toward the assimilated price (Lichtenstein and Bearden, 1989; Monroe and Chapman, 1987; Urbany *et al.*, 1988). An advertised reference price that raises the internal reference price of the consumer will make the lower sale price appear more attractive and will increase transaction utility (Thaler, 1985, p. 212). Therefore, as the reference price increases from plausible-low to plausible-high, it subsequently makes the advertised offer more attractive by increasing the consumer perception of savings. However, if the reference price provided is too high to be acceptable, it is likely to be contrasted (Lichtenstein and Bearden, 1989; Monroe and Petroshius, 1981; Urbany *et al.*, 1988). In this situation, consumers may either disregard the very high reference price completely (i.e. no effect) or react negatively at the retailer's intention to deceive or, it may be discounted to a more reasonable level and still have an impact on the consumers' internal price standards (Urbany *et al.*, 1988). According to Lichtenstein *et al.* (1989), too high reference prices may have less impact on the internal price standards of the consumers because of a contrast effect.

In this study we propose that the effects of reference prices (plausible-low, plausible-high and implausible) are moderated by individual's need for cognition. Based on characterization-correction model (Gilbert, 1989), we posit that the HNFC individuals are more likely to discount an implausible reference price. The characterization-correction model holds that people tend to engage in a two-stage process when exposed to information that they would normally discount or consider false. The characterization stage requires little effortful processing and results in an initial acceptance of the message. The cognitions related to the message claims are easily accessible and influence consumer judgments of an offer.

The correction stage involves further elaborated processing and this stage will be entered by those who are willing to expend more cognitive effort. Since HNFC individuals are likely to seek out and elaborate on relevant information, and arguably may have greater knowledge about range of prices, it is reasonable to assume that these individuals are more likely to enter the correction stage.

One possible consequence of entering the correction stage is complete disregard for the implausible reference price. A more viable option for the HNFC individuals is to discount the implausible reference price to a more acceptable level and still be positively affected by it. This effect is likely to be the same as the effect of the plausible high reference price.

LNFC individuals, on the other hand, are not motivated enough to think beyond the message content. They are likely to undergo a more of an automatic perceptual process rather than an inferential process, implying that they have

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remained in the characterization stage. If consumers are not motivated to process information elaborately or do not have the knowledge to do so, they rely more on the simple comparison between the reference price and the selling price and therefore, are more susceptible to implausible reference prices (Compeau and Grewal, 1998). Since, LNFC individuals are not motivated enough to think beyond the message content and research seems to support a positive relation between the need for cognition and knowledge (Martin *et al.*, 1993; Tidwell *et al.*, 2000; Wolfe and Grosch, 1990), we expect an implausible reference price to have a greater influence on LNFC individuals since they are more likely to be attracted to the higher bargain in the offer than the HNFC individuals. Overall, we suggest that while LNFC individuals are likely to be influenced positively as the level of reference prices increases (from plausible-low to plausible-high to implausible), HNFC individuals are not likely to react positively to implausible reference prices. Thus, we hypothesize:

H2. Need for cognition will moderate the effects of reference price on consumers' perceptions of value of the offer and shopping intentions. For LNFC individuals, (a) value perception and (b) shopping intention increase as the level of reference price increases. For HNFC individuals, (c) value perception and (d) shopping intention increases up to the plausible-high level beyond which there is no incremental effect.

Methodology

Subjects and procedure

One hundred and seventy one undergraduate students were randomly assigned to the cells in a 3×2 between-subjects experimental design. The factors were reference price (plausible-low, plausible-high and implausible) – a manipulated variable, and need for cognition (high vs low) – a measured variable. The subjects were exposed to a print ad for a digital camera. They were assigned at random to one of the three levels of reference price for the camera – plausible-low ($299.99), plausible-high ($499.99) and implausible ($799.99). Each condition had the same sale price of $249.99. The advertisement was followed by the measures of the dependent variables, manipulation check measures and finally, the need for cognition measures.

Independent and dependent variables

A pretest was conducted to select the three levels of reference prices – plausible-low, plausible-high and implausible. Twenty-five undergraduate students were provided with the sale price of $249.99 for a digital camera and were asked to indicate a valid regular price. The average regular price indicated by the respondents was $304.99. The plausible-low reference price was therefore set at $299.99. The plausible-high reference was set at $499.99, the highest regular price indicated by the respondents, and the implausible reference price selected for the camera was $799.99.

Need for cognition was assessed by asking the subjects to complete an 18 item NFC scale (Cacioppo *et al.*, 1984, $\alpha = 0.89$) at the end of the experiment. The median NFC score of all subjects was 0.7778 ($SD = 1.21$). The average NFC score of the HNFC after the median split was 1.5 ($SD = 0.56$) and the average score of the LNFC was -0.11 ($SD = 0.88$). The dependent variable measures for value perception and shopping intention were similar to the first study.

Results

Manipulation check

The manipulation of the three levels of reference price was checked by asking the subjects to indicate their perceptions of plausibility/implausibility of the reference prices (1 = very implausible, 7 = very plausible). First, a 3 (reference price levels) × 2 (NFC) ANOVA was run which indicated that there was no interaction effect of reference price level and NFC on consumer perceptions of price plausibility.
As expected, there was a main effect of reference price level ($F = 11.857$; $p < 0.001$). Planned contrasts indicated that the plausible-low reference price was perceived as more plausible (mean = 4.55), than plausible-high reference price (mean = 3.93; $t = 2.302$; $p < 0.05$) and the implausible reference price (mean = 3.33; $t = 4.44$; $p < 0.001$). Additionally, the plausible-high reference price (mean = 3.93) was perceived as more plausible than the implausible reference price (mean = 3.33; $t = 2.01$; $p < 0.05$).

Hypothesis test

The results of the second study show that need for cognition interacts with reference price as predicted by *H2* (Wilk's Lambda = 0.941, $F = 2.451$, $p = 0.046$). The multivariate interaction is attributable to the dependent variables of value perception ($F = 3.416$, $p = 0.035$) and shopping intention ($F = 3.984$, $p = 0.02$). The multivariate analysis of variance results are shown in Table III. *H2* was tested by conducting appropriate planned mean comparisons (Tables IV and V).

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Table III The effects of reference price and need for cognition on value perception of the offer and shopping intention (Study 2)

	MANOVA					ANOVA	
Sources	**Wilks' Lambda**	**Effect size**	***F*-value**	**Sig.**	**d.f**	**Value perception**	**Shopping intention**
Main effects							
Reference price (RP)	0.792	0.110	9.848	0.000	1	20.92 (0.000)*	6.452 (0.002)
NFC	0.985	0.015	1.170	0.313	1	0.123 (0.726)	0.178 (0.142)
Interaction effect							
RP * NFC	0.941	0.30	2.451	0.046	1	3.416 (0.035)	3.984 (0.020)
Residual					160		

Notes: **p*-values are provided in parentheses; NFC: need for cognition

Table IV Means and *t*-values (Study 2)

	High need for cognition			Low need for cognition		
Variables	**PL-L RP**	**PL-H RP**	**IMPL RP**	**PL-L RP**	**PL-H RP**	**IMPL RP**
Value perception	4.34 (0.825)*	5.49 (0.878)	5.40 (1.113)	4.57 (0.656)	4.95 (0.905)	5.60 (0.817)
Shopping intention	5.32 (0.874)	6.20 (0.541)	5.98 (1.051)	5.47 (0.839)	5.46 (1.096)	5.97 (0.787)

Notes: *Standard deviations are provided in parentheses; PL-L RP: Plausible-low reference price; PL-H RP: Plausible-high reference price; IMPL RP: Implausible reference price

As the results indicate, for LNFC individuals value perception in the plausible-low condition (mean = 4.57) was significantly lower than that in the plausible-high reference price conditions (mean = 4.95) ($t = -1.775$, $p < 0.05$, 1-tailed). However, the shopping intention in the plausible-low reference price condition (mean = 5.47) was not significantly different from that in the plausible-high reference price condition (mean = 5.46) ($t = 0.026$, $p > 0.05$). In the implausible reference price condition, value perception of LNFC individuals (mean = 5.60) is significantly higher than that in the plausible-high reference price condition ($t = -2.954$, $p < 0.01$). Likewise, shopping intention (mean = 5.97) is also significantly higher ($t = -2.064$, $p < 0.05$) in the implausible compared to the plausible-high reference price condition. Overall, these results provide full support for *H2a* and partial support for *H2b*.

For HNFC individuals, we find that the plausible-high reference price is more attractive than the plausible-low reference price since they perceive a higher amount of savings associated with the plausible-high reference price. The value perception is significantly higher for plausible-high reference price (mean = 5.49) than the plausible-low reference price condition (mean = 4.34) ($t = -5.202$, $p < 0.001$). Also, as expected, the value perception of the HNFC individuals was not enhanced any further in the implausible compared to the plausible-high reference price condition (mean = 5.40; $t = 0.299$, $p > 0.05$). As hypothesized, shopping intention of HNFC individuals was significantly higher in the plausible-high reference price condition (mean = 6.20) than in the plausible-low reference price condition (mean = 5.32; $t = -4.695$, $p < 0.05$). Also, shopping intention of the HNFC individuals did not differ across the implausible (mean = 5.98) and plausible-high reference price conditions ($t = 0.913$, $p => 0.05$). Taken together, these results provide full support for *H2c* and *H2d*.

Findings of the second study show that LNFC consumers are increasingly influenced by higher levels of reference prices, including reference prices that are implausible; whereas, HNFC consumers are no more affected by implausible reference prices than by plausible-high reference prices. For HNFC consumers, the effects of plausible-high reference price were significantly higher than the effects of plausible-low reference price indicating that they consider the sale price as a better bargain when compared to the plausible-high reference. Further, their responses

Table V (Study 2) *t*-values for value perception and shopping intention of HNFC and LNFC consumers across the reference price levels

	High need for cognition			Low need for cognition		
Variables	**PL-L RP vs PL-H RP**	**PL-H RP vs IMPL RP**	**PL-L RP vs IMPL RP**	**PL-L RP vs PL-H RP**	**PL-H RP vs IMPL RP**	**PL-L RP vs IMPL RP**
Value perception	-5.202^{a}	0.299	-4.012^{a}	-1.775	-2.973^{a}	-5.157^{a}
Shopping intention	-4.695^{a}	0.847	-2.485^{b}	0.026	-2.098^{b}	-2.322^{b}

Notes: a = $p < 0.01$; b = $p < 0.05$; PL-L RP: Plausible-low reference price; PL-H RP: plausible-high reference price; IMPL RP: Implausible reference price

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to implausible price were not significantly different from their responses to plausible-high reference price implying that HNFC consumers may have discounted the implausible reference price before making their final judgment.

General discussion

The result of our first study presents empirical evidence of the effects of market price dispersion of a product category on consumer perceptions and behavior. Adaptation-level theory states that the magnitude of impact of a price depends on the consumers' adaptation level, and in most cases this adaptation level is not the price that physically appears on the product but the price that consumers form in their minds due to past experience or knowledge (Kalyanaram and Little, 1994). The price range that the consumers evoke in their minds is used to determine the attractiveness of the market price. The evoked price range is not only influenced by the advertised selling and reference prices (Della Bitta *et al.*, 1981) but also by the variability in the prices in the market place (Kalyanaram and Little, 1994). Based on the above implications, we suggest that in situations when the price dispersion of a product category in the market is wide, consumers' expected price range becomes larger. Similarly, when the price dispersion in the market is narrow, consumers do not expect large variations in prices of the product. As a consequence, an implausible reference price is less likely to be discounted in the wide market price dispersion situation. Consistent with assimilation-contrast theory, we posit that an implausible reference price is more likely to have a positive effect on consumer evaluations when market price dispersion is wide than when it is narrow. The findings lend support to our hypothesized effects. In sum, the first study extends our present knowledge regarding the effectiveness of implausible reference pricing by investigating its persuasive influence in the context of price dispersion of a product category in the marketplace.

The second study examines the influence of NFC on consumer processing of reference prices. We examined the effectiveness of three different levels of reference price (plausible-low, plausible-high and implausible) on HNFC and LNFC individuals. Applying the characterization-correction model, we suggest that the HNFC individuals will scrutinize the information more and therefore, will enter the correction stage to either reject or discount an implausible reference price. On the other hand, the LNFC individuals will remain in the characterization stage due to their lack of motivation to assess the information thoroughly and therefore, will be more vulnerable to implausible reference price claims. Hence, the HNFC individuals were expected to respond favorably to the plausible-high reference price condition as the savings are higher than in the plausible-low reference price condition, but reflect greater discernment in the implausible reference price condition and either disregard the price completely or discount it before making a decision. Conversely, the attractiveness of the offer to the LNFC will increase as the reference price increases, and therefore, the implausible reference price will be highly effective simply because it indicates large savings.

The findings were consistent with our expectations. The plausible-high reference price resulted in higher value perception of the offer and shopping intention than plausible-low reference price but there was no incremental effect of implausible reference price on HNFC consumers. The HNFC consumer evaluations in the implausible reference price condition were not significantly different from the plausible-high reference price condition. However, the LNFC individuals showed a steady enhancement in their evaluations of the offer as reference prices increased from the plausible-low level to the plausible-high level and further, to the implausible level. However, it should be noted that while the implausible reference price did not enhance value perception and shopping intention beyond that of plausible-high reference price for HNFC consumers, it resulted in significantly greater effect compared to plausible-low reference price.

Public policy and managerial implications

The research provides additional insight regarding the role of important contextual and individual variables in the effectiveness of reference prices. The findings have important public policy implications. The findings demonstrate the potential of market dispersion of prices in strengthening the impact of implausible reference prices on consumer evaluations, contradicting the findings of Liefield and Heslop (1985) and Sewall and Goldstein (1979) which suggest that reference prices have little potential for misleading consumers. This leads to concerns about consumer protection against misleading reference prices for product categories that have a wide range of prices in the market. From the managerial perspective, marketers must be wary of the fact that if consumers perceive the reference price as very high, which is more likely to happen for a product with narrow price dispersion in the

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market, chances of reference pricing not being effective also will be high. Moreover, there is even a chance of rejection or negative impact of such implausible prices on consumers.

The findings of the second study imply that marketers may benefit from implausible reference prices regardless of need for cognition. Although HNFC are not influenced by implausible reference prices beyond plausible-high reference prices, the implausible reference price appears to be effective for both HNFC as well as LNFC individuals. Therefore, even in case of HNFC individuals, marketers may benefit from implausible reference prices compared to plausible-low reference prices. However, given that there is always a chance of an implausible reference price being rejected or perceived negatively by HNFC consumers, it would be practical for retailers to stay with plausible-high reference prices. Additional reasons for avoiding the use of implausible reference prices are that it may be difficult to segment target market according to the NFC of consumers, and that there is always the chance of running afoul of the FTC.

Limitations and future research

The research has certain limitations. The studies were conducted only with reference price and sale price combinations while the "sale price only" control condition was not used. Further, in this study, we did not investigate the effect of the different levels of reference prices on skepticism, which was found to influence the effects of reference prices (Urbany *et al.*, 1988). Examining skepticism of HNFC and LNFC individuals may help us better understand the difference in their responses to the reference price advertising. Moreover, use of student sample could limit the generalizability of the findings. Future research could address the above issues as well as investigate whether the moderating effect of market price dispersion and NFC may vary across product types. The effects of reference prices should also be studied in other contexts and for other individual difference factors since the findings are likely to be important both theoretically and managerially.

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Consumer price knowledge in the German retail market

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Keywords

Prices, Consumer behaviour, Marketing, Retailing

Abstract

Price knowledge as a construct has been one of the top behavioral pricing themes in the last four decades, especially in the Anglo-American literature. In Germany, scientists have paid relatively little attention to this topic during the last 15 years – with some notable exceptions. Therefore, this study analyzes German consumers' price knowledge and, by doing so, replicates and extends existing international work.
After reviewing earlier attempts at assessing the construct, a measure is developed for the price estimation error "PEE", based on explicit price knowledge stored in long-term memory. Results, including data from about 1,000 consumers on 69 products from a German retail chain, indicate that price knowledge in Germany is relatively low. Based on that observation, implications for the management are discussed.

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Introduction

The price of a product is one of the most important marketing-mix tools. Especially in the German retail market, it is currently used excessively to attract consumers to a certain product or store (GfK, 2002). Nearly every poster, brochure, and advertisement emphasizes price. "Smart shoppers" seem to be the only consumers targeted in these price wars. Moreover, in the German retail market, there are 237.6 outlets per 1 million inhabitants, whereas the Netherlands has 190.3 and Great Britain only 119.7 (IGD, 2003).

Because the price of a product has a major influence on the buying decision (Alba *et al.*, 1999; Monroe, 1973), it is natural to focus on it. But do consumers realize and understand favorable pricing? As a precondition to valuing a price as low, the consumer must have at least a vague idea of the normal price. Only if that idea of "normal price" is present consumers can assess whether or not the offer is a bargain.

Price knowledge is a psychological construct that is relevant to the success of the retailer, since it influences a consumer's buying decision. At the same time, it can help the retailer to exploit the consumers' "willingness to pay" by using information about price knowledge for the pricing of products.

Based on these observations, this paper gives a brief overview of the conceptual background of the price knowledge construct. This is followed by a summary of relevant price knowledge studies over the past four decades. This present study can be seen in part as a replication and extension of these studies in the German retail market. Replications are natural, as building blocks for knowledge advancement in a specific discipline. Replicatability is almost universally accepted as the most important criterion of genuine scientific knowledge (Armstrong, 2003; Hubbard and Vetter, 1996; Kane, 1984). Leone and Schultz (1980) argue that replication is the key to generalization in marketing. In support, Hubbard and Vetter (1996) pointed out that only 21 percent of replication-studies in marketing fully supported

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the findings of the original study, whereas 46 percent found conflicting results. Despite these facts, it is interesting to note that economists in general, and marketing scientists in particular, acknowledge that there is still far too little replication work, especially in a cross-cultural setting (Armstrong, 2003; Campbell and Stanley, 1963; Easley *et al.*, 2000). Our study tries to fill that gap for price knowledge studies.

Three relevant indicators of price knowledge are introduced and subsequently used to present our current price knowledge study of German consumers. A discussion of the findings, the fact that estimated prices are generally higher than actual prices, leads to the conclusion that sales managers can increase revenue through moderate price increases without losing consumers. The paper ends with a brief outline of the limitations of our study and suggests where further research is needed.

Conceptual background

A common definition of price knowledge is the consumers' ability to keep prices in mind (Aalto-Setälä and Raijas, 2003a, b; McGoldrick and Marks, 1987). In that sense, price awareness is used as a substitute for price knowledge, with almost identical meaning. Usually, the construct is operationalized in three ways (Monroe and Lee, 1999):

(1) buyers' ability to tell the exact prices of products recently purchased;
(2) buyers' ability to rank alternative products according to their prices; and
(3) buyers' ability to recognize the price of a certain product.

The construct of price knowledge consists of two parts. One is it deals with the "knowledge concerning a price", which includes accurate, figure-oriented content, and the other is it deals with "price feeling". A consumer for instance, only has vague (ordinal, or nominal) price knowledge expressed as a price judgment such as expensive or inexpensive. This distinction is made in the work of Monroe and Lee (1999), who distinguish between price knowledge as a part of the implicit and explicit memory. Price knowledge as part of the explicit memory can be consciously remembered, while price knowledge of the implicit memory is an unconscious function. Therefore, it is possible that buyers would be unable to recall the price when asked, although at a non-conscious level, price knowledge is present in, for instance, the form of an ability to identify whether a price is within a "normal" price range (Monroe and Lee, 1999).

In our study, we operationalize price knowledge as the ability to keep a price in mind, even when not having recently been confronted with that particular price (e.g. if the product has been just purchased). That price is referred to as the "normal price" of a particular product. Moreover, we operationalize price knowledge by the ability to identify a price band, a range of acceptable prices ranging from an estimated "low" to an estimated "high" price of a particular product.

Literature review

Price knowledge has been a research object in behavioral pricing theory for more than 40 years. Many studies have focused on different products (e.g. food vs non-food products), places (US vs other countries), and aims (e.g. macro-economic vs socio-demographic determinants). Additionally, these studies used a range of different measuring methods for the construct.

The differences in the findings concerning price knowledge presented in Table I can be (among others) the result of the following causes (Estelami and Lehmann, 2001; Estelami *et al.*, 2001; Vanhuele and Drèze, 2002):

- socio- and macro-economic as well as environmental determinants;
- product/product category characteristics; and
- research design characteristics.

The socio-economic environment can bring about different findings in price-knowledge studies. Vanhuele and Drèze (2002, p. 76) provide evidence of a divergence between price knowledge in France and the US. One possible explanation is that French consumers pay less attention to prices and, as a result, have a much lower level of price knowledge than their US counterparts. In contrast, Estelami *et al.* (2001, p. 350) found no cross-country variations in price knowledge between the American and non-American consumers. However, they note that this may be due to the relatively small number of non-American pricing surveys included in their analysis. Even in different parts of a single country, in this case the US, price knowledge varies (Brown, 1969, p. 187, Table I). The reason for this distinction is that the respondents in different cities rely on the same price signals, which indeed vary depending on the number of shopping opportunities (Brown, 1969, p. 187). As additional considerations, some studies focus on external/ macro-economic determinants of price knowledge, such as the effects of inflation, unemployment, GDP growth, and interest rates. Estelami *et al.* (2001) found a positive relationship

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Table I Survey of selected previous price knowledge research in the food retailing

Author, year of publication	Sample size, location of survey	Subject under investigation	Method	Measure	Price knowledge results
Aalto-Setälä and Raijas (2003a)	1.000 consumers, Finland	Eight grocery products (milk, margarine, coffee, sausage, soft drink, sugar, orange juice, frozen fish)	Telephone interview in Finland, October 2001	Long-term memory, explicit price knowledge	Six out of the eight differences in the medians are within 5 percent (average 7.9 percent)
Aalto-Setälä and Raijas (2003b)	1.000 consumers, Finland	Eight grocery products (milk, margarine, coffee, sausage, soft drink, sugar, orange juice, frozen fish)	Telephone interview in Finland, October 2001 and March 2002	Long-term memory, explicit price knowledge	Three out of the eight differences in the medians are within 5 percent (average 10.4 percent)
Brown, (1969, 1971)	1.063 consumers, USA	80 products	Personal observation and interviews with store managers	Long- vs short-term memory: not clearly reported, implicit price knowledge	Price level rankings depend on the community: high price knowledge: $r^2_{Haverton} = 0.98$ low price knowledge: $r^2_{SF/St\ Louis} = 0.00$
Buzas and Marmorstein (1988)	Reanalysis of three studies	Analysis of the three data sets	Analysis of the three data sets	Meta-analysis	Price recall accuracy is directly related to retail dealing, brand loyalty, private label penetration, average dollar purchase, and brand concentration ration Price recall accuracy is inversely related to manufacturer couponing, number of items, and purchase cycle
Conover first study (1986)	168 shoppers in a supermarket, USA	Nine product categories (milk, bread, mayonnaise, cola, margarine, coffee, detergent, orange juice, paper towels)	Questioning at the point of sale after the purchase if some thing from the corresponding product category was bought	Long- and short-term memory, explicit and implicit price knowledge	Exact price knowledge over all products: 51.2 percent (from 35.6 percent for milk to 65 percent for bread)
Conover second study (1986)	66 adult women, USA	Four product categories (cola, flour, toothpaste, peanut butter)	Laboratory setting in which store shelves were located Phone survey two days later	Long- and short-term memory, explicit and implicit price knowledge	Exact price recalls vary between 9.3 percent for peanut butter and 44.4 percent for flour Exact price recalls vary between 13 percent for peanut butter and 42.6 percent for flour
Dickson and Sawyer (1990)	802 consumers, USA	Four product categories (toothpaste, margarine, coffee, cereal)	Questioning at the point of sale after the purchase	Long- and short-term memory, explicit price knowledge	Exact price knowledge over all products: 47.1 percent Price knowledge over all products within a 5 percent range: 55.6 percent

(continued)

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Table I

Author, year of publication	Sample size, location of survey	Subject under investigation	Method	Measure	Price knowledge results
Diller (1988)	320 consumers, Germany	Ten product categories (toothpaste, chocolate, sparkling wine, aluminum foil, adhesive plaster, sugar, salt, ketchup, cooking oil, potato chips)	Phone survey	Long-term memory, explicit and implicit price knowledge	Medium Price: 84.7 percent Price ranking stores: 26.2 percent Price ranking brands: 61.7 percent
Estelami (1998)	670 candidates of the quiz-show "The Price is Right", USA	670 products in 29 product categories (e.g. toys, boat, chest, jewelry, home audio, telescopes)	Analysis of the data from the quiz-show	Long-term memory, explicit price knowledge	PAD over all products: 30.9 percent Price knowledge over all products in a 20 percent range varies between 10 percent for pool tables and 57 percent for dishwashers
Estelami and Lehmann (2001)	Meta-analysis of 22 former studies	Analysis of the data sets	Analysis of the data sets	Meta-analysis	A significant amount of variation in the accuracy of consumers' price recall is related to research design characteristics such as the presence of financial rewards, respondents' task size and the price elicitation
Estelami *et al.* (2001)	Meta-analysis of 297 former studies	Analysis of the data sets	Analysis of the data sets	Meta-analysis	Economic expansion (as reflected by GDP growth rates), inflation, interest rates and passage of time decrease consumer price knowledge. No significant effects of unemployment rate and country of study on price knowledge were found
Gabor and Granger (1961) cited in Müller and Mai (1986, p. 107)	422 female consumers, Great Britain	Seven products (tea, coffee, sugar, jam, margarine, flour, cereal)	Interview with the test persons at home (cited from McGoldrick and Marks, 1987, p. 66)	Long-term memory, explicit price knowledge	Exact price knowledge over all products: 59 percent (between 79.3 percent for tea and 34.8 percent for cereal Price knowledge over all products within a 5 percent range: 65 percent (cited from McGoldrick and Marks, 1987, p. 66)

(continued)

Table I

Author, year of publication	Sample size, location of survey	Subject under investigation	Method	Measure	Price knowledge results
Goldman (1977)	383 female consumers, Israel	One product category (meat) with three products (fresh poultry, fresh beef, imported frozen beef)	Interview with the test persons at home	Long-term memory, explicit price knowledge	Price knowledge over all products within a 5 percent range: 51 percent (between 46 percent for fresh beef and 58.2 percent for poultry)
Helgeson and Beatty (1987)	260 students, USA	Four products (jeans, 10-speed bicycles, soap, toothpaste)	Questionnaire (25 minutes after product presentation), phone survey two days later	Long- and short-term memory, explicit price knowledge	Accurate price recall after 25 minutes: soap 75 percent, toothpaste 58 percent, bicycle 53 percent, jeans 28 percent Accurate recall after two days: soap 62 percent, toothpaste 45 percent, bicycle 43 percent, jeans 20 percent
Krishna *et al.* (1991)	400 consumers in a super-market in NY, USA	Nine products (Coke, Pepsi, Minute Maid, 7UP, Sealtest, Dolly Madison, Brawny, Bounty, Ruffles)	Mail survey and personal interview	Long-term memory, explicit price knowledge	Exact price knowledge over all products (regular price): 15.0 percent Exact price knowledge over all products (special offer): 19.5 percent
Kujala and Johnson (1993)	1,600 consumers, Finland	Fresh produce (e.g. fruits and vegetables) and fresh meat	Mail survey in 1987	Not clearly reported	Price knowledge and search behavior are not directly related. Rather, they each have price importance as a common antecedent
Le Boutillier *et al.* (1994)	235 consumers in New Hampshire, USA	Two product categories (coffee and soda)	Questioning at the point of sale after the purchase	Short-term memory, explicit price knowledge	Exact price knowledge over all products: 61.3 percent (between 71.3 percent for soda and 45.7 percent for coffee)
Lenzen (1984)	578 female consumers, Germany	Ten products (toast, margarine, coffee, cheese, jam, butter, eggs, roast pork, liver sausage, brandy)	Interview with the test persons at home about prices of three stores	Long-term memory, explicit price knowledge	Exact price knowledge over all products: 0.7 percent Price knowledge over all products within a 5 percent range: 3.5 percent
Manning *et al.* (2003)	623 consumers, USA	Unspecified grocery products	Questionnaire in a widely used metropolitan public rail system	Long-term memory, implicit price knowledge	Percentage of lifetime spent in the US, education and price consciousness had a positive effect on consumers' price usage knowledge Percentage of household shopping and income had no effect

(continued)

Table I

Author, year of publication	Sample size, location of survey	Subject under investigation	Method	Measure	Price knowledge results
Mazumdar and Monroe (1990)	90 female consumers, USA	Four product categories (orange juice, can soup, cereal, pasta)	Experiment	Long- and short-term memory, explicit and implicit price knowledge	Exact price knowledge over all products: 47.78 percent (between 42.2 percent for soup and orange juice to 53.3 percent for pasta and cereal)
McGoldrick and Marks (1987)	214 female shoppers in two supermarkets, Great Britain	Ten product categories (coffee, beans, fish fingers, cereal, canned soup, flour, sauces, extracts, vegetable oil, digestives)	Questioning at the point of sale after the purchase if something from the corresponding product category was bought	Short-term memory, explicit price knowledge	Exact price knowledge over all products: 28.7 percent (from 18 percent for oil to 39 percent for beans) Price knowledge over all products within a 5 percent range: 54.6 percent (from 20 percent for extracts to 69 percent for fish fingers)
Müller and Mai (1986)	383 female consumers, Germany	One product category (wine)	Questioning at the point of sale directly after the purchase	Short-term memory, explicit price knowledge	Exact price recall: 65.5 percent
Partch and Litwak (1990) cited in Wakefield and Inman (1993, p. 230)	480 households, USA	25 products	Phone survey	Not clearly reported	Price recall $<$ 50 percent
Progressive Grocer (1964) cited in McGoldrick and Marks (1987, p. 66)	Several thousand shoppers, USA	59 products	Questioning at the point of sale regardless of whether the items were used or not	Short- and long-term memory, explicit price knowledge	Price knowledge over all products within a 5 percent range varies between 91 percent (Coca-Cola) and 12 percent (Nestlé Quick)
Stephens and Moore (1975)	312 students in Wisconsin, USA	Nine products (e.g. milk, bread, ice cream, TV console, radio, regular gas, refrigerator, soap)	One-hour self-administered questionnaire	Long-term memory, explicit price knowledge	High-school students know better than grammar-school students the prices of six out of nine products (e.g. milk, soap, gas). Indeed, the price knowledge of ice cream and milk is lower
Urbany and Dickson (1991)	Sample of 59 women from two cities, USA	18 products (e.g. mayonnaise, paper towels, sugar, soup, tuna, toothpaste, cheese, coffee, orange juice, coke, salad)	Interview with the test persons at home	Long-term memory, explicit and implicit price knowledge	Exact price knowledge over all products: 53 percent

(continued)

Table I

Author, year of publication	**Sample size, location of survey**	**Subject under investigation**	**Method**	**Measure**	**Price knowledge results**
Vanhuele and Drèze (2002)	400 consumers in a super-market, France	Eight products (toilet paper, mayonnaise, yogurt with fruit, liquid detergent, granulated sugar, mineral water, milk, toothpaste)	Survey at the point of sale before the shopping occasion of products that are usually bought in this location	Long-term memory, implicit price knowledge	Exact price recognition over all products: 2.1 percent Price recognition over all products in a 5 percent range: 21.3 percent
Wakefield and Inman (1993)	289 consumers, USA	Four product categories (toothpaste, coffee, margarine, cereal)	Questioning at the point of sale after the purchase	Short-term memory, explicit price knowledge	Exact price knowledge over all products: 55 percent Price knowledge over all products within a 5 percent range: 8.7 percent
Wilkinson *et al.* (1980)	67 consumers, USA	32 unspecified supermarket items	Personal, in-home interview	Long- vs short-term memory: not clearly reported, implicit price knowledge	Price knowledge and specific self-confidence were positively related
Zeithaml (1982) and Zeithaml and Fuerst (1983)	160 female consumers, USA	90 products in 12 categories (e.g. beans, peas, deodorant soap, dish detergent, ketchup, salad dressing, pea-nut butter, paper towels)	Laboratory setting which simulated the conditions of exposure	Short-term memory, explicit price knowledge	Exact price recall error between 17.16 and 26.26 percent depending on the age of the consumers

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between economic growth, inflation rate, and price recall error. It has also been documented, how the changeover to the Euro has affected consumer price knowledge in Finland (Aalto-Setälä and Raijas, 2003b).

In addition to these causes of differences in findings, the lack of similarity between products and product categories (e.g. food and non-food) leads to different results. Note that Table I shows studies primarily of grocery products. For example, one survey indicates that in heterogeneous product categories with a larger price range and more references (e.g. toothpaste), the accuracy of consumer price estimations is lower than in homogenous categories (e.g. sugar) (Vanhuele and Drèze, 2002, p. 79). For instance, if the price range is large, the product group will be associated in the memory with many different prices and therefore, becomes an unreliable cue to remembering any given price. In the first group, the increased complexity in price information can have a negative impact on memory performance (Vanhuele and Drèze, 2002). Nevertheless, there are conflicting results with respect to the price knowledge of frequently purchased products. Within the context of grocery shopping, fast-moving grocery products such as coffee, milk, and butter are characterized by a higher level of price knowledge than products purchased less frequently (Estelami, 1998; Krishna *et al.*, 1991; Le Boutillier *et al.*, 1994). Estelami and Lehman – (2001) do not find support in their meta-analysis for the hypotheses that frequently purchased goods can be described by a higher level of price knowledge than services and consumer durables. They found no evidence of significant variation in price recall accuracy across the three aforementioned product categories, although, due to a high level of shopping experience in a certain category, consumers may have developed a better memory for relevant price information, e.g. for frequently purchased goods (Estelami, 1998).

It has been demonstrated that a significant amount of variation in price knowledge is related to research design characteristics, such as the offer of financial rewards and the price elicitation approach (Estelami and Lehmann, 2001). As shown in Table I, the most common sampling methods are telephone interviews, mail questionnaires, and face-to-face interviews at the point of sale, in a laboratory or in the test person's home. These methods influence the accuracy of price knowledge, as evidenced by the results of two studies from Conover (1986, p. 592) which are based on different methods. Interviews administered before shopping, as consumers enter the store, reveal information about price knowledge stored in long-term memory. Interviewing after the purchase, on the other hand, reveals what is stored in the short-term memory. That knowledge comes from the perception of price information at the point of sale (Monroe and Lee, 1999, p. 207; Vanhuele and Drèze, 2002, p. 72).

The use of different price knowledge definitions is closely connected with the research design, as shown by Monroe and Lee (1999, p. 213). Some researchers (Dickson and Sawyer, 1990; Estelami, 1998; Wakefield and Inman, 1993; Zeithaml, 1984) use the "Percentage Absolute Deviation" (PAD), and others define different levels of price knowledge, (e.g. prices falling within a range, such as ±5 percent: Goldman, 1977; McGoldrick and Marks, 1987). Another group counts every answer about the price, irrespective of the correctness (Goldman, 1977).

The different focus of each study complicates the comparability of results (e.g. determinants of promotions on price knowledge) (Krishna *et al.*, 1991). Some researchers attempt to confirm the hypotheses about socio-demographic aspects of consumers such as age (Aalto-Setälä and Raijas, 2003a; Stephens and Moore, 1975; Zeithaml and Fuerst, 1983), income (Estelami and Lehmann, 2001; Goldman, 1977), and gender (Estelami and Lehmann, 2001; Wakefield and Inman, 1993), while others explore price knowledge in a global consumer context (Conover, 1986; Estelami, 1998; Manning *et al.*, 2003; Urbany and Dickson, 1991). Even studies focusing on the socio-demographic determinants reveal different results. For example, some surveys show price knowledge differences depending on age differences (Brown, 1971; Zeithaml and Fuerst, 1983), whereas others do not find such differences (Estelami, 1998; Goldman, 1977; Krishna *et al.*, 1991; McGoldrick and Marks, 1986; Wakefield and Inman, 1993). That could be due to the combined effects of the design characteristics (Estelami and Lehmann, 2001, p. 42).

Use of generalization and comparability in studies requires careful consideration, because different methods, contents, and definitions can lead to different results. Even in cases where almost identical procedures are used, different results have been found (Table I). By extending the construct of price knowledge of (predominantly) grocery products to the German market, we add to the ongoing discussion on consumer price knowledge. It is the first such study performed in Germany in over 15 years.

Data collection and methodology

For our German study, we collected data on the accuracy of supermarket shoppers' price knowledge. The sampling time frame was between March and June 2002. Interviewers were stationed in supermarkets that are part of a major German grocery chain, located in five different cities. The retailer selected these five locations as a representative sample of the grocery chain. Presenting the products for which prices should be estimated, the interviewers approached 993 consumers directly as they entered the store. Following Vanhuele and Drèze (2000), no incentives were given to participants in order to avoid attracting price-sensitive shoppers.

The method of interviewing shoppers immediately after they enter the store, though contrary to many earlier studies (Conover, 1986; Dickson and Sawyer, 1990; Le Boutillier *et al.*, 1994; McGoldrick and Marks, 1987; Wakefield and Inman, 1993) which requested product prices immediately after purchase, avoids measuring price knowledge based on price recall from short-term memory and focuses instead on price knowledge from long-term memory. By doing so, we follow the format of Vanhuele and Drèze (2002, p. 74) in measuring long-term price knowledge by asking consumers at the start of the purchasing occasion. In this way, we maximize the number of contextual cues (e.g. beginning of a purchase in a particular store) to ensure the presence of generally available shopping knowledge and to avoid bias of in-house surveys such as Urbany and Dickson's (1991) or surveys in public places (a rail system as with Manning *et al.*, 2003). Moreover, we are able to avoid measuring consumers' capability to store price information in their short-term memory, as can be the case when asking immediately after purchase. Price knowledge stored in long-term memory is more likely to affect a buying decision than the price knowledge stored in short-term memory.

Another important topic that must be addressed when choosing a methodology is the distinction between explicit and implicit memory and the respective price knowledge. Explicit price knowledge involves the conscious retrieval of factual information, whereas implicit price knowledge involves unconscious information storage, which nonetheless influences buying behavior (Estelami and Lehmann, 2001). Explicit price knowledge is usually operationalized by asking the exact price of a certain product, whereas implicit knowledge can be assessed by offering a semantic differential such as "more expensive-less expensive" or "good value-poor value" (Coulter, 2003).

In our study, we focus on measuring explicit price knowledge stored in long-term memory. It is not unusual for a consumer to decide whether or not to buy something in a certain store by comparing some price information (e.g. in a brochure or poster) with his or her explicit price knowledge stored in the long-term memory. Therefore, we asked the shoppers a variety of questions relating to their price knowledge and their demographics. The sample consisted of 49 percent males and 51 percent females, with an average age of 44 years and an average monthly net income of 1.680 Euros (about 2,000 US dollars). Concerning gender, age-group differentials, and income, the panel was found to be quite representative of the German population (Statististisches Bundesamtes, 2003).

In our survey, we selected a total of 69 products from three product groups: detergents/cosmetics, retail food brands, and dairy products. Moreover, we selected a "shopping basket" consisting predominantly of strong brands of different product categories. (For details on products and product groups, refer Table II). The definition of these strong brands is based on a "typical" shopping basket of German food consumers. This basket includes brands with the highest turnover (Statististisches Bundesamtes, 2003).

For each product, the consumers were asked to indicate its normal, low, and high price. In this way, we were able to identify the consumer's estimation of the normal price of a particular product and, additionally, a price band, a range of acceptable prices ranging from "low" to "high" for that particular product (Monroe and Lee, 1999). The width of this range can be interpreted as an indicator of price uncertainty (Adam, 1958). We did not use the information about the price band to calculate a mean value of, for example, high price and low price (similarly Helgeson and Beatty, 1987) as a proxy for "normal price". We asked the shoppers to directly name the "low", "high", and "normal" prices of certain products. In order to calculate the price estimation error (PEE), we use the direct measure of the normal price estimation of the shoppers.

The price knowledge data were calculated on the level of the individual product and then aggregated to the level of the product group ("detergents/cosmetics", "retail food brands", "dairy products", and "shopping basket") in order to generalize our findings. The accuracy of the price estimation was measured by three indicators. First, non-responses were used as a proxy of "no price knowledge". This measure of price knowledge is very simple and counts the percentage of respondents who were unable to estimate prices at all. Nonetheless, it is important

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Table II PEEs for the four product groups (results well rounded)

Product group	Product	Estimated low price (€)	Estimated normal price (€)	Estimated high price (€)	Actual sales price (€)	PEE (percent)	Price band (percent)
Detergents and cosmetics	Detergent A	4.33	5.05	5.35	5.45	7.29	21.11
Absolute PEE = 40.2 percent	Detergent B	1.79	2.79	2.90	1.45	−92.41	47.18
	Cleaning agent A	1.70	2.31	2.86	1.75	−32.00	50.95
	Cleaning agent B	1.30	1.73	2.17	1.35	−28.15	50.31
	Scavenger	1.24	1.76	2.02	1.35	−30.37	47.65
	Toilet paper A	2.89	2.80	2.92	2.45	−14.29	1.02
	Toilet paper B	2.50	3.05	3.17	2.25	−35.56	23.66
	Tissue	2.41	2.77	2.72	2.65	−4.53	12.00
	Kleenex	1.73	2.36	2.49	2.36	0.00	36.36
	Tampon	3.71	4.23	4.47	4.95	14.55	18.36
	Hair spray	1.64	2.33	2.43	1.75	−33.14	39.04
	Shampoo A	1.14	1.79	1.96	1.65	−8.48	52.63
	Shampoo B	0.78	1.45	1.50	0.89	−63.24	63.16
	Cream A	1.41	1.81	1.95	1.55	−16.67	32.23
	Cream B	6.32	6.37	7.85	8.95	28.83	21.63
	Shower gel A	1.47	2.05	2.09	1.25	−64.00	34.74
	Shower gel B	1.31	1.59	1.75	0.65	−144.62	28.57
	Soap	0.70	1.00	1.55	0.55	−81.82	75.39
	Deodorant	1.66	1.92	2.15	1.77	−8.47	25.40
	Tooth paste A	1.11	1.53	1.82	0.75	−104.00	48.35
	Tooth paste B	1.48	1.89	1.97	1.25	−51.20	28.76
	Razor blade	4.44	4.84	6.25	6.26	22.56	33.95
	Alcoholic cosmetics	5.00	5.24	5.50	8.39	37.54	9.52
	Average						34.87
Dairy products	Milk A	0.53	0.57	0.75	0.49	−16.33	33.53
Absolute PEE = 34.1 percent	Milk B	0.56	0.60	0.76	0.55	−9.09	30.11
	Milk C	0.56	0.61	0.78	0.49	−24.49	32.51
	Margarine A	0.85	0.94	1.17	0.99	5.05	31.47
	Margarine B	0.58	0.68	0.97	0.59	−15.25	50.34
	Butter A	0.82	0.96	1.25	0.79	−21.52	40.94
	Curd	0.55	0.59	0.82	0.56	−7.27	39.97
	Yoghurt A	0.24	0.34	0.40	0.15	−126.67	50.66
	Cheese A	0.90	1.07	1.78	0.43	−149.81	65.67
	Butter B	0.86	1.02	1.19	1.09	6.42	32.74
	Buttermilk	0.56	0.68	0.84	0.49	−38.78	40.72
	Cheese B	1.04	1.21	1.51	1.19	−1.68	37.04
	Milk D	0.71	0.80	0.82	0.55	−45.45	15.19
	Milk E	0.61	0.69	0.71	0.95	27.37	14.71
	Yoghurt B	0.52	0.66	0.87	0.49	−34.69	50.27
	Margarine C	0.89	1.06	1.18	0.99	−7.07	28.45
	Cream	0.47	0.56	0.73	0.39	−43.59	43.21
	Average						37.50
Retail foods	Flour	0.45	0.52	0.83	0.29	−79.31	59.72
Absolute PEE = 36.7 percent	Sugar	0.67	0.74	0.98	0.89	16.85	37.13
	Milk A	0.53	0.57	0.75	0.49	−16.33	33.53
	Milk B	0.56	0.60	0.76	0.55	−9.09	30.11
	Milk C	0.56	0.61	0.78	0.49	−24.49	32.51
	Margarine A	0.85	0.94	1.17	0.99	5.05	31.47
	Margarine B	0.58	0.68	0.97	0.59	−15.25	50.34
	Butter A	0.82	0.96	1.25	0.79	−21.52	40.94
	Curd	0.55	0.59	0.82	0.56	−7.27	39.97
	Yoghurt A	0.24	0.34	0.40	0.15	−126.67	50.66
	Cheese A	0.90	1.07	1.78	0.43	−149.81	65.67
	Sausage	0.88	0.94	1.30	0.97	3.09	38.36

(continued)

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Table II

Product group	Product	Estimated low price (€)	Estimated normal price (€)	Estimated high price (€)	Actual sales price (€)	PEE (percent)	Price band (percent)
	Condensed milk A	0.39	0.46	0.66	0.38	−17.95	51.93
	Canned cherries	0.90	1.07	1.43	0.79	−35.44	45.48
	Canned pineapples	0.67	0.78	1.10	0.89	12.36	48.55
	Beer	0.40	0.45	0.60	0.39	−12.50	39.44
	Snacks A	0.74	0.85	1.11	0.86	1.16	40.13
	Snacks B	0.65	0.80	1.26	0.49	−63.27	63.57
	Snacks C	0.74	0.97	1.40	0.37	−162.16	62.45
	Coffee A	3.07	3.66	4.19	3.99	8.27	30.81
	Coffee B	2.86	3.54	3.88	3.59	1.39	30.19
	Oil	0.94	1.22	1.66	1.49	18.12	55.54
	Average						44.48
Shopping basket	Chocolate A	2.55	2.82	3.98	4.49	37.19	43.85
Absolute PEE = 26.3 percent	Chocolate B	1.61	1.96	2.28	1.69	−15.98	33.95
	Chocolate C	1.37	1.57	1.64	1.54	−1.95	17.46
	Chocolate D	0.53	0.68	0.74	0.65	−4.62	32.39
	Sanitary napkin	2.03	2.60	3.38	2.05	−26.83	50.00
	Shampoo C	1.26	1.66	1.92	1.65	−0.61	41.46
	Detergent C	6.68	7.52	8.26	4.34	−73.21	21.13
	Butter B	0.86	1.02	1.19	1.09	6.42	32.74
	Buttermilk	0.56	0.68	0.84	0.49	−38.78	40.72
	Cheese B	1.04	1.21	1.51	1.19	−1.68	37.04
	Milk D	0.71	0.80	0.82	0.55	−45.45	15.19
	Milk E	0.61	0.69	0.71	0.95	27.37	14.71
	Yoghurt B	0.52	0.66	0.87	0.49	−34.69	50.27
	Margarine C	0.89	1.06	1.18	0.99	−7.07	28.45
	Cream	0.47	0.56	0.73	0.39	−43.59	43.21
	Convenience food A	0.71	0.90	1.03	0.69	−30.43	37.10
	Coffee A	3.00	3.63	3.77	7.99	54.59	22.66
	Coffee B	2.91	3.54	4.06	3.59	1.39	33.27
	Coffee C	3.07	3.77	4.01	3.99	5.51	26.40
	Condensed milk B	0.64	0.70	0.71	0.75	6.67	11.02
	Convenience food B	1.21	1.54	1.54	1.39	−10.79	24.48
	Canned tomatoes	0.88	1.06	1.15	0.76	−39.47	27.02
	Convenience sauce	0.70	0.41	0.89	0.99	58.59	23.21
	Coke	0.31	0.40	0.55	0.35	−14.29	55.71
	Bananas A	1.49	1.91	2.41	1.39	−37.41	47.08
	Bananas B	1.59	1.57	2.32	0.99	−58.59	37.34
	Average						32.61

to identify persons with no price knowledge at all. If they were "forced" to make estimations, results could be biased. Secondly, we calculated the width of the price band as an indicator of price uncertainty. It is calculated by subtracting the estimated high price from the estimated low price and dividing the result by the mean value of the two prices. By doing so, we obtain a percentage-value which is comparable across all products.

Apart from these rather simple indicators, we measured consumer price knowledge with a third indicator: the PEE. This indicator is based on the PAD (Dickson and Sawyer, 1990; Estelami, 1998; Mazumdar and Monroe, 1992; Wakefield and Inman, 1993). It is calculated as follows:

$$\mathrm{PEE} = \frac{\text{actual price} - \text{estimation of normal price}}{\text{actual price}}$$

As we asked the consumers to indicate the normal price of a particular product, we were able to calculate the error of estimation of the normal price. The greater the difference between the estimated normal price and actual price, the higher the absolute value of the PEE and consequently, the lower the consumers' price knowledge. In addition to the absolute value of the PEE, its algebraic sign can be interpreted as follows. A positive PEE means that the actual sales price is higher than the expected price, and hence the sales price is underestimated. Conversely, a negative PEE implies an overestimation of sales prices.

Results

The following results relate to the German consumers' price knowledge of three product groups and a shopping basket of strong brands. Independent of the product group, it can be noted that the price knowledge of German consumers is low. This is reflected by the high percentage of non-responses in the survey: on an average, less than 50 percent of the consumers have any idea of the price for a particular product. That figure varies from 34 percent of consumers having at least a vague idea of the price for retail brands to 54 percent for strong brands. A test of the two groups (those who failed to estimate prices and those who did not) yielded no significant differences with respect to age, gender, income, and education.

The width of the price band as an indicator of price uncertainty varies from 32.6 to 44.5 percent at the group level. An analysis of variance (ANOVA) with price band as the dependent variable and product category as the independent variable indicate that variations observed are significant ($F = 3,206$; $p < 0.05$).

As noted, we operationalized consumer price knowledge with a modified version of the PAD, the PEE. We calculated this indicator for all products. We then aggregated data to the three product groups and the shopping basket. Moreover, Table II shows the price band of all products and the average price band of each group of products.

The price knowledge measured by the PEE ranges from -162.1 to 58.6 percent at the product level. The range of absolute PEE extends from 26.3 to 40.2 percent at the group level. It can be noted that group means do not significantly differ ($p > 0.1$). That is not unexpected since groups include strong and retail brands from the different product categories. Therefore, variances within groups are larger than between groups.
That finding is consistent with Estelami and Lehmann (2001), who found no significant impact of product category on price recall. There is some support for a statistically significant difference between the group "detergents and cosmetics" and the "shopping basket" ($p = 0.107$) due to the fact that the shopping basket includes only strong brands.

Price knowledge is the lowest for detergents and cosmetics. For all the 69 products the average absolute PEE is 34.3 percent. In contrast to our results, Estelami and Lehmann (2001, p. 41) explored 250 price knowledge studies and found that the average PAD for frequently purchased goods is just 14.2 percent. In our study, the absolute PEE even for the strong brands of our shopping basket is nearly twice as high, which again establishes the conclusion that price knowledge in Germany is relatively low.

Results for individual products reveal that, for instance, consumers of the major German brand of tissues ("Tempo") have nearly perfect price knowledge (PEE $= 4.5$ per cent), whereas a PEE of -144.6 percent for shower gel expresses one of the lowest price knowledge levels of all products.

Looking at the PEE (including algebraic sign), we conclude that consumers estimate prices at too high a level. A modified PEE with a negative sign indicates that actual prices are lower than estimated prices. Consumers overestimate prices in almost 80 percent of all cases. Looking at individual products, we note that the price knowledge of retail brand chips ("snacks C") with a PEE of -162.2 percent is the lowest. A hollandaise sauce produced by Nestlé ("convenience sauce") has a PEE of 58.6 percent, which is the maximum positive average deviation of all products. The findings that negative variations from the actual price are greater than the positive are also obtained for many other products (refer Table II for details). The data results suggest that the PEE is predominantly negative. Positioning the actual price in the context of the estimated low and high prices, four different cases can be identified (Figure 1).

First of all, it is possible that the actual price is even lower than the expected low price (position 1). This case occurs in 44.3 percent of all products. Earlier studies confirm this overestimation of actual prices (Aalto-Setälä and Raijas, 2003a, b; Conover, 1986). An overestimation of prices can occur even if the actual price is higher than the estimated low price, or, more precisely, if it is found between the low and normal estimated price (position 2). A total of 28.4 percent of all product estimations can be integrated here. The remaining 27.3 percent (position 3 and 4) underestimate prices while only 12.5 percent of the products are more expensive than the estimated high prices (position 4 Table III).

Discussion

Generally speaking, the price knowledge of German consumers is rather low. That is indicated by results showing more than 50 percent of consumers who assert that they have no price knowledge at all. In addition, we discovered high price uncertainty, indicated by a wide price band up to almost 75 percent at product level and about 45 percent at product group level. The reason for the relatively low price knowledge, especially for retail brands, can be explained by frequent variation in

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Figure 1 Position of the actual price in relation to the estimated low, normal and high prices

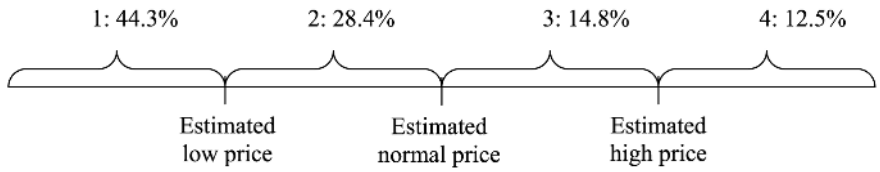

Table III Position of the actual price in relation to the estimated low, normal and high prices for the four product groups

	Position 1 (percent)	Position 2 (percent)	Position 3 (percent)	Position 4 (percent)
All products	44.32	28.41	14.77	12.5
Detergents and cosmetics	34.78	43.48	0.00	21.74
Dairy products	58.82	23.53	11.76	5.89
Retail foods	54.55	9.09	36.36	0.00
Shopping basket	34.62	34.62	11.54	19.23

their prices (usually unnoticed by consumers) and a lack of consumer awareness for such products. Therefore, it is difficult for consumers to establish a consistent estimation of the price level. A relatively sound price knowledge concerning strong brands ("shopping basket") can be noticed. As in other studies, our study confirms that there is generally higher price knowledge for strong brands (Aalto-Setälä and Raijas, 2003b). These observations expand the existing findings about price knowledge to the German retail market.

Reasons for relatively high price knowledge of strong brands could be their higher shopping frequency and their familiar image. A high shopping frequency implies that the consumer is confronted with these products more often and therefore, learns prices more easily. Furthermore, it is typical for German retailers to use strong brands for price-promotions. These well-known products are used in a loss leader strategy to attract consumers to the particular retailer. Since consumers have high price knowledge for these products, they value the bargain. The goal of focusing on prices is twofold:

First, retailers can deliver the price they advertise. Therefore, a consumer's expectation is met and hence, satisfaction is the result (Oliver, 1980). Focusing on – say – quality is much harder for the retailer in terms of estimating consumer expectations. Therefore, satisfying consumers is a much more demanding task.

Secondly, consumers are attracted to the retailer due to price promotions of strong brands. The idea behind this pricing strategy is that consumers, once in the store to get the "leader product", buy additional products that generate higher profits (Nelson and Hilke, 1986, on the "featuring" phenomenon). In line with this, Walters and MacKenzie (1988) found out that most loss leader promotions had no effect on store profits, and those loss leaders that did effect profits did so through their effect on store traffic rather then their effect on sales of the promoted item[1].

It can be noted that consumers not only demonstrate low price knowledge but also tend to overestimate prices. This fact is expressed by a negative PEE, a finding which indicates that the actual prices are lower than expected. Again, it is noticeable that for the strong brands in the shopping basket, the PEE is significantly lower than for products from the three other product groups. An important implication of these results is that the pricing of products can be modified. Since the actual prices in the product groups are generally overestimated, retailers have room for price variation. Moderate price increases would not convince consumers that the product is "expensive", and they would still buy the product even at a higher price. If we expect sales volume to remain constant, a hypothetical calculation for the retailer in our study showed that for "cleaning agent B" (we had access to scanner data for that product: annual turnover of about 55,000 Euros), an increase of the actual sales price to the estimated normal price would increase revenue for that product by about 28 percent which corresponds to extra revenue of about 15,000 Euro/year just for that particular product.

The discussion shows that the pricing of products should not be exclusively based on neoclassical price theory, but also on consumers' price knowledge. By doing so, German retailers, in particular, can improve their poor revenues by moderately increasing the prices for products with low price knowledge. For strong brands, the sales manager must be cautious about varying prices. Reduced prices will most likely be noticed by consumers. This very fact can jeopardize the brand by positioning it as a "discount" brand rather than a "premium" brand. This, combined with the observation that most price promotions have an effect on store profitability by increasing traffic in the store, urges the store management to introduce price promotions in cooperation with the producer of strong brand products. For instance, some brands can function as "traffic builders", increasing profits for the retailer, whereas other brands function as "cash cows" for producers, with lower margins for the retailer. We would call such a cooperative brand and price management "Strategic Brand Coordination" (SBC), an extension of the well-known ECR-concept, and would expect mutual benefits for producer and retailer alike.

Limitations of the study/future research

Our study generally confirms much of the research on price knowledge. Price knowledge is relatively low and depends on the products evaluated. Thereby our understanding of the construct "price knowledge", which has been tested mainly in the Anglo-American market, is extended to the German market.

However, there are some limitations to our study. Since the research design follows a majority of earlier studies, some generalization is possible, but it is not possible to include all earlier studies in a meta-analytic procedure. Moreover, we use PEE as a measure of price knowledge and aggregate it at product group level as well.

Our data were collected between March and June 2002, less than half a year after the introduction of the Euro. Owing to this change in currency, consumers may not yet be familiar with prices. A change in consumer perceptions of price levels could very well have taken place in the meantime (Aalto-Setälä and Raijas, 2003a, p. 189). This fact can be an explanation of the relatively poor price knowledge found in our survey.
A starting-point for further research would be the examination of longitudinal data on PEE for the German market.

Another reason for the relatively poor price knowledge could be our measurement approach. Because we asked for the exact low, normal, and high price, we focused primarily on explicit memory, neglecting information on prices stored in implicit memory. Even though some consumers could not have recalled prices accurately, they could have an adequate general price feeling. For example, they could indicate if the sales price is relatively low or high with respect to other products. Thus, this implicit knowledge can influence behavior even though it often cannot be remembered (Monroe and Lee, 1999; Vanhuele, 2002). Therefore, in a follow-up study, both types of price memory should be investigated. That would further enrich our knowledge of price awareness.

Another limitation concerns the product category in which we analyzed price knowledge. Our study tested mainly food products. Thus, it is possible that our findings are influenced by the product life cycles in this sector. There is reason to believe that products characterized by shorter life cycles (e.g. fashion textiles) may have even lower price knowledge than products in the food sector. Further research is needed in this field.

Furthermore, we focused only on a single retail chain in order to increase the validity of our comparison of remembered prices in contrast to actual store prices (as in Vanhuele and Drèze's (2002) survey). Because the price data were collected in large grocery stores, the selected products have a lower average price level than in small stores. This fact can explain the identified overestimation of sales prices. Differences in price knowledge depending on the type of store (e.g. discount vs supermarket) could be a fruitful avenue for future research.

However, we do not believe that there are severe limitations in the generalization or the substantive implications of our results. The retailer we analyzed is typical in size and success for the German market. Moreover, we were able to control the most important environmental variables, especially sales promotions, during the period of our survey. Nonetheless, we would recommend replications of this study in different environmental and cultural contexts as indicated above. In particular, longitudinal data would further improve our understanding of one of the most heavily researched constructs in pricing theory, price knowledge.

Note

1 It is worth mentioning that retailers may have additional reasons for pursuing a leader price strategy. Hess and Gerstner (1987) identified four additional reasons: price differentiation, forward buying, peak load pricing, and introductory offers of new products. These reasons are not further analyzed here; reference is made to the literature mentioned.

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Price knowledge: effects of consumers' attitudes towards prices, demographics, and socio-cultural characteristics

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Keywords

Prices, Consumer behaviour, Attitudes

Abstract

The accuracy of consumer price knowledge is dependent on numerous factors. This study examined the effect of some variables related to consumers' attitudes towards prices and some demographic variables on price knowledge. Results showed that consumers were more knowledgeable about the relationships between the prices of competitor brands than about the actual prices in themselves. When certain error margins were allowed, the differences between absolute and relative price knowledge were not as evident. In addition, the accuracy of consumer knowledge of prices was found to be dependent on how much importance they placed on price, and it influenced subjects' perceptions of themselves as shoppers. In this study, women and people with low income level were more knowledgeable about prices. The statistical effects and relationships between these variables were analyzed taking into account the economic, social, and cultural setting in which the research was conducted.

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Theoretical foundation

Consumer knowledge of prices plays an important role in price management since it not only determines how prices are perceived and valued but also influences consumers' purchase decisions (Binkley and Bejnarowicz, 2003; Dolan, 1995; Mesak and Clelland, 1979; Monroe, 1973, 1992; Shapiro, 1968; Simon, 1989; Turley and Cabaniss, 1995; Vanhuele and Drèze, 2002).

A key assumption in economic theory is that consumers tend to know with a reasonable degree of accuracy the prices of the products they buy. At the same time, some behavioral and psychological theories of consumer behavior and information processing such as the adaptation level theory (Helson, 1964), the assimilation-contrast theory (Sherif and Hovland, 1965), the Weber-Fechner law (Monroe, 1971), and the prospect theory (Kahneman and Tversky, 1979) are rooted, at least implicitly, on the premise that consumers are aware of prices: prices are evaluated, codified, and integrated in memory. However, previous research in this area shows that this assumption is not always correct (Dickson and Sawyer, 1990; Le Boutillier *et al.*, 1994; McGoldrick and Marks, 1987; Vanhuele and Drèze, 2002; Wakefield and Inman, 1993) and that many consumers do not make a deliberate and conscious effort to remember the prices of the products they buy (Helgesson and Beatty, 1987; Mazumdar and Monroe, 1990).

The empirical evidence available regarding consumer price knowledge and the factors that influence it lacks consistency and coordination, and, in some cases, it yields contradictory results (Kim *et al.*, 1999; Rosa Díaz, 2001). These circumstances have made it difficult to draw clear conclusions and establish reliable comparisons between studies, particularly because of the significant variation in their respective research designs and methodologies (Estelami and Lehmann, 2001). In addition, most studies in this area of research have been conducted in very specific geographic and cultural contexts, mainly in the US, England, and France. However, it has been established that cultural differences may lead to heterogeneous behaviors on the part of consumers (Estelami *et al.*, 2001; Ger and Belk, 1996; Griffin *et al.*, 2000; McGowan and Sternquist, 1998; Mooij and Hofstede, 2002), which suggests the need for further research that

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evaluates consumer price knowledge in different geographic and cultural settings.

The purpose of the present study is twofold, namely to assess the accuracy of consumers' price knowledge and to determine whether such accuracy is influenced by consumers' socio-demographic characteristics as well as by certain aspects of their attitudes toward prices. This study may also contribute to a better cross-cultural understanding of price knowledge, since it was conducted in Spain, which offers an economic and socio-cultural context that has rarely been investigated from this perspective.

The importance of price in purchase decisions

Studies on price knowledge have often analyzed the importance of price in consumers' purchase decisions. Most of these studies have found that those consumers who perceive prices more accurately are the ones who place a higher degree of importance on them (Brown, 1971; Hirn, 1986; Kujala and Johnson, 1993; McGoldrick and Marks, 1987). This premise has also been largely confirmed by studies in which the importance of price in purchase decisions was operationalized indirectly, through other related variables: the attention consumers pay to prices (Chanson *et al.*, 1986; Conover, 1986; Dickson and Sawyer, 1990), the use of price information (Mazumdar and Monroe, 1990), and the tendency to compare prices on a regular basis (Le Boutillier *et al.*, 1994; Vanhuele and Drèze, 2002). One of the working premise of the present study is that, if one pays attention to prices, makes an effort to compare prices, and uses this information to make purchase decisions, it must be because prices are "important".

The arguments offered thus far can be reinforced through an examination of the relationship between the importance of price for consumers and the way they perceive and interpret price information. When presented with price information, consumers behave as "information processors", who selects the information to which they will pay attention, interpret it, and translate it into an internal representation that influences their actions and that is stored in their memory to be recovered when they need it (Zeithaml, 1982; Zeithaml and Fuerst, 1983). This so-called process of selective perception determines not only which stimuli will be the focus of consumers' attention but also the way in which those stimuli will be interpreted (Conover, 1989; Desai and Hoyer, 2000). Within this process of selection and interpretation of stimuli, consumers' needs, values, level of involvement, and expectations play a fundamental role (Conover, 1989; Solé Moro, 1999). Consequently, the importance that individuals place on price stimuli can be a critical element, since it may capture their attention and therefore, guide their assessment (Vanhuele and Drèze, 2002; Wolverton and Diaz, 1996).

In conclusion, there are a number of factors that can act as antecedents to the importance of price; e.g. the budgetary restrictions and the perceived usefulness of money, the use given to the product and the context in which it is utilized, the perceived differences between prices, the association between price and quality, the degree of differentiation among products, the consumer's ability to evaluate the products, the information available, and the image of the brand and the store (Biswas and Blair, 1991; Briesch *et al.*, 1997; Campbell, 1999; Cooper, 1969; Dodds *et al.*, 1991; Emery, 1969; Grewal and Baker, 1994; Mazumdar and Papatla, 2000; Monroe *et al.*, 1977; Mulhern *et al.*, 1998; Rajendran and Tellis, 1994; Rhee, 1996; Sampson, 1969; Sinha and Batra, 1999; Thaler, 1985; Urbany and Dickson, 1991). Regardless of the reasons why consumers place importance on prices, this importance appears to determine whether they will pay more or less attention to them and consequently, whether they will develop more or less accurate price knowledge. One of the objectives of the present investigation was to determine whether this relationship between the importance of price and the level of price knowledge could be confirmed for an economic, social, and cultural environment that had not been analyzed before. Furthermore, the present study was carried out at a particularly interesting juncture, namely Spain's currency transition from the peseta to the euro.

On the basis of the previous discussion, the following hypothesis was formulated:

H1. Consumers who place higher importance on prices as a factor in their purchase decisions have a more accurate knowledge of prices.

Consumers' confidence about their own price awareness

In addition to the importance of price as a factor in consumers' purchase decisions, this study addressed the effects of consumers' confidence about their own price awareness. The empirical evidence available regarding the influence of this variable on price knowledge is scarce and contradictory. Through a review of research conducted in the psychology field (Erev *et al.*, 1994; Griffin and Varey, 1996; Klayman *et al.*, 1999), Alba and Hutchinson (2000) confirmed the lack of consensus among studies that have analyzed whether confidence in one's own

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knowledge is a good indicator of the accuracy of that knowledge.

Brown (1971) conducted a study in which consumer confidence was operationalized as the assessment of one's own shopping ability. The researcher found that there was a negative relationship between consumers' confidence about their own price awareness and their actual knowledge of prices. As a possible explanation for this result, the author states that " those who think they are better shoppers have a false sense of security, perhaps not recognizing the complexity of the situation, and so do not perceive price as validly as others" (p. 111). Moreover, some individuals may consider themselves to be good shoppers if they are able to shop quickly, if they are able to shop and do something else at the same time (for example, bringing small children along), if they feel they do not need a shopping list in order to remember what they need to buy, or if they follow their impulses. All of these situations may hinder the development of accurate price knowledge. Additionally, in contrast with Brown (1971), Zbytniewski (1980) found a positive (although weak) relationship between consumers' confidence about their own price awareness and the accuracy of their actual knowledge. However, this study was conducted with consumers who had little knowledge of prices and it included a single measure of price knowledge (absolute knowledge, i.e. the exact figure), which could have obscured the analysis of the relationship between the two variables under consideration.

Another interesting frame of reference for the present investigation is the cost-benefit perspective: the search for price information can be motivated by economic and non-economic reasons: to use it in the purchase decisions, and to store it in the memory because of its usefulness for subsequent purchase decisions – i.e. intentional learning – and because of the actual search and analysis activity in itself – i.e. incidental learning (Binkley and Bejnarowicz, 2003; Kujala and Johnson, 1993; Mazumdar and Monroe, 1990; Monroe and Lee, 1999; Urbany *et al.*, 1996); shopping enjoyment (Beatty and Smith, 1987; Kolodinski, 1990; Le Boutillier *et al.*, 1994; Marmorstein *et al.*, 1992; Swinyard, 1993; Urbany *et al.*, 1996), or social recognition (Feick and Price, 1987; Higie *et al.*, 1987; Inman *et al.*, 1990; Urbany *et al.*, 1996). Regardless of the reasons that may make individuals seek and analyze price information, it is these activities in themselves (as well as the learning they generate) that lead consumers to believe that they are aware of prices (Biswas, 1992; Rajendran and Tellis, 1994).

Based on the previously-discussed arguments, the following hypothesis was formulated:

H2. Consumers who demonstrate greater confidence about their own price awareness have a more accurate knowledge of prices.

Empirically testing this hypothesis was considered to be of interest for various reasons. First, it is important to understand to what extent consumers are confident about their own memory given that, on occasion, they make purchase decisions based on the information they remember (Alba and Hutchinson, 2000; Monroe *et al.*, 1986). Second, the few empirical studies that have been conducted in this area are inconclusive and have obtained contradictory results. Third, the present investigation could contribute to a better understanding of cultural differences (Yates *et al.*, 1989, 1996). Finally, the previously-mentioned currency transition in Spain required that consumers modify the frame of reference they used to evaluate prices (Rosa Díaz, 2002a; Vissol *et al.*, 1999). This change had economic and psychological implications that could have had a significant impact and possibly reduced consumers' confidence about their own price awareness (Burgoyne *et al.*, 1999; Pérez Plaza, 1999; Théret, 1999). As Servet (1999) puts it, "each citizen has to develop a sense of confidence regarding the euro in order to learn how to use this new monetary code, by creating a new scale of prices and a new set of monetary references" (p. 7).

Socio-cultural and demographic factors

A review of the existing body of research that investigate the effects of consumers' socio-cultural and demographic characteristics on price knowledge shows a lack of consensus in the studies' general results: whereas in some studies these characteristics appear to determine in a fundamental way the level of price knowledge (Estelami and Lehmann, 2001; Gabor and Granger, 1969a; Hirn, 1986; Hoch *et al.*, 1995; Lawson *et al.*, 1995; Urbany *et al.*, 1996; Zeithaml, 1982; Zeithaml and Fuerst, 1983), in some others, results show a generalized absence of significant relationships (Brown, 1971; Chanson *et al.*, 1986; Conover, 1986; Estelami, 1998; Kim *et al.*, 1999; McGoldrick and Marks, 1987; Meer, 1995; Murphy, 1978; Turley and Cabaniss, 1995; Vanhuele and Drèze, 2002; Wakefield and Inman, 1993). This division of results can be due to differences in the studies' respective economic, socio-cultural, and temporal context (Gentry *et al.*, 2003; Maynes and Assum, 1982; Rosa Díaz, 2003; Yates *et al.*, 1989, 1996, 1997), and suggests the need to further examine this issue. Thus, the present investigation analyzes the influence of gender, age, marital status, education, and income on price knowledge.

With respect to gender, social changes (an increase in women's average education level and their massive incorporation into the workforce) have brought about a transformation in the traditional shopping roles within the household unit (Casares Ripol, 2003). Specifically, men and women share house chores more frequently and children participate more often as well. Therefore, the traditional role of the housewife has become increasingly diluted. Consequently, it would be reasonable to predict that gender would not generate significant differences in price knowledge (Brown, 1971; Chanson *et al.*, 1986; Estelami, 1998; Otnes and McGrath, 2001).

However, part of the empirical evidence available on this subject indicates that women have a better knowledge of prices than men (Estelami and Lehmann, 2001; Fady and Seret, 1985; Maynes and Assum, 1982; Zeithaml and Berry, 1987, cited in Zeithaml, 1988). A possible explanation for this finding could be that women continue to assume more responsibility than men for the house chores (including shopping) even though the differences have lessened – at a different rate depending on the culture (Ekström, 2003; McGinnis *et al.*, 2003; McGoldrick *et al.*, 1999; Martín Cerdeño, 2003; Putrevu, 2001; Shankarmahesh *et al.*, 2003). This tendency is particularly evident in Spain (Castaño Collado, 2002; Instituto Nacional de Estadística de España -INE, 2003a; Salido, 2002; Secretaría General de Asuntos Sociales de España, 2002). Additionally, most studies on price knowledge have used frequently-purchased consumer goods intended to cover the needs of the family (Estelami and Lehmann, 2001), which again, would be in line with the female role discussed above.

Similar to gender, the empirical evidence available on the impact of age on price knowledge is contradictory. While some studies have found no significant effect (Chanson *et al.*, 1986; McGoldrick and Marks, 1987; Turley and Cabaniss, 1995; Zbytniewski, 1980), others have shown a clear influence. For example, Brown (1971) and Urbany *et al.* (1996) observed that older consumers have a better knowledge of prices. A possible explanation is that this age group tends to have more spare time, which allows them to spend more time studying the prices. In the case of Spain, older age groups tend to have, on average, low income levels (Instituto Nacional de Estadística de España -INE, 2003b), which could make individuals pay more attention to prices. In addition, Spain's elderly population belongs to an austere generation that lived in a time of scarcity, which could have made individuals more sensitive to prices, regardless of their income levels and capacity for consumption. However, Spain's currency change can intensify older consumers' tendency to make routine purchase decisions without processing price information.

Zeithaml (1982) research provides an additional perspective on this issue. The results of her study reveal that the older the participants, the higher the price recall error. This result could be due to their lesser ability to memorize and perform mental calculations, as well as to their lower educational level (Gabor, 1988; Zeithaml, 1982; Zeithaml and Fuerst, 1983). The latter can be clearly observed in Spain's society, where 85.4 percent of the population with no formal education is older than 65 years of age (Instituto Nacional de Estadística de España -INE, 2003b). Finally, younger people are prone to rely on the head of the household to handle the shopping for the family. This tendency is especially clear in the case of Spain (Saralegui and Seoane, 1999).

On the basis of the previous discussion it would be reasonable to predict that middle-aged people would demonstrate a more accurate knowledge of prices, since they are able to process and retain this information and they generally assume the responsibility for the household.

With respect to marital status, it would be expected that single people would be less knowledgeable about prices given that, for the most part, they meet the following two conditions: they are young and they live with their parents, who are the providers for the household (Hirn, 1986; Instituto Nacional de Estadística de España -INE, 2003a; Martín Cerdeño, 2003; Zeithaml and Berry, 1987, cited in Zeithaml, 1988). In addition, widowed persons typically belong to older age groups, which suggests that their price knowledge would tend to be less accurate.

Regarding education level, a higher level of education could be associated with a higher capacity to process and retain price information (Turley and Cabaniss, 1995; Zeithaml and Fuerst, 1983). However, researches by Brown (1971), Estelami and Lehmann (2001), Gabor and Granger (1969c), Heller (1974), and Wakefield and Inman (1993) established a negative relationship between the consumers' income level and price recall ability. The reason could be that highly educated people generally have more favorable job situations and higher income levels. In addition, the results of other investigations have not made it possible to establish a consistent relationship between consumers' memorization of prices and their education or income level (Conover, 1986; Dickson and Sawyer, 1986 cited in Monroe, 1992; Zeithaml, 1982).

Based on the previous discussions regarding the influence of gender, age, marital status, education level, and income level on price knowledge, together with the characteristics of the setting of this investigation, the following hypothesis was put forward:

H3. The most accurate knowledge of prices corresponds to women, to middle-aged and married persons, and to people with lower incomes. With respect to education level, the type of effect on price knowledge could not be hypothesized given that studies obtained contradictory results and no studies on this issue have been conducted in Spain.

H3 could be divided into three sub-hypotheses:

H3a. The most accurate knowledge of prices corresponds to women, who tend to shop more frequently than men.

H3b. The most accurate knowledge of prices corresponds to middle-aged and married persons, who assume the responsibility for the household.

H3c. The most accurate knowledge of prices corresponds to people with lower incomes, who must adjust their budgets.

Research design and methodology

Operationalization of price knowledge

With respect to price knowledge, four different measures were used to operationalize it. They are as follows

(1) Possession of an internal reference price, as demonstrated by the ability to name a price (Chernatony and Knox, 1992; Dickson and Sawyer, 1990; Gabor and Granger, 1969b, c; Heller, 1974; Hirn, 1986; Krishna *et al.*, 1991; Kujala and Johnson, 1993; Lawson *et al.*, 1995; Le Boutillier *et al.*, 1994; McGoldrick and Marks, 1987; Mazumdar and Monroe, 1990; Miyazaki *et al.*, 2000; Monroe and Lee, 1999; Turley and Cabaniss, 1995; Urbany and Dickson, 1991; Wakefield and Inman, 1993; Zbyniewski, 1980; Zeithaml, 1982; Zeithaml and Graham, 1983). A consumer's ability to name a price indicates that he or she has an internal reference price and that he or she may have made some type of effort to recall this price. For the purpose of this investigation, two levels were defined for this variable, either "naming a price" or "not naming a price."

(2) Accuracy of the internal reference price (i.e. the exact price recalled), is evaluated through the following formula (Zeithaml, 1982):

$$\text{Percentage of recall error} = \left|\frac{\text{price recalled} - \text{correct price}}{\text{correct price}}\right|$$

This formula is the most commonly used indicator of internal reference price accuracy (Estelami and Lehmann, 2001). The present investigation considered both absolute and the non-absolute value of the percentage of recall error, which allowed the researcher to establish whether the recalled price was over or under the correct price (Conover, 1986).

(3) Possession of a frame of reference that includes the relative position of a variety of brands according to their prices, as demonstrated by a subject's ability to price-rank different brands (Mazumdar and Monroe, 1990, 1992; Rosa Díaz, 2001, 2003; Zeithaml, 1982; Zeithaml and Fuerst, 1983). This way of operationalizing price knowledge allows for the evaluation of sensory encoding versus semantic encoding of prices (Zeithaml, 1982). In this respect, Monroe and Lee (1999) state the following:

> While a buyer may not be able to remember explicitly the price he or she last paid for an item, he or she might be very capable of judging a new price for products in the item category as "too high", "a good deal" or "inexpensive". To be capable of such a judgment, the buyer must have some knowledge of prices of similar items in the category, even though he or she may not be able to recall any specific prices (p. 215).

This underlying knowledge regarding the price range of the product category is the basis for customers' internal reference prices (Gruca *et al.*, 2002).

The previous arguments were considered in this study by asking customers (as part of a questionnaire used to elicit data) to price-rank three brands of a product category from the highest to lowest price. Two levels of this variable were identified on the basis of whether subjects were or were not able to rank the three brands.

(4) Accuracy of brand rankings (i.e. relative price recall), was operationalized as the absolute difference between the correct ranking and the recalled ranking (Mazumdar and Monroe, 1990, 1992; Zeithaml, 1982). As indicated earlier, subjects were asked to price-rank three brands of a selected product. Three levels were established for this variable, namely "three brands correctly ranked," "one brand correctly ranked" and "zero brands correctly ranked."

Sample selection, data collection, and analysis

Target population and sample

Consumers in general, regardless of their socio-cultural and demographic profile, were targeted for this investigation. Data were collected in Seville, a city in the South of Spain. Participants were recruited either inside or at the exit of retail stores of different sizes, always after they had finished their shopping. In order to ascertain that they were indeed shoppers, the researcher checked their customer receipt.

Prior to collecting data for this investigation, a pilot study with 60 participants was conducted. Its objective was to verify the validity of a questionnaire designed to collect the data. Results showed a high degree of collaboration and comprehension (82 percent of the people who were asked to participate agreed to do it and reported of not having problems in understanding the questions). In order to maintain interviews within a "reasonable" length – between three and four minutes (Camacho *et al.*, 2000) – subjects would be asked about a single product. This method is in line with Estelami and Lehmann (2001)'s recommendation to refrain from asking participants to complete extremely long or complex tasks.

With respect to the size of the sample, a random selection procedure was used. The absolute sampling error was set at 4 percent (percentages were used as reference parameters) and the confidence level was set at 95 percent, which yielded a sample comprising of 600 subjects. A total of 769 people were asked to participate, of which 600 were admitted because they agreed to participate and they had purchased at least one of the products included in this investigation. Of the remaining 169 people, 47 could not be admitted because they had not bought any of the products under consideration, and the remaining 122 people did not agree to collaborate. This sample size is one of the highest in the studies conducted so far in this area of research.

In order to encourage participation, two different types of incentives were used. In some stores, a raffle was conducted (the prize was a 60-euro gift certificate to be used in that store). In some other stores that did not agree to collaborate, the participants received a gift (a house plant).

Questionnaire

As indicated above, data were elicited by means of a questionnaire that the researcher prepared and administered as a short interview with each participant. For the purpose of this investigation, 25 commonly purchased commodities, including both food and non-food products, were selected (the questionnaire and the list of products are shown in Appendix, Figure A1). Each participant was asked to provide information about one single product of the 25 included in the study. The product discussed in each interview was determined by looking at the customer's receipt (which the researcher requested at the outset of the interview) and selecting the first product included in it that was also part of the researcher's product list. This way, randomization of the target product was ensured in each case.

Following Mazumdar and Monroe's (1990) study, the importance of price in the decision to purchase was evaluated through a five-point scale, with 1 being the lowest level of importance and 5 being the highest. Next, the customer was asked to recall the exact price of the product under consideration. It was considered acceptable to allow subjects not to name a price, since including this possibility resulted in a decrease in price recall error (Estelami and Lehmann, 2001). The correct price was established by looking at the customer's receipt.

In order to evaluate the relative knowledge of prices, each subject was asked to price-rank three different brands of the target product from the highest to lowest. One of the three brands had to be the one purchased by the customer; the other two brands (which were named by customers themselves) had to be sold at the store where the interview was being conducted. In order to identify the exact product that the customer had bought, the researcher asked the person to specify the size and type of container, since there could be price variations in the same brand depending on the product size and container type.

Regarding participants' level of confidence about the accuracy of their price recall and about their ranking of the three brands, a five-point scale was used, with 1 being the lowest level of confidence and 5 being the highest. This was a variation of the seven-point scale used by Zeithaml (1982). The reason for this change was the difficulty reported by participants in the pilot study to use a seven-point scale to rate both importance they placed on price and their level of certainty regarding the price recalled and the ranking produced. On the basis of this feedback, it was decided to reduce the scale to five points, which participants reported to have facilitated the task.

At the end of the interview, participants were requested to provide some information pertaining to the demographic characteristics included in this investigation. Results of the pilot study were used to define the levels for some of these variables. Specifically, the researcher observed that subjects were particularly reluctant to report their age and income level. With respect to age, this problem was addressed by grouping the levels of this variable as follows: younger than 18 years, between 18 and 25 years, between 26 and 35 years, between 36 and 45 years, between 46 and 55 years, between 56 and 65 years, and older than 65. These ranges were considered to be wide enough to ensure a high level of response.

In the case of income level, the focus of this investigation was to estimate the income level for the entire household, since the products under consideration were to be consumed by the participant's family unit. Given that, as indicated earlier, most participants in the pilot study were unwilling to report their household monthly income (and those who were willing had difficulty in calculating it), it was decided not to ask this question directly. Rather, income levels were calculated on the basis of the number of people in the household and the average monthly income corresponding to the profession reported for each family member[1].

Three different income levels were established: low, medium, and high. In order to determine which income levels should be assigned to each of these three categories, a general reference range was first determined using the average monthly salary for all professions. This method yielded a range of 494 euros as the minimum and 2,387 euros as the maximum (Instituto Nacional de Estadística de España, 1995). This reference range was then divided into three ranges with a similar spread: (494-1,125 euros) for low-income level, (1,126-1,757 euros) for medium income level, and (1,757-2,387 euros) for high-income level. Next, the combined income of the household (e.g. the sum of the average earnings for each family member) was divided among the number of members, which yielded an average income per person. This figure was then compared with the three income ranges established.

In order to have as representative a sample as possible, interviews were conducted at different times of the day and week (e.g. morning, afternoon, evening, weekday, weekend).

Data analysis methodology

Data were analyzed through contingency tables, measures of association, and ANOVA (after it was established that all requirements regarding normality and independence of the observations – through the data collection method – and regarding the homogeneity of variances – through the application of the Levene test – were met). For the variable "percentage of price recall error" normalizing transformations were performed. Specifically, null values (i.e. correct prices) were eliminated, absolute values were used, and the natural logarithm was applied. Results yielded a skewness coefficient of -0.109, a kurtosis coefficient of -0.0557, and a p-value of 0.098 for the Kolmogorov-Smirnov test.

Results

Price knowledge

The first measure of price knowledge was whether or not consumers possessed an internal reference price, as demonstrated by their ability to name a price. In this study, 78.3 percent of the participants were able to recall the price. This percentage is in line with the results of Chanson *et al.* (1986, 94 percent), Dickson and Sawyer (1990, 78.9 percent), Gabor and Granger (1969a, 82 percent), and McGoldrick and Marks (1987, 88 percent). In contrast, considerably lower percentages were obtained by Fady (1976, 61.7 percent) and Turley and Cabaniss (1995, 42.7 percent).

With respect to the accuracy of consumers' internal reference price (i.e. the absolute price recalled), roughly 20 percent of the subjects were able to recall the exact price of the product targeted in the interview. This percentage would increase to 25.5 percent if calculated on the basis of the number of respondents who named a price (470). These results showed that the participants in this investigation had a relatively inaccurate knowledge of prices, which was lower than that found in the studies by Conover (1986, 51.2 percent), Dickson and Sawyer (1990, 47.1 percent), Gabor and Granger (1969a, 51.1 percent), and McGoldrick and Marks (1987, 29 percent), although higher than that found by Chanson *et al.* (1986, 17 percent), Fady, (1976, 7.8 percent), Vanhuele and Drèze, (2002, 10 percent), and Zbytniewski, (1980, 8 percent).

Should certain margins of error be permitted, a considerable increase in the percentage of prices correctly recalled would be observed: 61.5 percent of the subjects who were able to name a price were off by less than 5 percent. If the margin of error were raised to 10 percent, the percentage of prices correctly recalled would increase to 78.3 percent. Therefore, when a 5 and 10 percent error margins are allowed, the results of the present study reflect a much higher level of price awareness than that shown in the previous investigations (Gabor and Granger, 1969a, 65.3 and 73.1 percent; Fady, 1976, 25 and 41 percent; McGoldrick and Marks, 1987, 54.6 and 69.6 percent; Vanhuele and Drèze, 2002, 30 and 54 percent).

In addition, the mean error in price judgments was 8.47 percent when it was calculated after excluding the null errors (i.e. the prices named correctly) and 6.26 percent when it was calculated

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without such exclusion. Finally, 58 percent of the prices incorrectly reported by the subjects were below the correct price and 42 percent were above it ($\chi^2 = 9.01$; $p \leq 0.003$). This tendency to underestimate prices is consistent with the results obtained by Dickson and Sawyer (1990), Fady (1976; cited in Fady and Seret, 1985), and Maynes and Assum (1982), and it differs from those obtained by Zbytniewski (1980), who found that the majority of participants overestimated the prices.

The third measure of price knowledge included was whether or not consumers' frame of reference included the relative position of a variety of brands according to their prices. Results showed that 73.1 percent of the individuals produced rankings of brands by price. This percentage is slightly lower than the percentage of subjects who named a price (78.3 percent). The most frequently found case in the data was that of subjects who were able to name a price as well as price-rank the brands. In fact, a statistically significant relationship was obtained for these two variables ($\chi^2 = 67.51$; $p \leq 0.0001$). With respect to participants who were able to do only one of the two things, most of them named a price rather than price ranking the brands (Table I). Moreover, the ability to rank various brands according to their price was found to have a significant effect on the percentage error of the price recalled ($t = 2.15$; $p \leq 0.003$), so that participants who price-ranked the brands were more accurate (mean percentage error = 7.5 percent) than participants who did not (mean percentage error = 10.6 percent). Finally, subjects who were not able to produce a ranking of brands according to prices, demonstrated a stronger tendency to underestimate prices than subjects who were able to rank the brands (69.6 vs 55 percent; $\chi^2 = 4.72$; $p \leq 0.03$).

With respect to the accuracy of the brand rankings produced (i.e. relative price recall), 46 percent of subjects rank-ordered the three brands correctly, 40.6 percent accurately rank-ordered only one brand, and 13.4 percent produced a completely incorrect ranking. Moreover, participants who named a price had a tendency to rank-order the brands more accurately than individuals who did not recall a price (46.9 and 39.6 percent correct rankings, respectively). However, the relationship between these two variables was not found to be statistically significant ($\chi^2 = 3.02$; $p > 0.221$). The degree of accuracy of the ranking produced had a significant effect on the percentage error of the price recalled, as the results of the one-way ANOVA show ($F = 12.21$; $p \leq 0.0001$). Specifically, as the accuracy of the ranking increased, the mean error decreased (5.7 percent mean error for a completely correct ranking, 7.3 percent for one correctly-ranked brand, and 13.7 percent for a completely incorrect ranking). In summary, the results of this investigation indicate that consumers who have a better knowledge of absolute prices, also tend to have a better knowledge of relative prices and vice versa. Finally, no significant relationship was found between the degree of accuracy of the ranking produced and the tendency to underestimate prices ($\chi^2 = 1.91$; $p > 0.386$).

Table I Contingency table for naming a price by producing a price ranking of brands

Naming a price	Count	Producing a price-ranking of brands: Yes	No	Total
Yes	Count	358	83	441
	Naming a price (percent)	81.2	18.8	100
	Price ranking the brands (percent)	87.1	55.0	78.5
No	Count	53	68	121
	Naming a price (percent)	43.8	56.2	100
	Price ranking the brands (percent)	12.9	45.0	21.5
Total	Count	411	151	562
	Naming a price (percent)	73.1	26.9	100
	Price ranking the brands (percent)	100	100	100

Effect of the variables related to consumers' attitudes toward prices

The descriptive statistics obtained in this study indicate that price was an important factor in participants' purchase decisions: more than 74 percent of the subjects were of the opinion that price was "moderately important" (30.2 percent), "quite important" (35.2 percent) or "the most important" factor (8.8 percent) – the average score was 3.24, and the mode was four (in a 5-point scale). Only 3.5 percent of the participants stated that price was not important at all in their purchase decisions.

The analysis of the data showed a statistically significant relationship between the importance of price in purchase decisions and all four measures of price knowledge: naming a price ($\chi^2 = 25.86$; $p \leq 0.0001$), accuracy of the price recalled ($F = 13.40$; $p \leq 0.0001$; Pearson and Spearman correlation coefficient $= -0.396$ and -0.472; significant at 0.01), producing a ranking of brands according to price ($\chi^2 = 13.75$; $p \leq 0.008$), and accuracy of the rankings produced ($\chi^2 = 26.95$; $p \leq 0.001$). Specifically, the data showed that the higher the importance that consumers placed on price, the higher the percentage of prices and brand rankings recalled and the higher the degree of accuracy of these prices and of the brand rankings. Nonetheless, this relationship should be

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understood as a general tendency, since there were some exceptions to it (Table II).

For instance, those participants who stated that price was "the most important" factor in their purchase decisions were also the ones who most frequently named a price and ranked the brands correctly. However, the lowest percentage error in the prices recalled and the lowest percentage of brand rankings corresponded to those subjects who indicated that price was "quite important". In addition, customers who placed no importance on price demonstrated a more accurate knowledge of prices than those who considered prices to be of little importance.

These results partially confirm the first hypothesis formulated in this study, namely that consumers who place higher importance on prices as a factor in their purchase decisions have a more accurate knowledge of prices. While it was found that the importance of price in purchase decisions had a statistically significant impact on price knowledge, the highest levels of importance did not always generate a better price knowledge; rather, there was some variation depending on the measure of price knowledge considered.

Regarding the second attitudinal variable identified in this study, subjects showed a high degree of confidence about the accuracy of the prices recalled, with 54 percent of participants reporting that they were "quite sure" (35.5 percent) or "absolutely sure" (18.5 percent) that the price they named was correct, and with 27.9 percent of participants reporting that they were "moderately certain". Only 17.7 percent of subjects reported that they had "little certainty" about the accuracy of the prices recalled and 0.4 percent responded that they were "not sure at all".

Consumers' degree of confidence about the accuracy of the prices recalled was found to have a statistically significant relationship with the ability to rank-order the brands ($\chi^2 = 21.62$; $p \leq 0.0001$) as well as a significant effect on the accuracy of the prices recalled ($F = 44.20$; $p \leq 0.0001$; Pearson and Spearman correlation coefficient $= -0.650$ and -0.788; significant at 0.01) and on the accuracy of the rankings produced ($\chi^2 = 37.48$; $p \leq 0.0001$). In addition, the data showed that, in general, as the degree of confidence with respect to the prices recalled increased, the percentage of rankings produced and the accuracy of the rankings and prices named also increased (Table III). As an exception, it is worth mentioning that those subjects who indicated that they were "quite sure" about the prices recalled, tended to have a more accurate knowledge of prices than participants who reported that they were "absolutely sure" (mean error: 4.2 vs 5.6 percent; three brands correctly ranked: 57.6 vs 53.3 percent).

Additionally, participants showed a medium degree of confidence about the way they rank-ordered the brands (mean = 3.43; mode and median = 3). This degree of confidence had a significant impact on the accuracy of the rankings produced ($\chi^2 = 84.03$; $p \leq 0.0001$) and on the accuracy of the prices recalled ($F = 6.01$; $p \leq 0.0001$; Pearson and Spearman correlation coefficient $= -0.268$ and -0.265; significant at 0.01) but not on the ability to name a price ($\chi^2 = 6.67$; $p > 0.154$). Those participants who were more confident about their rankings tended to produce more correct responses and to name a price more frequently (Table III).

In conclusion, the second hypothesis formulated in this study was confirmed for two of the measures of price knowledge: accuracy of the prices recalled and accuracy of the brand rankings produced. In the case of consumer confidence about the prices recalled, the hypothesis was confirmed for one additional measure of price knowledge, namely consumers' ability to produce a ranking of brands. In other words, shoppers who were more certain of the accuracy of the prices

Table II Results for importance of price in purchase decisions

	Operationalization of price knowledge							
	Naming a price (percent)		Accuracy of price recalled (percent)	Producing a ranking of brands (percent)		Accuracy of the ranking of brands[a] (percent)		
Importance of price	**Yes**	**No**	**Mean error**	**Yes**	**No**	**Three**	**One**	**Zero**
No importance (1)	52.4	47.6	11.9	66.7	33.3	42.9	35.7	21.4
Little importance (2)	70.1	29.9	12.9	68.5	31.5	33.3	43.7	23.0
Moderately important (3)	75.1	24.9	8.2	66.3	33.7	36.6	48.2	15.2
Quite important (4)	86.3	13.7	5.4	81.9	18.1	55.7	37.3	7.0
The most important (5)	88.7	11.3	7.1	76.9	23.1	62.5	27.5	10.0

Notes: The percentages included in this table show the distribution of subjects who selected each level of importance by the different levels of the four measures of price knowledge included in this investigation; [a]the three levels identified for this variable were "three" (three brands correctly ranked), "one" (one brand correctly ranked), and "zero" (zero brands correctly ranked)

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Table III Results for consumer confidence about the prices recalled and the rankings produced

Degree of certainty	Naming a price (percent)		Producing a ranking of brands (percent)		Accuracy of price recalled[a] (percent)		Accuracy of the ranking of brands[b] (percent)					
	Yes	No	Yes	No	Mean error		Three[a]		One[a]		Zero[a]	
Not sure at all (1)	81.8	18.2	100.0[c]	0.0	19.5	12.5	0.0	9.1	50.0	18.2	50.0	72.7
Little certainty (2)	82.6	17.4	67.5	32.5	16.4	9.9	18.5	11.4	153.7	52.3	27.8	36.2
Moderate certainty (3)	83.3	16.7	75.2	24.8	7.5	8.9	43.2	14.4	45.5	70.5	11.3	15.2
Quite sure (4)	90.8	9.2	87.4	12.6	4.2	5.8	57.6	77.9	31.7	21.4	10.7	0.8
Absolutely sure (5)	92.6	7.4	90.4	9.6	5.6	4.9	53.3	97.1	42.7	1.5	4.0	1.5

Notes: The percentages included in this table show the distribution of subjects who selected each level of confidence by the different levels of four measures of price knowledge (for the first measure, "naming a price", it did not make sense to establish a relationship with the variable "consumer confidence about the prices recalled"; for the second measure, "producing a ranking of brands", it did not make sense to establish a relationship with the variable "consumer confidence about the rankings produced"); [a]the percentages included in the column on the left correspond to consumer confidence about the prices recalled, and the percentages included in the column on the right correspond to consumer confidence about the rankings produced; [b]the three levels identified for this variable were "three" (three brands correctly ranked), "one" (one brand correctly ranked) and "zero" (zero brands correctly ranked); [c]there were only two participants who produced a ranking of brands and were not sure at all about the price recalled

named and the rankings produced, showed a better knowledge of prices.

A final finding worth mentioning is that none of the three variables related to consumers' attitudes toward prices had a statistically significant relationship with the tendency to underestimate prices (importance of price in purchase decisions: $\chi^2 = 0.07$; $p > 0.999$; degree of confidence about the accuracy of the prices recalled: $\chi^2 = 2.98$; $p > 0.560$; degree of confidence about the rankings produced: $\chi^2 = 5.06$; $p > 0.281$). Nonetheless, the researcher observed that, in all three cases, most participants (between 51 and 60 percent) underestimated the price, with the only exception that, of all participants who recalled an incorrect price even though they said they were "absolutely sure", 40 percent underestimated the price whereas 60 percent overestimated it.

Effect of the socio-cultural and demographic variables

The descriptive statistics of the data collected for this investigation reveal that the participants were predominantly women (64.7 percent female vs 35.3 percent male) and that there was a balanced distribution of subjects according to age (35 percent were younger than 35 years, 37.4 percent were between 36 and 55 years, and the remaining 27.7 percent were older than 55). Shoppers interviewed were primarily married persons (67.2 percent) with medium income levels (43.3 percent) whose households had between two and four members (72.3 percent) – on an average 3.32 members per family. Subjects' education levels were evenly distributed (approximately 25 percent for each level).

The results of this study indicate that income level had a significant effect on the accuracy of the prices recalled ($F = 5.778$; $p \leq 0.003$) and on the accuracy of the price rankings produced ($\chi^2 = 12.45$; $p \leq 0.014$). It was observed that the lower the income level, the lower the mean percentage error of the price recalled (low income = 6.2 percent; medium income = 8.6 percent; high income = 9.5 percent) and the more accurate the ranking of the brands by price (the percentages of subjects that ranked the brands correctly were as follows: 56.5 percent for low income, 47 percent for medium income, and 34.7 percent for high income). These results confirm *H3* with respect to income level for these two measures of price knowledge. However, no statistically significant relationship was identified between the income level and the remaining two measures of price knowledge: ability to name a price ($\chi^2 = 0.09$; $p > 0.956$, approximately 78 percent of subjects in all three income levels recalled a price) and ability to produce a ranking of brands ($\chi^2 = 4.04$; $p > 0.133$, low income = 71.1 percent; medium income = 77.4 percent; high income = 69 percent).

With respect to gender, the analysis of the data revealed a statistically significant relationship between this variable and all the four measures of price knowledge: ability to name a price ($\chi^2 = 58.32$; $p \leq 0.0001$), accuracy of the price recalled ($t = 3.28$; $p \leq 0.001$), ability to produce a ranking of brands ($\chi^2 = 66.24$; $p \leq 0.0001$), and accuracy of the brand ranking produced ($\chi^2 = 6.32$; $p \leq 0.042$). In general, women demonstrated more accuracy than men in their knowledge of prices. Specifically, 87.7 percent of females were able to recall a price versus 60.8 percent of males; the mean percentage error for females was 7.4 percent versus 10.7 percent for males; 84.5 percent of females were able to produce a ranking of brands by price versus 52.7 percent of males; and 49.2 percent of females ranked the three brands correctly versus 36.8 percent of males. These results confirm *H3* with respect to gender. Finally, women evidenced a stronger tendency than men to underestimate prices: 62 percent of women versus 50 percent of men ($\chi^2 = 4.51$; $p \leq 0.034$).

With respect to age, a statistically significant relationship was only found when price knowledge was operationalized as the ability to rank-order three brands of a product according to their price ($\chi^2 = 61.57$; $p \leq 0.0001$). The percentage of subjects who produced a ranking of brands was higher than 76 percent for all age groups except for two: "between 56 and 65 years" (64.0 percent) and "older than 65" (36.9 percent). Even though no statistically significant effects of age were found for the other three measures of price knowledge – ability to name a price ($\chi^2 = 9.01$; $p > 0.173$), accuracy of the price recalled ($F = 1.08$; $p > 0.375$), and accuracy of the ranking of brands ($\chi^2 = 6.80$; $p > 0.871$) – it was observed that the highest mean percentage error corresponded to the younger groups (8.4 percent), and the lowest corresponded to the oldest group (7.3 percent). Nonetheless, younger groups rank-ordered the brands more accurately (50 percent of subjects younger than 35 years ranked the three brands correctly versus 44 percent of subjects older than 36 years), whereas the oldest group presented the lowest percentage of correct rankings (41.7 percent). The main conclusion that can be reached from these results is that younger people tend to process price information in relative terms (i.e. semantic encoding), whereas older people tend to process this information in absolute terms (i.e. sensory encoding).

Similar to age, a statistically significant relationship was only found for education level when price knowledge was operationalized as the ability to rank-order the brands by price ($\chi^2 = 15.33$; $p \leq 0.002$). The percentages of subjects who produced a ranking were as follows: lower than elementary school = 59.3 percent; elementary school level = 79 percent; high-school level = 76.9 percent; and university level or higher = 74.3 percent. These results suggest that people with the lowest education level are the ones who most frequently lack a frame of reference to evaluate prices.

Even though a statistically significant relationship was not found between education level and the remaining measures of price knowledge – naming a price ($\chi^2 = 5.51$; $p > 0.138$), accuracy of the price recalled ($F = 1.91$; $p > 0.128$), and accuracy of the ranking of brands ($\chi^2 = 5.46$; $p > 0.486$) –, it is worth mentioning that participants with lower education levels were more accurate in their knowledge of prices than people with higher education levels: the lowest percentage error (6.9 percent) and the most accurate rankings (50 percent) were found in participants with lower education levels, and the highest percentage error (9.4 percent) and the least accurate rankings (38.3 percent) corresponded to participants with university-level studies.

With respect to marital status, this variable had a statistically significant relationship with price knowledge defined as the ability to price-rank the three brands ($\chi^2 = 11.34$; $p \leq 0.023$), but not with the remaining measures of price knowledge – naming a price ($\chi^2 = 4.83$; $p > 0.304$), accuracy of the price recalled ($F = 1.23$; $p > 0.296$), and accuracy of the ranking of brands ($\chi^2 = 10.97$; $p > 0.203$). In general, married participants had a slightly better knowledge of prices than single participants (naming a price: 78 and 80 percent, respectively; producing a ranking of brands: 74.5 and 71.5 percent, respectively; accuracy of the price recalled: 7.8 and 10.3 percent error, respectively; accuracy of the brand-rankings recalled: 46.3 and 47.3 percent, respectively). Widowed participants showed the lowest accuracy levels (65.9 percent named a price, 42.1 percent rank-ordered the three brands correctly, and the mean error in price judgments was 11.7 percent).

Finally, a tendency to underestimate prices could only be identified for gender: 62 percent of females versus 50 percent of males ($\chi^2 = 4.51$; $p \leq 0.034$). No statistically significant relationship was found between this variable and the rest of demographic variables (income level: $\chi^2 = 0.99$; $p > 0.608$; age: $\chi^2 = 7.29$; $p > 0.294$; education level: $\chi^2 = 0.147$; $p > 0.701$; and marital status: $\chi^2 = 6.18$; $p > 0.186$), although, once again, participants showed a clear tendency to name prices below the actual price of the product (between 50 and 60 percent), with the only exception of the subjects older than 65 years, of which 74.4 percent named a price over the correct price.

Discussion

In the present investigation, consumers' absolute knowledge of prices was quite inaccurate. Specifically, even though most subjects (78.3 percent) had internal reference prices, only 25.5 percent of these prices were correct. According to previous research, a variety of explanations can account for this finding: lack of time on the part of consumers to analyze the information (Dickson and Sawyer, 1990; Monroe and Lee, 1999); lack of ability to process and memorize it (Gabor and Granger, 1969a; Zeithaml, 1982; Zeithaml and Fuerst, 1983); limited attention paid to prices

(Brown, 1971; Chanson *et al.*, 1986; Kujala and Johnson, 1993; Monroe, 1990); diversity of container types (Fady, 1976, cited in Fady and Seret, 1985; Friedman, 1966); frequency of price changes (Conover, 1986; Fady and Seret, 1985; Gabor and Granger, 1969c), or consumers' perception that there are only slight price differences among brands (Berne Manero *et al.*, 1998; Gabor and Granger, 1969c; Maynes and Assum, 1982; Urbany *et al.*, 1996). All these circumstances are applicable to the socio-cultural and economic setting of the present study.

In addition, two macroeconomic factors that characterize the current situation in Spain can also help explain subjects' low knowledge of prices, namely the high economic growth (2 percent in 2002; 2.2 percent in 2003), and the high inflation rates (3.6 percent in 2001; 3.5 percent in 2002) (Ministerio de Economía de España, 2003a, b). Thus, a higher availability of resources can diminish the importance of prices in purchase decisions, while price instability can make it more difficult to know them (Estelami *et al.*, 2001). Furthermore, the tendency to underestimate prices identified in this study, as well as the lack of differences across product categories ($\chi^2 = 32.06$; $p > 0.126$) could be due to the constant and widespread price increase brought about by inflation (Bolton *et al.*, 2003).

The percentage of prices correctly recalled by the participants in this study was very different from the results of other studies (Chanson *et al.*, 1986, 17 percent; Conover, 1986, 51.2 percent; Dickson and Sawyer, 1990, 47.1 percent; Fady, 1976, 7.8 percent; Gabor and Granger, 1969a, 51.1 percent; Vanhuele and Drèze, 2002, 10 percent; Zbytniewski, 1980, 8 percent). A possible explanation for this finding could be that price knowledge may vary depending on the product category (Estelami, 1998; Estelami *et al.*, 2001; Hirn, 1986; McGoldrick and Marks, 1987), due to a variety of factors such as purchase frequency (Fady, 1976, cited in Fady and Seret, 1985; Le Boutillier *et al.*, 1994), price level (Grewal and Marmorstein, 1994; Maynes and Assum, 1982; Mazumdar and Monroe, 1990; Rosa Díaz, 2001), and loyalty to the brand (Dickson and Sawyer, 1990; Gabor and Granger, 1969c; Zeithaml, 1982). The results of this investigation confirmed the above line of reasoning for some of the measures of price knowledge (Table IV): product category did not have a statistically significant relationship with ability to name a price ($\chi^2 = 6.67$; $p > 0.154$), but it did have such a relationship with ability to produce a ranking of brands according to their price ($\chi^2 = 39.22$; $p \leq 0.006$) and accuracy of the rankings produced ($\chi^2 = 77.07$; $p \leq 0.0001$). Finally, product category had a significant effect on the accuracy of the prices recalled ($F = 3.68$; $p \leq 0.0001$).

Products with higher percentages of prices recalled did not always correspond with higher percentages of rankings produced, and vice versa (e.g. olive oil and toilet paper). In addition, price knowledge was more accurate for some products in absolute terms (e.g. orange-lemon soft drinks, dishwasher detergent, shampoo, and toilet paper) and for others in relative terms (e.g. coffee, cola soft drinks, butter, and yogurt). Some cases are worth noting, such as, for instance, cola soft drinks and canned tuna (for which prices were recalled with a high degree of accuracy both in absolute and relative terms), breakfast cereals (which showed the opposite case), tomatoes (which presented a very high percentage of recall error), and toilet paper (for which the prices recalled tended to be much higher than the correct price). These results are consistent with those of previous investigations for some of the products –, e.g. cola soft drinks (Conover, 1986); breakfast cereal (Gabor and Granger, 1969c; Zbytniewski, 1980); and toilet paper (Zbytniewski, 1980) – but not for others. For instance, this study showed a very accurate knowledge of the price of coffee in relative terms, which differs from the studies of Conover (1986) and Gabor and Granger (1969c), where absolute price knowledge prevailed.

This investigation also showed that the way of evaluating price knowledge led to quite different results. Thus, price knowledge was more accurate in relative terms than in absolute terms when no error margin was allowed (46 percent of the subjects rank-ordered the three brands correctly, but only 25.5 percent of the subjects were able to recall the exact price of the product targeted in the interview). However, if an error margin of 5 percent was allowed, the percentage of "accurate" prices increased to 61.5 percent. It is worth mentioning that a statistically significant relationship was found between these two ways of processing price information: participants who were able to produce a price ranking of brands recalled the exact prices more accurately than those lacking that frame of reference. Furthermore, it was observed that, as the accuracy of the price rankings increased, the mean price recall error decreased. Therefore, it was apparent that the different ways of evaluating and storing price information were not independent from each other: buyers who were more interested in prices seemed to process this information in absolute terms and in relative terms simultaneously, albeit with a different degree of accuracy.

Results also indicated that the importance of price in purchase decisions and degree of confidence about the accuracy of the prices

Table IV Price knowledge by product category

Product category	Frequency	Naming a price (percent)	Producing a price-ranking of brands (percent)	Percent of exact prices recalled[a]	Mean percent of recall error	Percent of "three brands correctly ranked"
Coffee	15	66.7	86.7	10.0	10.9	69.2
Instant coffee	17	76.5	82.4	15.4	8.3	35.7
Hot chocolate powder	12	75.0	75.0	0.0	6.5	22.2
Soft drinks (cola)	28	78.6	96.4	31.8	5.7	74.1
Soft drinks (orange/lemon)	22	81.8	72.7	38.8	5.4	56.3
Olive oil	32	90.6	50.0	13.8	6.0	37.5
Sunflower oil	20	85.0	75.0	47.0	8.2	40.0
Washing machine detergent	29	89.7	79.3	26.9	9.0	43.5
Dishwasher detergent	17	94.1	82.4	31.2	5.8	64.3
Clothes softener	30	73.3	56.7	45.4	7.3	52.9
Shampoo	34	85.3	64.7	17.2	6.2	31.8
Shower gel	39	74.4	71.8	20.7	8.1	21.4
Toothpaste	25	80.0	76.0	15.0	7.6	26.3
Milk	56	73.2	58.9	34.1	8.4	45.5
Butter	28	78.6	67.9	9.0	8.9	68.4
Water	20	65.0	80.0	9.3	11.6	37.5
Yogurt	39	82.1	87.2	37.5	10.2	64.7
Juice	37	86.5	75.7	31.2	12.5	39.3
Canned tuna	23	65.2	87.0	33.3	4.8	70.0
Breakfast cereal	24	75.0	66.7	11.1	12.4	6.3
Toilet paper	15	53.3	80.0	0.0	5.1	33.3
Kiwi fruit	12	66.7	–	0.0	6.5	–
Pears	11	81.8	–	33.3	8.5	–
Apples	8	75.0	–	0.0	13.8	–
Tomatoes	7	85.7	–	66.6	47.5	–
Total	600	–	–	34.3	–	–

Notes: [a]Percentages were calculated with respect to the number of times that a price was recalled (for each product), regardless of whether or not the price was right

recalled and brand rankings produced had a significant influence on price knowledge. Similar findings were also obtained in studies by Brown (1971), Chanson *et al.* (1986), Dickson and Sawyer (1990), Kujala and Johnson (1993), Le Boutillier *et al.* (1994), Lichtenstein *et al.* (1993), McGoldrick and Marks (1987), Mazumdar and Monroe (1990), and Zbytniewski (1980). However, *H1* and *H2* were only partially confirmed. Thus, subjects who considered price as being "the most important" factor in their purchase decisions were those who ranked the brands more accurately, but they had a higher percentage of price recall error than those who reported that price was "quite important" (7.1 vs 5.4 percent). Therefore, it seems that these subjects processed price information mainly in relative terms, although it could also be possible that they stated that price was "the most important" factor because they knew they were participating in a study about prices or because they thought that this answer reflected what was expected from a "good shopper", although in practice they may not have paid as much attention to prices as they said they did (Feick and Price, 1987; Higie *et al.*, 1987; Inman *et al.*, 1990; Urbany *et al.*, 1996).

The latter reason reflects a social reality, still quite widespread in Spain, whereby a good performance of the "housekeeper" role, which is still predominantly played by women, entails optimizing the family budget (Martín Cerdeño, 2003; Secretaría General de Asuntos Sociales de España, 2002). In this regard, the interviews carried out in this study showed that many of the women who did not work outside the home assumed the responsibility of managing the income provided by their husbands. The idea that "they weren't the ones who earned the money" weighed heavily in their responses. This idea was reinforced by the scarce possibilities of accessing the labor market in optimal conditions, in general due to their low education level (until recent times, women in Spain had difficulty in accessing university studies due to social reasons or tradition). The study also highlighted the fact that, in general, women who did not work outside the home had more children than those who held remunerated jobs (probably because they had more time to take care of them), which reduced their available budget even further.

Additionally, subjects who stated that price was not important at all recalled prices and ranked the three brands more accurately than those who considered price to be of "little importance" in their purchase decisions (mean error: 11.9 vs 12.9 percent; three brands correctly ranked: 42.9 vs 33.3 percent). This may be partly due to the negative social connotations associated with "bargain hunters" and the association between low price and poor product quality (Dawar and Parker, 1994; Hanf and Von Wersebe, 1994; Rosa Díaz, 2003; Sethi, 2000; Teas and Agarwal, 2000; Zeithaml, 1988). In fact, the interviews carried out in this study showed that many people who stated that price was not important at all purchased products that were on sale. This finding coincides with the two opposite profiles detected among consumers in Spain: some openly state their concern about prices, while others consider that, although price is an important element, it is not socially acceptable to state this, especially when the social status of the person is middle to high (Martín Cerdeño, 2003; Rosa Díaz, 2001; Solé Moro, 1999).

Finally, individuals who were "quite sure" about the prices recalled showed a more accurate knowledge of prices than those who were "absolutely sure". Again, a possible explanation for this finding could be that individuals were trying to come across as being "good shoppers". Nonetheless, it is also possible that overconfidence in one's own knowledge of prices may result in price information not being processed with a sufficient degree of attention or updated at an appropriate rate, as suggested by Brown (1971).

Another interesting finding is that, in general terms, subjects considered price to be an important factor in their purchase decisions. This can be due to Spain's special economic juncture when the data were collected (interviews were held at a time of currency transition, which could have increased consumer sensitivity to prices), and to the high variation in prices and the budgetary restrictions due to Spain's high inflation rates (Berne Manero *et al.*, 1998; Rosa Díaz, 2001, 2002a, 2003). In fact, many of the people surveyed stated that they paid more attention than usual to prices because they were trying to adjust to the new currency. Nevertheless, as indicated earlier, this fact did not result in a high level of price knowledge in absolute terms, rather, subjects demonstrated a more accurate knowledge of prices in relative terms. Therefore, price sensitivity seemed to be mainly aimed at creating new reference systems – i.e. establishing price comparisons – (Servet, 1999; Vissol *et al.*, 1999), generating new price and value scales, and producing a new "price memory" to be able to reconstruct the reference points (Dejemeppe, 1999; Théret, 1999). Surprisingly, despite this changing economic environment, subjects showed a medium-to-high degree of confidence about the accuracy of the prices recalled and brand-rankings produced. A reason for this could be that the double price labeling in the stores (product prices were quoted both in pesetas and euros) allowed them to continue using price information in pesetas (Burgoyne *et al.*, 1999; Rosa Díaz, 2002a). At present, although the total integration of the euro is a reality, a special concern over prices remains, due to the fact that the majority of consumers consider that the currency change has resulted in an overall increase in prices (Rosa Díaz, 2002a, 2003).

Another reason that could explain the importance of price in purchase decisions is the "passive" attitude that characterizes consumers from Spain. Various studies reveal that Spaniards tend to simplify purchase decisions related to common consumer goods and they mainly use information that is easy to obtain and interpret, such as price (Díez de Castro *et al.*, 2002; Martín Cerdeño, 2003; Oubiña Barbolla, 1997). Furthermore, many of the people interviewed in this study stated that, when they made large or hasty purchases, they basically used price information for comparing competitor brands.

Interestingly, a statistically significant relationship was identified between the importance of price and the confidence consumers had about their own absolute and relative price knowledge ($\chi^2 = 182.62$; $p \leq 0.0001$ and $\chi^2 = 40.95$; $p \leq 0.001$, respectively). Specifically, the more importance they placed on prices, the more confident they were with respect to their price recall and brand rankings. Moreover, those individuals who had a higher degree of certainty about their recollection of prices were also more confident about the accuracy of the brand rankings they generated ($\chi^2 = 66.92$; $p \leq 0.0001$). In conclusion, if consumers consider price to be an important factor in their purchase decisions, they are likely to analyze this type of information, which will make them more confident about their own price knowledge, and this will ultimately lead to a real improvement of this knowledge.

The characteristics of society in Spain contribute to a better understanding of the influence of demographics on price knowledge. Although respondents had been randomly selected, almost two-thirds of the sample were women. This finding confirmed that women were more frequently involved in grocery shopping activities than men. This tendency is still widespread in Spain (Castaño Collado, 2002; Salido, 2002; Secretaría General de Asuntos Sociales de España, 2002), especially among individuals older than 45 years of age.

In this study, *H3* was confirmed with respect to gender: women were more knowledgeable about prices than men for all the four measures of price knowledge. In addition, results showed that gender had a statistically significant relationship with importance of price in purchase decisions ($\chi^2 = 21.29$; $p \leq 0.0001$) as well as with consumer confidence about the accuracy of the prices recalled ($\chi^2 = 30.20$; $p \leq 0.0001$) and the brand-rankings produced ($\chi^2 = 11.78$; $p \leq 0.0019$). In particular, women placed more importance on prices and were more confident about the prices and brand rankings they generated. In this regard, it is possible that the currency transition encouraged women even more to adapt to the ongoing changes in the scale of values and in the memorization of prices (Vissol *et al.*, 1999).

It is important to note that the proportion of male participants was much higher in this study than in previous investigations (Conover, 1986, 18.2 percent; Heller, 1974, five percent), which is a reflection of the significant social changes that have taken place in Spain over the last three decades (Casares Ripol, 2003; Cebollada Pascual and Múgica Grijalba, 1997; Flavián Blanco and Martínez Górriz, 1995; Martín Cerdeño, 2003; Pedret Yebra *et al.*, 1994). Indeed, men's price knowledge was considerably more accurate than women's for certain products (e.g. coffee, cola soft drinks, and canned tuna), probably because they bought them more frequently, as shown in their purchase receipts. Thus, it was confirmed that gender differences in traditional shopping roles are progressively decreasing in Spain.

H3 was also confirmed with respect to income level, and the directionality of the relationship was as predicted, i.e. as income levels decreased, accuracy of price knowledge increased. However, no statistically significant relationship was identified with ability to name a price and ability to produce a ranking of brands.

For the remaining demographic variables analyzed (i.e. age, marital status, and education level), significant differences were only detected when price knowledge was operationalized as the ability to produce a ranking of brands: younger groups, married persons, and people with elementary school, high-school, or higher education levels demonstrated a stronger tendency to process price information in relative terms (i.e. semantic encoding), whereas older groups, widowed persons, and people with the lowest education level (i.e. lower than elementary school) were more likely to process this information in absolute terms (i.e. sensory encoding). This finding suggests that the demographic and biological characteristics of the subjects could influence the way they process price information (Putrevu, 2001; Wolverton and Diaz, 1996).

When all the results related to demographic variables are considered together, it can be concluded that women, middle-aged consumers, married people, and individuals with low income and education levels are the groups that have a better knowledge of prices. These findings confirm *H3* and suggest the type of effect that education level had on price knowledge (this effect could not be hypothesized at the outset of the study). These findings are also consistent with the relationships found within the various demographic variables considered, as follows: women in the sample were predominantly married, whereas men were mainly single ($\chi^2 = 16.61$; $p \leq 0.002$) – which confirms that women continue to assume the responsibility of shopping for the household – men had, on average, higher education ($\chi^2 = 22.66$; $p \leq 0.0001$) and income levels ($\chi^2 = 7.58$; $p \leq 0.023$) than women; single shoppers belonged to younger age groups ($\chi^2 = 391.78$; $p \leq 0.0001$) and were more likely to have medium and higher education levels ($\chi^2 = 301.41$; $p \leq 0.0001$); the lowest education and income levels ($\chi^2 = 57.24$; $p \leq 0.0001$) were found in middle-aged and older groups; and income levels increased in parallel to education levels ($\chi^2 = 221.40$; $p \leq 0.0001$).

In conclusion, gender and income level were the demographic variables with the strongest influence on price knowledge; age, marital status, and education level influenced price knowledge indirectly, through their relationship with the two dominant demographic variables. In this regard, the social and economic environment seems to determine consumers' level of price knowledge, which, along with differences in the experimental designs, could explain, at least in part, the contradictory results obtained by the existing investigations on the influence of demographic variables on price knowledge.

Finally, a number of statistically significant relationships between some of the demographic variables and consumers' attitudes toward prices were identified. Once again, these relationships could provide some insight on the economic and social context of the study. With respect to the importance of price, women, older groups, consumers with lower education levels, and those with lower income levels placed more importance on price as a factor in their purchase decisions (gender: $\chi^2 = 21.28$; $p \leq 0.0001$; age: $\chi^2 = 53.23$; $p \leq 0.001$; education level: $\chi^2 = 94.16$; $p \leq 0.0001$; income level: $\chi^2 = 112.24$; $p \leq 0.0001$).

Regarding confidence about the accuracy of the prices recalled, the highest degree of certainty was found in women, shoppers with lower education

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levels, participants with low and medium income levels, and those who placed higher importance on price (gender: $\chi^2 = 30.20$; $p \leq 0.0001$; education level: $\chi^2 = 38.52$; $p \leq 0.0001$; income level: $\chi^2 = 68.28$; $p \leq 0.0001$; importance on price: $\chi^2 = 182.62$; $p \leq 0.0001$).

With respect to certainty about the correctness of the rankings produced, the highest degree of confidence corresponded to women, married participants, subjects who placed higher importance on price, and subjects who felt more certain about the accuracy of the prices recalled (gender: $\chi^2 = 11.78$; $p \leq 0.019$; marital status: $\chi^2 = 49.42$; $p \leq 0.0001$; importance of price: $\chi^2 = 40.95$; $p \leq 0.001$; confidence about the accuracy of the prices recalled: $\chi^2 = 66.92$; $p \leq 0.0001$).

Managerial implications

The study of consumer knowledge of prices is extremely important to businesses for various reasons. First, it can provide valuable insights as to what kind of information consumers use at the stores when making their purchase decisions (Dickson and Sawyer, 1990), since the numerous factors that affect the setting of the sale price (i.e. cost, demand, competition, regulations and product life cycle) make it difficult to establish general formulas for making optimal pricing decisions. It is necessary to determine which factors are important and the appropriate prices based on these factors. Within this framework, price knowledge represents a key element, as the informative function of price goes further than its own exact level. In other words, the meaning of price goes beyond a strictly monetary one, and the various ways of presenting information with a similar economic content can elicit different responses on the part of consumers. Several elements play a role in this process, such as the price levels considered, the value of money, the importance of the economic sacrifice within the purchase decision, the magnitude of the difference in price, the variability of prices, the way and order of presenting prices, the available information on prices, adaptation levels or reference prices, assimilation or contrast effects, acceptable price intervals, associations between price and quality, and the price image of the store. In short, the study of consumers' knowledge of prices can provide valuable information in the determination of the significance of price. On the basis of the results obtained in this investigation, it is possible to sketch a profile of which consumer characteristics and purchase contexts lead to more or less price awareness, which may in turn help in managing prices.

Second, the study of consumer knowledge of prices can help dentify the optimal strategy for price-based promotions (Chen *et al.*, 1998; Greenleaf, 1995; Inman and McAlister, 1993; Inman *et al.*, 1990; Kahn and Raju, 1991; Kalika, 1982; Kalwani and Yim, 1992; Kim *et al.*, 1999; Krishna *et al.*, 1991; Lattin and Bucklin, 1989; McGoldrick and Marks, 1987; Mulhern and Padgett, 1995). Most of the subjects included in this study were able to recall a price for the product targeted in each interview. These prices represent a reference point in consumers' valuations (Bell and Bucklin, 1999; Briesch *et al.*, 1997; Chang and Wildt, 1994; Cooper, 1969; Gabor and Granger, 1969c; Grewal *et al.*, 1998; Gruca *et al.*, 2002; Kopalle *et al.*, 1996; Lilien *et al.*, 1992; Mazumdar and Jun, 1993; Puto, 1987; Walser-Luchesi, 1998; Winer, 1988; Zeithaml and Graham, 1983). Even though quite often the price recalled was not the correct one, in general, the difference between the two was small (below 5 percent error in 61.5 percent of cases). Therefore, the reference values of many consumers were close to reality and they reproduced a more or less correct image of the pricing policies of the stores. However, this is not always so, and sometimes the internal reference price is very different from the real price. In this case, it is important to keep in mind that, regardless of whether or not the price recalled by the consumer is absolutely correct, this price represents the reference point or the image price used in the purchase decision and, hence, if it is not the right one, the price manager should take action to correct the situation (i.e. price-based promotions and retail price advertising).

Furthermore, within the context of this study, consumers seemed to pay considerable attention to prices, which could have increased the accuracy of their knowledge. In this respect, it was observed that many consumers were able to rank order different brands of a product according to their prices, and they did so quite accurately. In other words, consumers had not only internal reference prices (i.e. absolute prices), but also frames of reference about how the prices of competitor products were related (i.e. relative prices). In general terms, these frames of reference were more accurate than internal reference prices. Therefore, any effect on those reference points (e.g. price changes, price-based promotions, communication campaigns) may have an influence on purchase decisions (Lichtenstein *et al.*, 1991). Additionally, marketing managers should consider the different processes through which consumers may develop their knowledge of prices: they not only pay attention to the prices of the brands they usually buy and to changes in those prices, but they also perceive, perhaps even to a greater extent, the

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relationships with the prices of competitor brands. Therefore, in shaping their price perceptions, consumers use certain reference indexes in which previous prices for the product and the prices of competitor products play an active role, and they tend to group new prices around key figures that are easier for them to remember. In short, when a company decides to change the price of its product, this decision will also affect its relationship with other alternative products, which, in turn, could have a profound impact on consumers' decisions.

Interestingly, some tendencies were detected relating to differences in price knowledge across the various product categories analyzed: for some products consumers knew the exact prices better, whereas for other products they were more knowledgeable about relationships between the prices of different brands. This is important in retail price advertising. Specifically, if consumers know the exact price of a product, the slightest change therein will be immediately perceived, and therefore, it will not be necessary to include the former price in marketing communications. However, if they do not know the product price, they will not be able to assess the magnitude of the change, and therefore, marketing communications should include the former price or the percentage discount. Finally, for products whose prices are better known in relative terms, consumers may not perceive changes in price, provided the framework of price relationships among competitor brands remains unchanged (Vanhuele and Drèze, 2002).

Third, the study of consumer knowledge of prices can help gain a better understanding of how consumers set the price image of the store (Brown, 1969; Cox and Cox, 1990; Dhar *et al.*, 1999; Dickson and Sawyer, 1990; Díez de Castro *et al.*, 2002; Simester, 1995). This price image can significantly affect consumers' choices of stores, especially when they do not possess complete information about other stores' prices and when the cost of the search for price information is higher than the expected benefits (Alba *et al.*, 1994; Simon, 1989). The results of this investigation can serve as the basis for a series of specific managerial implications applicable to this particular context.

Specifically, the prices of several products considered in this investigation were known with a high degree of accuracy (both in absolute and relative terms), whereas there were other products for which the opposite was true. This fact is related to consumers' tendency to form a general idea of the store's general price level, which allows them to avoid having to make multiple comparisons between prices. To do this, they use as a reference the price of certain products of specific sizes and levels of quality, and then draw overall impressions based on this information. It would be important for marketing managers to understand which of these products have the greatest influence on the development of the price image of the store, since, if the knowledge of some of the product prices is inaccurate, the price image may not conform to reality. In addition, price perception can vary from one consumer to another based on variables such as income level, cultural habits, shared social norms, or certain demographic characteristics. In conclusion, when a consumer intends to buy a product whose price he or she does not know (at least, not exactly), the election of a particular store may be largely based on its price image (Alba *et al.*, 1994; Rhee and Bell, 2002; Rosa Díaz, 2001; Simester, 1995; Simon, 1989; Urbany *et al.*, 2000). Finally, price image evolves over time and therefore, its management should have a long-term focus.

Fourth, price awareness plays a key role in the establishment of prices for a line of products, in which each product's role is coordinated with the rest to reach the desired objectives. The way in which a client perceives a price within that line of products may depend on the place the price occupies in the established interval and on the order in which the consumer accesses it (consumers show more sensitivity to increases than to decreases in prices). Additionally, it is very difficult for the consumer to remember all of the prices in the product line, which is why they tend to select the prices that draw their attention the most to make their comparisons. Therefore, price management should primarily focus on the most salient prices, which tend to be the lowest and the highest. Lower prices result in reduced benefit margins, but they can positively affect buyers' perceptions of the product line as a whole. Similarly, higher prices are fundamentally oriented toward creating an image of quality or prestige – associations between price and quality (Monroe, 1992).

Fifth, most of the subjects included in this study were able to recall a price for the product targeted in each interview. In markets of products whose prices are widely known by consumers, price-based competition can be very intense, and therefore, product differentiation that is based on attributes other than price (i.e. product quality, service quality, brand name, store image) becomes more relevant (Estelami, 1998).

Sixth, demographic variables are frequently used in segmenting markets (Lin, 2002). Therefore, this study's findings with respect to the influence of gender and income level on price knowledge may be useful to companies whose activities are circumscribed to the context of the study: it would make sense to develop price information communications tailored to men and women, as well as to people with low, medium, and

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high income levels. In conclusion, even though organizations cannot control demographic factors, it is extremely important to know that these factors can have an impact on their activities and to gain an understanding of the nature of such an impact (Jones and Zufryden, 1982).

Lastly, companies' trading products and services in international markets must take into account, in managing prices, that the economic, social, and cultural context (e.g. economic growth, unemployment, and inflation rates, gender roles in society, and values and attitudes toward money) can have a significant effect on consumer price knowledge (Bolton *et al.*, 2003; Estelami *et al.*, 2001). This investigation showed that, in Spain, the main responsibility for house chores continues to rest mainly with women; that consumers tend to underestimate the prices they pay, maybe because of the increasing inflation rate; and that younger people are prone to rely on their parents to handle the household responsibilities. However, these tendencies may not be so prevalent in other socio-cultural and economic settings.

Limitations, future research, and conclusions

One of the main interests of this research is that it constitutes one of the first studies on price knowledge that has been conducted in Spain. This country represents an interesting context for analysis given the significant changes that have taken place in the last three decades, which have profoundly affected its society (e.g. the role of women in the workforce, changes in men and women's respective roles in society, birth rate decrease, aging population), its economy (e.g. high rates of economic growth, unemployment and inflation, currency transition), and its politics (e.g. establishment of democracy, inclusion in the European Union). At the same time, however, the particular characteristics of the social, economic, and political context limit the generalizability of the results (Estelami *et al.*, 2001; Rosa Díaz, 2001, 2003). Consequently, the present investigation should be interpreted within the specific conditions in which it was carried out, and its findings should not be overgeneralized. Additional research in the area of price knowledge should be conducted in different social, economic, and temporal settings.

With regard to the research design of this investigation, one of its main strengths was the fact that all data were collected within a real-life shopping context, which increased the reliability of the results (Zeithaml, 1982) – in simulation environments, subjects may modify their shopping behavior because they are aware that they are participating in a study. In addition, this study followed a series of basic principles identified by Estelami and Lehmann (2001) and Walser-Luchesi (1998), who defined "the next best study in price recall research as one that provides respondents with participation incentives in the form of financial rewards, uses tasks that require few price estimates per respondent, and gives respondents the option of not providing a price estimate" (pp. 44-45). Nevertheless, the analysis was limited to frequently purchased consumer goods, and consumers' relative price knowledge was assessed by asking them to rank only three brands for each product. Future studies in this area could diversify the product categories and expand the frames of reference for price comparison.

This line of research could also be expanded in other directions. First, it would be interesting to investigate whether the differences observed between men and women with respect to price knowledge may be due, not only to cultural factors but also to biological ones, such as differences in the way the information is processed (Putrevu, 2001; Wolverton and Diaz, 1996). Moreover, perceptions of male shopping behavior, as well as how men actually shop, remain largely unexplored (Otnes and McGrath, 2001). Second, marketers need to understand how consumers spend their time and how this may be changing over time. Since price knowledge may not be a stable construct (Estelami *et al.*, 2001) this investigation could be replicated after a certain period of time. Third, in this study, immediate price recall was used to analyze price knowledge, i.e. subjects were interviewed immediately after having bought the products. This begs the question, however, of which information remains stored in the consumers' memory and whether it will still be available the next time they purchase the same product.

All in all, this research contributes to a better understanding of price knowledge in a number of ways: it increases the frame of reference for the purpose of comparing results with other studies, most of which have been conducted in the US; it incorporates different measures of price knowledge in order to account for the fact that consumers may process and store price-related information in different ways; and it includes an extensive product list and the sample comprised of subjects with different demographic characteristics, thus creating a more real-life setting and providing a better insight into the reality of markets.

Note

1 Average monthly income was used because this is the most common earnings reference in Spain (Instituto Nacional de Estadística de España, 1995).

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Appendix

Figure A1 Questionnaire

PRODUCTS	COFFEE/ Hot Chocolate Powder	SOFT DRINKS	OIL	DETERGENT	HYGIENE	FRUITS	Miscellaneous (1)	Miscellaneous (2)	Miscellaneous (3)	Vegetables
	☐ Coffee	☐ Cola	☐ Olive	☐ Washing machine	☐ Shampoo	☐ Apples	☐ Milk	☐ Yoghurt	☐ Breakfast cereal	☐ Tomatoes
	☐ Instant coffee	☐ Orange-Lemon	☐ Sunflower	☐ Dishwasher	☐ Shower gel	☐ Kiwi fruit	☐ Butter	☐ Juice	☐ Toilet paper	
	☐ Hot chocolate powder			☐ Clothes softener	☐ Toothpaste	☐ Pears	☐ Water	☐ Canned Tuna		
Importance of price	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Price paid										
Degree of certainty	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Market price										
Price ranking of brands										
Degree of certainty	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5

Gender	Age	Marital status	Education
☐ Male	☐ < 18 years	☐ Single	☐ < Elementary
☐ Female	☐ 18 to 25	☐ Married/ Live together	☐ Elementary
	☐ 26 to 35	☐ Separated	☐ High school
	☐ 36 to 45	☐ Divorced	☐ University or higher
	☐ 46 to 55	☐ Widowed	
	☐ 56 to 65		
	☐ > 65 years		

Household size	Professions	
	Father	
	Mother	
	Children	
	Others..........................	

Date:		Time: ☐ Morning	☐ Afternoon
Store :			

Pricing dynamics in the online consumer electronics market

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Keywords

Online operations, Retailing, Pricing, Electronic commerce

Abstract

This paper investigates prices of consumer electronics sold on the Web by both online-only retailers (Dotcoms) and the online branches of multi-channel retailers (MCRs). Surprisingly, it finds that Dotcoms charge higher price than MCRs, a conclusion contradictory to the results of most of empirical studies. Also finds that the electronics prices decreased over the period of study in general, dropping about 0.6 percent per week, and the prices of MCRs and Dotcoms went down with time at a similar speed. Further, the prices across MCRs are 35.3 percent more dispersed than the prices across the Dotcoms based on full prices, and 33.1 percent more dispersed based on percentage prices. However, results show that price dispersion moved up with time in general, with no significant difference in the speeds between MCRs and Dotcoms.

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1. Introduction

With the steady growth of electronic commerce, many traditional retailers find that the Internet is a new channel of selling their goods. More and more conventional retailers have started selling online. It is interesting to see how these conventional retailers compete with online-only retailers on the Web. Based on data from books, CDs, DVDs and videos, empirical studies involving pricing of online branches of multi-channel retailers (MCRs) and online-only retailers (Dotcoms) have shown that MCRs charge higher prices than Dotcoms (Tang and Ho, 2003; Tang and Lu, 2001; Tang and Xing, 2001, 2003). But retailers may have different pricing behavior for different product categories sold in the Internet.

In this paper, we investigate prices of consumer electronics sold on the Web by both Dotcoms and MCRs. Brand names and after-sale services make the electronics market significantly different from the markets for books, music, and movies. Ward and Lee (2000) examined whether consumers used brands as sources of information when shopping online. They found that recent adopters of the Internet would be less proficient at searching and would rely more on brands. Thus, online shoppers are more likely to buy goods from the online branches of the well-established traditional retailers even if they charge higher prices. Nevertheless, Carlton and Chevalier (2001) investigated online prices for DVD players and found that the online branches of MCRs charged higher prices than online-only retailers. We want to use our data to examine if there exist such pricing differences in the online electronics market. As far as we know, this is the first study involving the online electronics market from such a perspective.

A variety of related studies of price comparison have investigated online and offline price differences among different retailer types, including single-channel and MCRs, but the results so far seem conflicting. For example, Bailey (1998) found that online prices for books, CDs, and computer software were higher than in conventional stores. Clay *et al.* (2001, 2002) compared prices between online and offline stores

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and found that average prices were similar in both online and offline book markets. But taking sales tax and shipping cost into account, total prices were lower in conventional stores than in online stores. Other studies discovered that online retailers tend to charge lower prices than traditional retailers. Brynjolfsson and Smith (2000) compared prices of books and CDs sold through Internet and conventional channels in 1998 and 1999 and found that online prices were 9-16 percent lower than that in conventional stores. Morton *et al.* (2001) compared prices of cars sold in online and conventional channels and found that, on average, online consumers paid two percent less than offline consumers. Carlton and Chevalier (2001) discussed free-riding problems on the sales and promotional efforts of retailers. They discovered that MCRs may internalize some of the free-riding between online and retail stores and therefore charge higher prices than do Dotcoms.

Since customers can obtain price information in online markets easily and inexpensively, it was expected that online price dispersion should be small. However, recent empirical studies have showed considerable price dispersion in online markets. Clemons *et al.* (2002) investigated online markets for airline tickets and found differences in prices across online travel agents as large as 20 percent, even after controlling for observable product heterogeneity. Baye *et al.* (2003a, b) examined online pricing for 1,000 of the best-selling consumer electronics products found on the price comparison site Shopper.com, and found substantial price dispersions (about 40 percent in the average range of prices and the average gap between the two lowest prices listed for a given product remained stable at around 5 percent). Even after controlling for shipping costs and firm heterogeneities, they found that prices did not converge, although the average range in prices did fall when the number of competing firms decreased. The difference in prices charged for homogeneous products could not be fully explained by firm heterogeneities, which implies that firms may randomize pricing strategies.

Although price dispersion exists in online markets, some empirical studies did find that such price dispersion was lower across Dotcoms as compared to MCRs. Tang and Xing (2001) found that in online DVD market, the price dispersions (and the prices) are significantly lower among Dotcoms than that among MCRs. Clay *et al.* (2001) observed that, in the online book market, although some MCRs set online prices very similar to their Dotcom rivals, others charge the same prices as their physical stores. Thus, there may be a great price difference among MCRs.

Our paper attempts to examine if there are different pricing patterns in the online electronics market. We seek to contrast the pricing dynamics of MCRs with those of Dotcoms and derive implications. In particular, we will examine if:

(1) Dotcoms and MCRs charge different prices in the online electronics market;
(2) the two types of retailers have different online price dispersions; and
(3) online prices and online price dispersion increase or decrease over time.

Our results show that the online electronics market is different from the online markets of books, music, and movies, which implies that retailers have different pricing strategies for different product categories in online markets. We will discuss economic reasons for the differences. In the following, Section 2 describes the data collection methodology and provides a brief summary of data. Section 3 introduces the econometric models and presents the results of our empirical analysis. In Section 4, we present our conclusions.

2. Data and summary statistics

Our analysis uses panel data collected in the online electronics market, which is one of the most successful markets that have migrated online and enjoy considerable growth and sales. The fact that branded electronics products are homogeneous makes data collection tractable and price comparison meaningful.

2.1 Data collection

Unlike the data collection in the online markets for books, music and movies, it was difficult for us to find enough common items carried by various retailers in the online electronics market There are many electronics products that MCRs carry in their land-based stores which are not yet sold online, and some manufacturers do not allow some retailers to sell their products online or limit the scope of online product offerings. Since electronics products are well-known for "branded variants", i.e. small changes in the product models and design to avoid comparison across retailers, we had to work very carefully to ensure that it is the identical item compared across retailers.

We checked each item's model and manufacturer part number, and made sure that the item was the same in every store. We have also been very careful in the whole process of data collection. Thus, our data deal with identical items with identical brand names across retailers. Since all the information about brands, product models and manufacturer part numbers are clearly posted on each retailer's

Web site, online shoppers are fully aware of the fact that these are identical brands and products. Among the hundreds of electronic products and nearly 30 online stores that we started with, we found 14 common items carried by eight major online retailers. These 14 items include four camcorders, four DVD players, two tube TVs, one portable CD player, one walkman, one VCR, and one Shelf system, and the eight retailers are Best Buy, Circuit City, J&D Music World, Abt Electronics, 800.com, Amazon.com, Buy.com and Output.com[1].

We determined the frequency of data collection as follows. The interval between data collection should not be so long as to miss the point of price change. Considering the fact that many retailers, such as Best Buy and Circuit City, issued a new catalog every week, indicating possible changes in price, we decided to collect data once in every week. We accessed the Web sites of the selected retailers and recorded the prices of the selected products for both types of retailers. Our data collection process started on 9 December 2000 and ended on 9 June 2001, but our actual analysis is based on the data from 9 December 2000 to 28 April 2001, because more than five items became unavailable in some retailers' sites after the April 28 week. We decided to exclude these weeks in our statistical analysis to avoid introducing unnecessary bias[2]. Also, no data collection was conducted after the February 10 week and before the March 10 week because we were occupied by other obligations. In total, we have obtained 2,016 price observations from 18 collections.

Shipping costs are another difficult issue in the electronics case. Unlike books, CDs, videos and DVDs, electronics products vary greatly in size and weight. Further, two MCRs (Circuit City and Best Buy) offer an in-store pick-up option (that is, buy online but pick up oneself in their land-based branch). We used the following method to estimate shipping costs: various baskets of one, two up to three electronics products were chosen and actual standard shipping costs (that is, not any special or express shipping) were obtained by checking the respective retailers' online calculated shipping rates for these baskets. For example, we found that the average shipping cost for the basket of one item is $23.38 for MCRs while $19.75 for Dotcoms. The p-values of the t-test (on individual items) and the Wilcoxon test (on the retailer-specific means) for comparing shipping costs between MCRs and Dotcoms are 0.37 and 0.44, respectively, showing that the difference in shipping cost between MCRs and Dotcoms is not significant in any conventional sense. This finding is qualitatively robust with baskets of two items or three items as well. For the in-store pickup option, we used another way to check the robustness of this finding. Brynjolfsson and Smith (2000) used the US government reimbursement rate of $0.32 per mile to approximate the pick-up cost for book and CD purchasers (for baskets of three items). Similarly, we replaced the standard shipping rates of Best Buy and Circuit City by $1.60 (for 5 miles) and $6.4 (for 20 miles) for the respective items and recalculated all the statistics. Nothing changed qualitatively either, that is, there is no significant difference in shipping costs between MCRs and Dotcoms even if in-store pickup option is taken[3].

2.2 Summary statistics

We first calculate the averages of the posted prices, percentage prices and full prices. The posted price is the posted dollar price, percentage price is the percentage of the posted dollar price relative to the manufacturer's suggested retail price (MSRP) for each title, and the full price is posted price plus the shipping costs. Clearly, the percentage price shows how much discount each retailer gives to each product compared to the MSRP for this product. The results summarized in Table I show that Dotcoms charge on average $12.26 or 3.1 percent more than MCRs in posted prices, 1.72 units more in percentage prices, and $10.1 or 2.4 percent more in full price. It seems that the MCRs on average offered a bigger discount than Dotcoms (21.65 percent vs 19.07 percent).

Breaking the analysis into product categories (Camcorder, DVD Player, Tube TV and others) allows us to see a more detailed picture on the price differences as well as the effect of adding shipping costs. Price differences occurred mainly on the more expensive items while the shipping costs made a difference mainly on the large items (not necessarily the expensive ones). MCRs charged more for shipping large items than Dotcoms did, which makes the full price of Tube TV higher for MCRs than for Dotcoms.

Table I Mean and median (lower entry) prices by retailer type and product category

	Posted price ($)		Percentage price (percent)		Full price ($)	
	MCR	Dotcom	MCR	Dotcom	MCR	Dotcom
Overall	393.54	405.80	78.35	80.07	414.47	424.57
	299.99	309.99	81.65	81.82	330.47	334.72
Camcorder	742.39	764.26	78.12	80.43	746.16	773.10
	743.50	719.99	81.82	81.82	743.50	736.69
DVD player	360.30	371.95	74.77	75.55	367.13	382.91
	258.99	249.99	75.01	76.00	264.47	269.44
Tube TV	363.06	377.91	85.23	88.93	440.98	432.13
	363.47	379.99	87.51	88.45	437.47	436.46
Others[a]	93.18	95.16	78.70	79.80	116.87	113.95
	69.75	69.99	84.23	83.11	78.33	78.23

Note: [a]Include portable CD players, walkman, VCR and shelf system

We also calculated the average prices of items for each of these online retailers (Table II). Interestingly, the lowest pricing one is the online branch of ABT Electronics while the highest pricing one is Buy.com, from either posted, full or percentage price sense. Buy.com frequently marketed itself as a lowest-pricing online retailer and was reputed to be so, but our data indicate that it charged higher prices than other online retailers in the electronics market.

3. Econometric model and empirical results

3.1 Econometric model and relative price levels

Clearly, a fair comparison can only be done when the unwanted price variations are controlled for There are three major factors that would affect the price levels: retailer, product and time period (in week). We thus propose the following econometric model:

$$\log(\text{Price}) = \alpha_0 + \alpha_1\,\text{MCR} + \alpha_2\,\text{Dotcom} + \sum_{i=1}^{8}\beta_i\,\text{Retailer}_i + \sum_{i=1}^{14}\theta_i\,\text{Product}_i + \sum_{i=1}^{18}\gamma_i\,\text{Week}_i + e \qquad (1)$$

where

$$\alpha_1 + \alpha_2 = 0, \quad \sum_{i=1}^{4}\beta_i = 0, \quad \sum_{i=5}^{8}\beta_i = 0,$$

$$\sum_{i=1}^{14}\theta_i = 0 \quad \text{and} \quad \sum_{i=1}^{18}\gamma_i = 0$$

are constraints that remove the redundant parameters. All the variables are binary with 1=present and 0 = absent of the factor level indicated by the variable. For example, Dotcom = 1 if the retailer involved is a Dotcom retailer and 0 otherwise. The most important variables in the model are MCR and Dotcom. Equality of their coefficients means that MCRs and Dotcoms charge the same price. Of secondary importance are the retailer variables. Similarly, equality of the βs means that all retailers charge the same price. Further, equality of the θs means that all products have the same price and equality of the γs means that price stays the same from week to week. The price variable in the model could be the posted price, full price or percentage price.
The errors (e) in the model are assumed to be independent normal with zero mean and constant standard deviation (SD). The results from running model (1) are shown in Table III.

From the results, we see that the coefficients of the retailer type variables (MCR and Dotcom) are significantly different from zero, irrespective of whether the analysis is based on log posted price, or log full price, or percentage price. This means that Dotcoms charge higher price than MCRs, a conclusion contradictory to the results of most of empirical studies (Brynjolfsson and Smith, 2000; Morton *et al.*, 2001; Tang and Xing, 2001).
The difference between the coefficients of Dotcom and MCR can be converted to give an estimate of percentage difference between the average prices of Dotcom and MCRs. That is, after controlling the product and time effects, we find that Dotcoms charge $100[\exp(2\times 0.0112) - 1] = 2.3$ percent higher than MCRs based on the posted price, and $100[\exp(2\times 0.0078) - 1] = 1.6$ percent based on the full prices (refer Table III for the numbers used in calculations). The difference in the percentage price model represents the average difference in percentage prices between the two types of retailers. The results show that MCRs offer 1.7 percent more discounts than Dotcoms. The t-statistics for the product dummies show that all the products have prices significantly different from the overall average. The 18 time dummies (week 1-week 18) reveal an interesting phenomenon: price dropping significantly by weeks.

To check the above analysis from another angle, an ANOVA model is run with retailer type, product and time as three qualitative factors, having 2, 14 and 18 levels, respectively. An ANOVA model including all the main effects and two-way interactions is fitted, and the results are presented in Table IV. The "type" factor is highly significant in all three models, indicating the prices of MCRs and Dotcoms do differ. Further, the product factor and the time factor, as well as the

Table II Mean and median (lower entry) prices by retailers

Retailer	Posted price ($)	Full price ($)	Percentage price (percent)
Best buy	392.42	408.41	77.98
	299.99	331.95	81.82
Circuit city	404.83	416.61	79.84
	309.99	328.48	83.34
J&D music world	402.04	436.19	79.00
	309.99	377.94	82.51
ABT electronics	374.88	396.67	76.56
	305.50	356.35	74.75
800.com	413.12	431.71	80.68
	324.95	358.40	83.11
Amazon.com	399.99	421.16	77.41
	316.24	353.68	77.86
Buy.com	417.93	443.92	82.18
	339.99	381.19	83.34
Output.com	392.18	401.51	80.02
	309.99	328.27	83.34

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Table III Analysis of price levels: estimated coefficients and their *t*-statistics of model (1)

	Log posted price		Log full price		Percentage price	
	Estimate	***t*-statistics**	**Estimate**	***t*-statistics**	**Estimate**	***t*-statistics**
MCR	−0.0112	−5.49	−0.0078	−3.62	−0.8623	−5.63
Dotcom	0.0112	5.49	0.0078	3.62	0.8623	5.63
BestBuy	−0.0070	−1.41	−0.0153	−2.89	−0.3615	−0.96
CircuitCity	0.0199	3.99	−0.0067	−1.27	1.4931	3.98
JDMWorld	0.0094	1.89	0.0535	10.10	0.6546	1.74
ABTElectronics	−0.0223	−4.47	−0.0314	−5.94	−1.7862	−4.76
800.Com	0.0104	2.08	0.0083	1.57	0.6052	1.61
Amazon.Com	−0.0362	−7.26	−0.0238	−4.51	−2.6578	−7.08
Buy.Com	0.0279	5.60	0.0480	9.07	2.1062	5.61
Output.Com	−0.0021	−0.42	−0.0325	−6.14	−0.0535	−0.14
Camcorder 1	0.9061	123.42	0.8387	107.68	−0.1705	−0.31
Camcorder 2	1.0994	149.75	1.0304	132.29	−0.9649	−1.75
Camcorder 3	1.0411	141.80	0.9725	124.87	2.2398	4.06
Camcorder 4	0.7768	105.80	0.7102	91.19	−0.8385	−1.52
CD Player	−1.5724	−214.17	−1.5678	−201.30	5.3111	9.62
Walkman	−1.7191	−234.15	−1.7007	−218.36	−6.1281	−11.10
DVD player 1	−0.2327	−31.69	−0.2704	−34.71	−3.5864	−6.49
DVD player 2	−0.1493	−20.33	−0.1899	−24.39	2.6589	4.82
DVD player 3	0.0273	3.72	−0.0189	−2.42	−5.9614	−10.80
DVD player 4	0.8912	121.38	0.8279	106.29	−9.2884	−16.82
VCR player	−1.0381	−141.39	−1.0306	−132.32	−6.4913	−11.76
Shelf system	−0.5488	−74.75	−0.2947	−37.84	7.4798	13.55
Tube TV 1	0.1789	24.37	0.2789	35.81	6.0768	11.00
Tube TV 2	0.3396	46.25	0.4144	53.20	9.6631	17.50
Week 1	0.0517	6.16	0.0508	5.70	3.8807	6.15
Week 2	0.0400	4.76	0.0399	4.48	2.9368	4.65
Week 3	0.0399	4.76	0.0393	4.41	2.9653	4.70
Week 4	0.0391	4.66	0.0385	4.33	2.8794	4.56
Week 5	0.0401	4.77	0.0394	4.42	2.9580	4.68
Week 6	0.0321	3.83	0.0320	3.59	2.3324	3.69
Week 7	0.0299	3.56	0.0291	3.27	2.1637	3.43
Week 8	0.0196	2.33	0.0189	2.12	1.3747	2.18
Week 9	0.0226	2.69	0.0220	2.47	1.6536	2.62
Week 10	−0.0039	−0.46	−0.0042	−0.48	−0.4171	−0.66
Week 11	−0.0238	−2.83	−0.0236	−2.65	−1.7961	−2.84
Week 12	−0.0281	−3.34	−0.0279	−3.14	−2.0610	−3.26
Week 13	−0.0313	−3.73	−0.0309	−3.47	−2.3034	−3.65
Week 14	−0.0379	−4.51	−0.0370	−4.16	−2.7828	−4.41
Week 15	−0.0436	−5.20	−0.0427	−4.79	−3.1951	−5.06
Week 16	−0.0444	−5.29	−0.0436	−4.90	−3.2316	−5.12
Week 17	−0.0465	−5.54	−0.0457	−5.13	−3.3418	−5.29
Week 18	−0.0555	−6.61	−0.0541	−6.08	−4.0157	−6.36
R^2	0.9902		0.9882		0.4750	

Table IV ANOVA for price

	Log posted price			Log full price			Percentage price		
Effect	**DF**	***F***	**Pr > *F***	**DF**	***F***	**Pr > *F***	**DF**	***F***	**Pr > *F***
Type	1	34.1	< 0.0001	1	13.8	0.0002	1	36.1	< 0.0001
Product	13	17308	< 0.0001	13	13338	< 0.0001	13	118.2	< 0.0001
Time	17	22.1	< 0.0001	17	17.6	< 0.0001	17	21.1	< 0.0001
Type * Product	13	11.0	< 0.0001	13	15.2	< 0.0001	13	11.9	< 0.0001
Type * Time	17	0.4	0.9895	17	0.3	0.9979	17	0.4	0.9836
Product * Time	221	2.1	< 0.0001	221	1.7	< 0.0001	221	2.1	< 0.0001
R^2		0.9924			0.9902			0.5965	

two-way interactions (except the interaction between type and time which has $\Pr > F = 0.9895$ as seen from Table IV), are all highly significant. Clearly, the implications of these are:
(1) when comparing the prices between MCRs and Dotcoms one has to control the effects of product and time;
(2) the price difference between MCRs and Dotcoms changes from one product to other but not with time;
(3) the product prices change with time and the way they change is different from one product to another; and
(4) the difference between prices charged by MCRs and Dotcoms does not change over time.

Hence, although Dotcoms charge higher price than MCRs in an overall sense, there might be only a part of the products responsible for such a price difference. Much insight has been gained by this ANOVA. We will carry out more detailed analysis in the following subsections.

3.2 Price dispersions

Following Brynjolfsson and Smith (2000) and Sorensen (2000), we use both price ranges and standard deviations (SDs) across retailers of the same type for each product at each date as measures to compare dispersions among Dotcoms with that among MCRs. Table V shows the average of all price ranges and the average of all price standard deviations (SDs), in posted, full, and percentage prices. From the table we see that the differences in price dispersion between MCRs and Dotcoms are sizable in full prices, but are negligible in posted or percentage prices. This is interesting and perhaps an indication that dispersions in shipping costs are different between MCRs and Dotcoms although their average levels are about the same. Formal tests for difference in price dispersion again should be carried out after controlling for certain factors.

In our formal econometric modelling, the price dispersion is defined as either the SD or the range of prices of a given product from the retailers of the same type. In other words, we are interested in comparing the price variations across MCRs with that across Dotcoms. The model has the similar form as equation (1) except the individual retailer effects disappear.

$$\log(\text{Price Dispersion}) = \alpha_0 + \alpha_1\,\text{MCR} + \alpha_2\,\text{Dotcom} + \sum_{i=1}^{14}\theta_i\,\text{Product}_i + \sum_{i=1}^{18}\gamma_i\,\text{Week}_i + e \qquad (2)$$

Similar parameter constraints as in equation (1) need to be imposed on αs, θs and γs. The results are shown in Table VI. The difference in price dispersion between MCRs and Dotcoms is insignificant based on posted prices, but significant based on full prices. Most of the product dummies are significant, indicating that price dispersion changes from one product to another. Contrary to the case of price analysis, the time dummies here indicate that price dispersion increase with time. Further, the prices across MCRs are 35.3 percent $(100[\exp(2 \times 0.1513) - 1])$ more dispersed than the prices across the Dotcoms based on the SDs of full prices, and 33.1 percent $(100[\exp(2 \times 0.1428) - 1])$ more dispersed based on the range of full prices. The result of lower price dispersion across Dotcoms may be because of the easier online search, which prompts online retailers to price close to each other. To avoid internal competition and conflict between online and offline channels, however, MCRs have to keep their prices same or similar in the two channels. Therefore, the prices across MCRs are more dispersed than that across Dotcoms.

Again, to re-examine the above results and to gain further insights on the price dispersion patterns, we run an ANOVA model with three factors and their two-way interactions. The results shown in Table VII clearly reveal that price dispersions differ between MCRs and Dotcoms in full price but not in posted price. Products and time periods make significant difference on the price dispersion. The difference in price dispersion between MCRs and Dotcoms also depends significantly on what types of products we are dealing with. These findings indicate that the online electronics prices and price dispersions are quite dynamic with a complicated structure, which will be further examined in detail in the following subsection.

3.3 Price trends

Analysis of price changes might be one of the most challenging issues in studying the online pricing dynamics. Table VIII shows the prices by week, where a clear decreasing trend is shown in each of the price forms and for each type of retailer.

Figures 1 and 2 give insightful graphical summary of the mean prices and price dispersion by product category, retailer type, and price form.

Table V Price dispersion summary

	Posted price ($)		Full price ($)		Percentage price (percent)	
	Dotcom	MCR	Dotcom	MCR	Dotcom	MCR
Mean	393.54	405.80	414.47	424.57	80.07	78.35
Range	65.66	69.74	73.73	90.57	10.44	11.21
SD	31.22	32.88	34.10	41.92	4.97	5.33

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Table VI Analysis of price dispersion: estimated coefficients and *t*-statistics of model (2)

Variable	Log SD (posted price) Estimate	*t*-statistics	Log SD (full price) Estimate	*t*-statistics	Log range (full price) Estimate	*t*-statistics
MCR	0.0277	0.42	0.1513	5.27	0.1428	5.05
Dotcom	−0.0277	−0.42	−0.1513	−5.27	−0.1428	−5.05
Camcorder 1	1.6383	6.86	1.0071	9.73	0.9805	9.63
Camcorder 2	2.5467	10.67	1.7635	17.04	1.7328	17.01
Camcorder 3	1.8603	7.79	1.2013	11.61	1.2151	11.93
Camcorder 4	0.8547	3.58	1.1129	10.75	1.0618	10.43
CD Player	−2.8004	−11.73	−2.0881	−20.17	−2.0756	−20.38
Walkman	−1.5997	−6.70	−2.8022	−27.07	−2.7790	−27.29
DVD player 1	0.8001	3.35	0.0165	0.16	0.0048	0.05
DVD player 2	−2.6737	−11.20	−0.8206	−7.93	−0.8053	−7.91
DVD player 3	−0.3211	−1.35	−0.8491	−8.20	−0.8338	−8.19
DVD player 4	1.5449	6.47	0.7105	6.86	0.6810	6.69
VCR player	−0.1115	−0.47	−0.5706	−5.51	−0.5839	−5.73
Shelf system	−0.2561	−1.07	0.3241	3.13	0.3337	3.28
Tube TV 1	0.4373	1.83	0.5804	5.61	0.6503	6.38
Tube TV 2	−1.9197	−8.04	0.4142	4.00	0.4175	4.10
Week 1	−0.3383	−1.24	−0.2074	−1.75	−0.2137	−1.83
Week 2	−0.6558	−2.40	−0.5050	−4.27	−0.4952	−4.25
Week 3	−0.6678	−2.45	−0.4322	−3.65	−0.4259	−3.66
Week 4	−0.4182	−1.53	−0.3089	−2.61	−0.3006	−2.58
Week 5	−0.4560	−1.67	−0.3174	−2.68	−0.3087	−2.65
Week 6	−0.3080	−1.13	−0.2489	−2.10	−0.2407	−2.07
Week 7	−0.2272	−0.83	−0.1149	−0.97	−0.1163	−1.00
Week 8	0.1055	0.39	0.0160	0.13	0.0194	0.17
Week 9	0.0736	0.27	0.0233	0.20	0.0246	0.21
Week 10	0.0769	0.28	0.0372	0.31	0.0513	0.44
Week 11	0.1727	0.63	0.1897	1.60	0.1825	1.57
Week 12	0.1738	0.64	0.1654	1.40	0.1438	1.23
Week 13	−0.1126	−0.41	0.0623	0.53	0.0606	0.52
Week 14	0.4167	1.53	0.2863	2.42	0.2737	2.35
Week 15	0.4162	1.52	0.2918	2.47	0.2772	2.38
Week 16	0.4564	1.67	0.3196	2.70	0.3212	2.76
Week 17	0.4846	1.78	0.3495	2.95	0.3587	3.08
Week 18	0.8075	2.96	0.3937	3.33	0.3881	3.33
R^2	0.5824		0.8102		0.8120	

Table VII ANOVA for price dispersion

Effect	Log SD (posted price) DF	*F*	Pr > *F*	Log SD (full price) DF	*F*	Pr > *F*	Log range (full price) DF	*F*	Pr > *F*
Type	1	0.23	0.6334	1	47.53	< 0.0001	1	42.16	< 0.0001
Product	13	61.96	< 0.0001	13	249.44	< 0.0001	13	243.77	< 0.0001
Time	17	2.96	0.0001	17	9.31	< 0.0001	17	8.95	< 0.0001
Type * Product	13	9.75	< 0.0001	13	16.48	< 0.0001	13	15.18	< 0.0001
Type * Time	17	1.20	0.2691	17	1.50	0.0955	17	1.39	0.1451
Product * Time	221	1.11	0.2141	221	1.57	0.0004	221	1.52	0.0009
R^2		0.8497			0.9481			0.9466	

In Figure 1, we plot dynamics of mean prices in both posted prices and full prices. Figure 2 demonstrates the changes in price SDs over time. From the plots we see that prices of camcorder are the most dynamic among the four product categories, followed by the prices of DVD players. Prices of camcorders decreased sharply, but their price dispersion increased sharply over the period of study. Prices of DVD players exhibit similar pricing behavior, but with changes in smaller magnitude compared with camcorders. Price and price dispersion for Tube TV and other products both remain fairly stable over the period of study. A closer examination of the plots reveals that the

Table VIII Mean prices by week and by retailer type

	Posted price ($)		Full price ($)		Percentage price (percent)	
Week	**MCR**	**Dotcom**	**MCR**	**Dotcom**	**MCR**	**Dotcom**
1	425.06	435.04	445.99	453.82	82.45	83.72
2	417.29	435.52	438.22	454.30	80.87	83.42
3	418.39	429.63	439.32	448.40	81.47	82.87
4	418.97	427.84	439.89	446.62	81.46	82.71
5	417.56	429.63	438.48	448.40	81.46	82.87
6	411.47	426.46	432.40	445.23	80.60	82.48
7	403.27	427.16	424.20	445.93	79.94	82.80
8	399.56	416.53	420.48	435.30	79.53	81.63
9	402.51	419.60	423.44	438.37	79.69	82.03
10	381.30	403.87	402.22	422.64	77.31	80.28
11	375.27	391.44	396.20	410.21	76.01	78.82
12	374.73	386.97	395.65	405.74	76.13	78.16
13	373.96	386.17	394.88	404.94	75.98	77.83
14	374.89	382.16	395.82	400.93	75.88	76.97
15	375.06	377.25	395.98	396.02	75.81	76.22
16	373.81	377.43	394.73	396.20	75.71	76.24
17	371.83	377.75	392.76	396.52	75.44	76.30
18	368.85	374.00	389.78	392.77	74.47	75.91

MCRs have a lower price but higher price dispersion compared to the Dotcoms. To obtain more concrete conclusions, formal tests using a well-designed econometric model need to be carried out.

Two econometric models are proposed for the analysis of price movements, one for the average prices and the other for the price dispersion. Several time trend variables are used in the model: an overall time trend Time, its interaction with MCR and Dotcom, and the three-way interactions among Time, Retailer type, and product category.

$$\begin{aligned}\log(\text{Price}) = {} & \alpha_0 + \alpha_1 \text{MCR} + \alpha_2 \text{Dotcom} \\ & + \delta \log(\text{List Price}) + \sum_{i=1}^{8} \beta_i \,\text{Retailer}_i \\ & + \sum_{i=1}^{4} \theta_i \,\text{Cat}_i + \sum_{i=0}^{10} \gamma_i \,\text{Trend}_i + e \end{aligned} \quad (3)$$

$$\begin{aligned}\log(\text{Price Dispersion}) = {} & \alpha_0 + \alpha_1 \,\text{MCR} \\ & + \alpha_2 \,\text{Dotcom} + \lambda \log(\text{mean price}) \\ & + \sum_{i=1}^{4} \theta_i \,\text{Cat}_i + \sum_{i=0}^{10} \gamma_i \,\text{Trend}_i + e \end{aligned} \quad (4)$$

where $\text{Cat}_i, i = 1, 2, 3, 4$ represents the product categories: Camcoder, DVD Player, Tube TV and others; Trend_i, $i = 0, \ldots, 10$, represents the time trend variable and its interaction with retailer type and product category. The results from fitting model (3) are shown in Table IX and the results from fitting the model (4) are shown in Table X.

The constraints in models (3) and (4) are as follows:

$$\alpha_1 + \alpha_2 = 0, \quad \sum_{i=1}^{8} \beta_i = 0, \quad \sum_{i=1}^{4} \theta_i = 0,$$

$$\gamma_1 + \gamma_2 = 0, \quad \sum_{i=3}^{6} \gamma_i = 0 \quad \text{and} \quad \sum_{i=7}^{10} \gamma_i = 0.$$

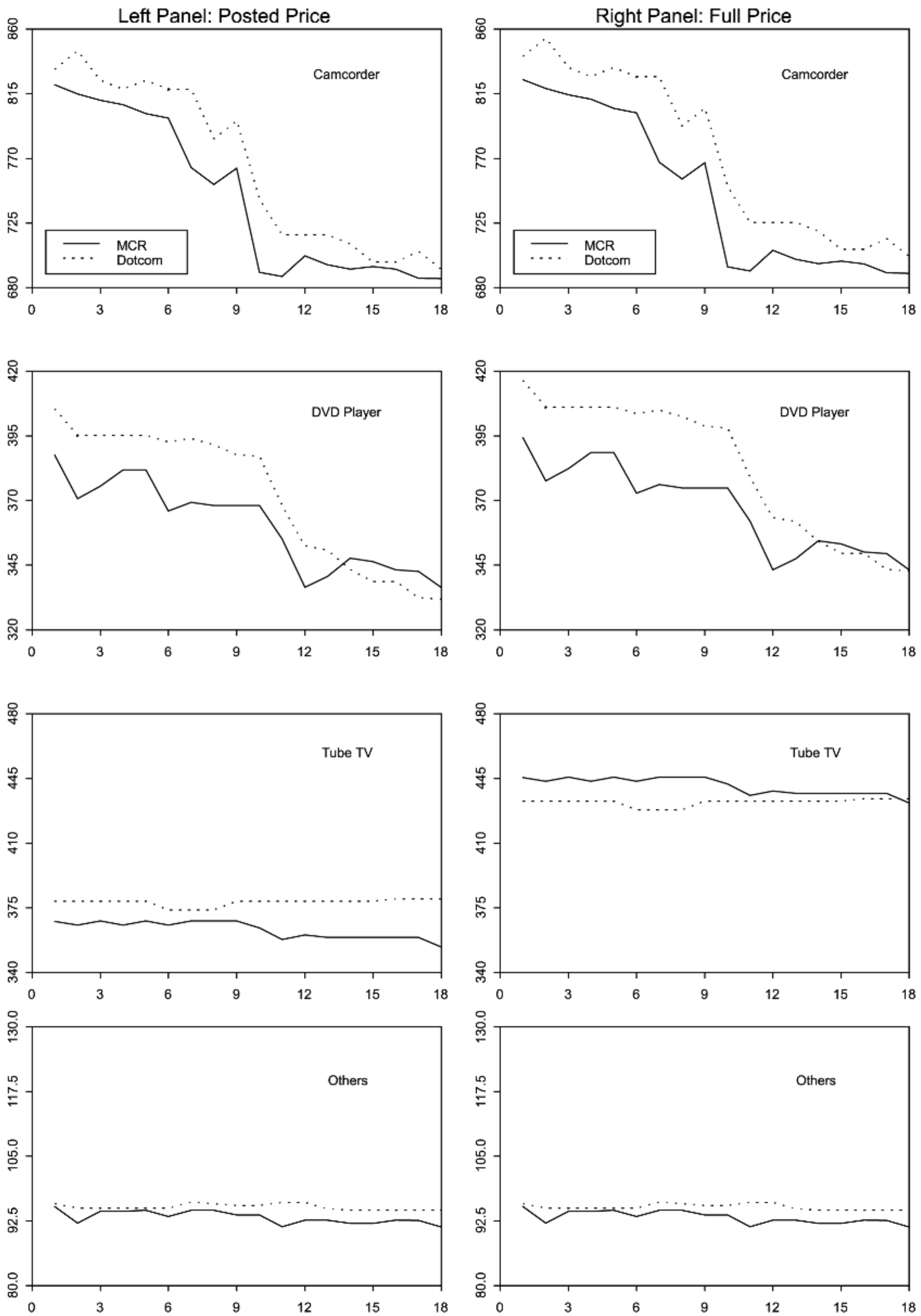
From Table IX we see that the Time variable (overall time trend) is highly significant and has a negative coefficient. Hence, the electronics prices decreased over the period of study in general. The coefficients of TM and TD variables are both no different from zero, showing that the prices of MCRs and Dotcoms went down with time at a similar speed. When the time trends are further broken into the product categories, we find that the price decreasing is mainly caused by the price drop in camcorders and DVD players. The prices for Tube TV and other products stayed fairly stable. To conclude, prices of MCRs and Dotcoms both went down with time. On top of this, we further conclude that their decreasing speeds are similar, and it was the camcorders and the DVD players that caused the overall price drop. The conclusions obtained from the model analysis are consistent with the plots given in Figure 1.

Quantitative estimates on price changes over time can be obtained from the results of Table IX, in particular the coefficients of time trends. For example, the per week price drop in posted price is about 0.6 percent overall, 0.6 percent for MCRs, 0.6 percent for Dotcoms, 1.4 percent for MCR camcorders, 1.4 percent Dotcom camcorder, 0.8 percent for MCR DVD player, and 0.9 percent for Dotcom DVD player. The same set of numbers corresponding to the full price becomes 0.6, 0.6, 0.6, 1.5, 1.3, 0.8 and 0.8 percent. Similarly, one can estimate per week price drops in percentage prices. Further calculations show that the prices of Tube TV and other products are almost unchanged during the period of our study.

From the results of Table X, we see that price dispersion moved in an opposite direction as the price level – it went up with time in general, with no significant difference in the speeds between MCRs and Dotcoms. Again, such an overall movement trend in price dispersion is mainly caused by the camcorder category. It might be the case that some retailers lowered down the camcorder price significantly over time while the others kept the price fairly constant. This made the overall price decreasing and price dispersion increasing with time.

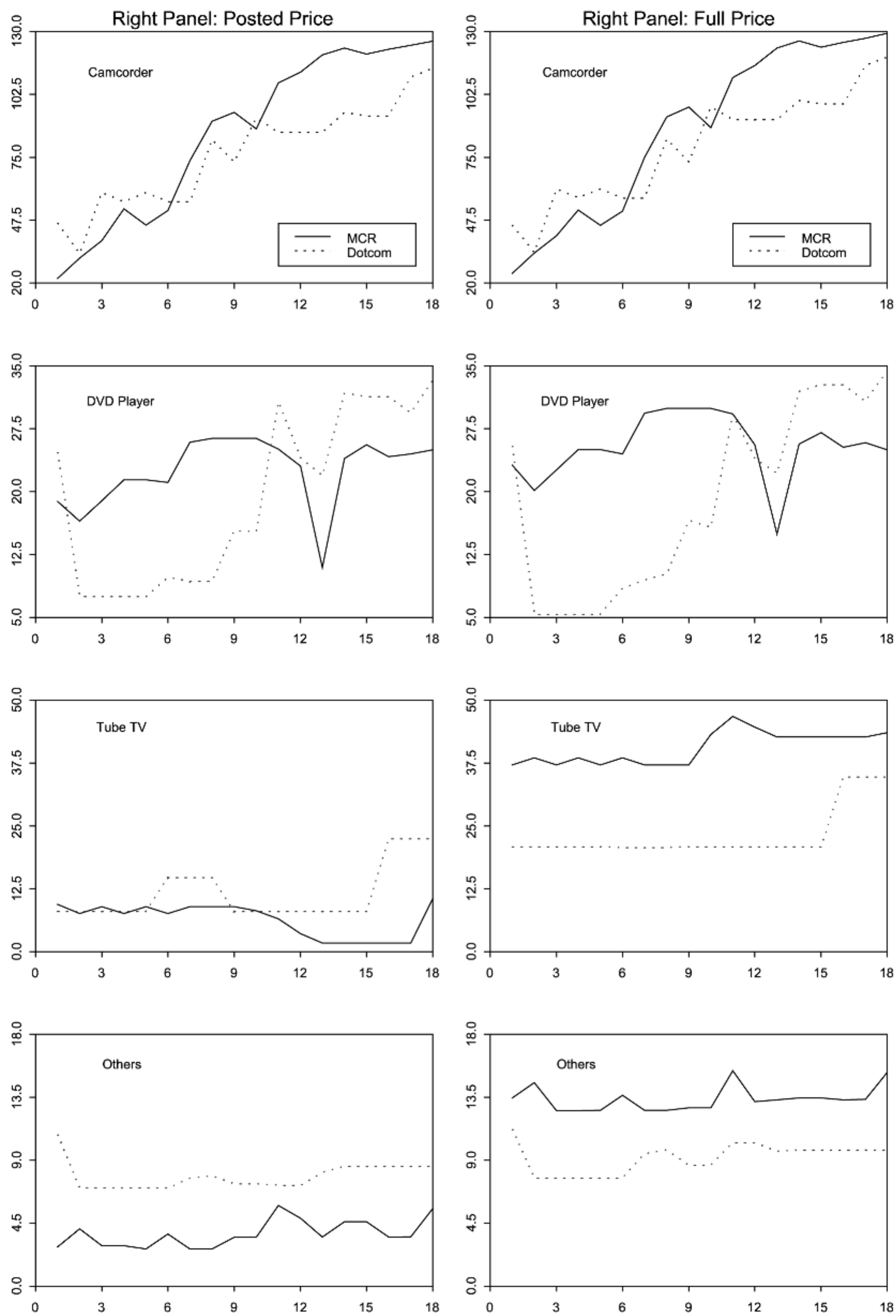
Price dispersions for MCRs and Dotcoms both changed with time. In particular, we

Figure 1 Time series plots of mean prices



conclude that they both went up with time at a similar speed. Quantitatively, the per week increment in price dispersion based on posted price is 8.1 percent overall, 7.6 percent for MCRs, 8.7 percent for Dotcoms, 24.3 percent for MCR camcorder, 20.7 percent for Dotcom camcorder, 13.1 percent for MCR DVD player, and 13.5 percent for Dotcom DVD player. The same set of numbers can be easily calculated based on the full price SD or full price range.

Figure 2 Time series plots of averages of price SDs



4. Conclusion

This study investigates consumer electronics market on the Internet. Surprisingly, we find that Dotcoms on average charge higher prices than do MCRs. This finding is contradictory to the results of most empirical studies involving books, CDs, videos and DVDs. One may think that as shopping

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Table IX Analysis of price movement based on model (3)

	Log posted price		Log full price		Percentage price	
	Estimate	*t*-statistics	Estimate	*t*-statistics	Estimate	*t*-statistics
MCR	−0.0132	−2.77	−0.0098	−1.56	−1.0940	−3.04
Dotcom	0.0132	2.77	0.0098	1.56	1.0940	3.04
Log list price	0.9683	152.10	1.0333	123.28	−2.0131	−4.19
Best Buy	−0.0070	−1.26	−0.0153	−2.08	−0.3615	−0.86
Circuit City	0.0199	3.56	−0.0067	−0.91	1.4931	3.54
JD Music World	0.0094	1.69	0.0534	7.25	0.6546	1.55
ABT Electronics	−0.0223	−3.98	−0.0314	−4.27	−1.7862	−4.23
800.com	0.0104	1.86	0.0083	1.13	0.6052	1.43
Amazon.com	−0.0362	−6.47	−0.0238	−3.24	−2.6578	−6.29
Buy.com	0.0279	4.99	0.0480	6.52	2.1062	4.99
Output.com	−0.0021	−0.38	−0.0325	−4.41	−0.0535	−0.13
Camcorder	0.0906	9.05	−0.0487	−3.70	6.7966	8.99
DVD player	−0.0364	−4.49	−0.1060	−9.93	−3.3371	−5.45
Tube TV	0.0434	4.23	0.1108	8.21	3.5973	4.65
Others	−0.0975	−8.66	0.0439	2.96	−7.0568	−8.30
Time	−0.0062	−13.45	−0.0061	−10.02	−0.4547	−13.08
TM (Time * MCR)	0.0001	0.15	0.0003	0.56	0.0107	0.32
TD (Time * Dotcom)	−0.0001	−0.15	−0.0003	−0.56	−0.0107	−0.32
TM * Camcorder	−0.0082	−9.92	−0.0090	−8.34	−0.6229	−10.02
TM * DVD player	−0.0012	−1.43	−0.0022	−2.02	−0.0564	−0.91
TM * TubeTV	0.0042	3.99	0.0061	4.41	0.2796	3.54
TM * Others	0.0052	6.28	0.0052	4.75	0.3997	6.43
TD * Camcorder	−0.0076	−9.26	−0.0069	−6.33	−0.6037	−9.71
TD * DVD player	−0.0033	−4.05	−0.0021	−1.95	−0.2298	−3.70
TD * TubeTV	0.0062	5.95	0.0043	3.14	0.4714	5.97
TD * Others	0.0047	5.74	0.0046	4.28	0.3620	5.83
R^2	0.9875		0.9769		0.3284	

Table X Analysis of price dispersion movement based on model (4)

	Log SD (posted price)		Log SD (full price)		Log range (full price)	
Variable	Estimate	*t*-statistics	Estimate	*t*-statistics	Estimate	*t*-statistics
MCR	0.0360	0.23	0.1954	3.05	0.1753	2.78
Dotcom	−0.0360	−0.23	−0.1954	−3.05	−0.1753	−2.78
Log mean price	1.8819	8.89	1.7209	21.72	1.7029	21.83
Camcorder	−1.1134	−3.29	−0.9874	−7.59	−1.0151	−7.92
DVD player	−0.7039	−2.65	−0.5899	−5.46	−0.5558	−5.23
Tube TV	−0.5031	−1.49	0.2631	1.90	0.2893	2.12
Others	2.3204	6.09	1.3142	9.02	1.2816	8.93
Time	0.0781	5.15	0.0565	9.12	0.0558	9.15
TM (Time * MCR)	−0.0051	−0.35	−0.0022	−0.36	−0.0011	−0.18
TD (Time * Dotcom)	0.0051	0.35	0.0022	0.36	0.0011	0.18
TM * Camcorder	0.1446	5.34	0.0731	6.60	0.0753	6.90
TM * DVD player	0.0502	1.86	0.0139	1.26	0.0096	0.88
TM * TubeTV	−0.1050	−3.05	−0.0283	−2.01	−0.0280	−2.02
TM * Others	−0.0898	−3.32	−0.0587	−5.31	−0.0569	−5.22
TD * Camcorder	0.1052	3.88	0.0822	7.43	0.0832	7.63
TD * DVD player	0.0433	1.60	0.0323	2.92	0.0281	2.58
TD * TubeTV	−0.0146	−0.42	−0.0449	−3.20	−0.0429	−3.10
TD * Others	−0.1339	−4.95	−0.0696	−6.29	−0.0684	−6.28
R^2	0.4433		0.7751		0.7769	

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online reduces search costs, online shoppers are more sensitive to prices. Lynch and Ariely (2000) experimentally investigated the relationships between search costs and price sensitivity. They found that price sensitivity for common products increased when cross-store comparison was made easy, but easy comparison had no effect on price sensitivity for differentiated goods. Thus, retailers have incentives to avoid price competition by carrying unique products. Unlike many other empirical findings, our results show that online-only retailers may have successfully established their reputations and differentiated themselves although they were selling homogenous products on the Internet. Lowering price is no longer the only tactic for Dotcoms to attract consumers.

We also find that the electronics prices decreased over the period of study in general, and the average prices of MCRs and Dotcoms went down with time at a similar speed. Breaking the time trends into the product categories, we find that the price decrease was mainly caused by the price drop in camcorders and DVD players, while the prices of Tube TV and other products were almost unchanged during the period of our study. Such a result is not surprising. Unlike books, CDs, and DVDs, the types of consumer electronics differ in terms of novelty and speed of innovation[4]. Camcorders and DVD players are newer products and have significantly faster pace of innovation than tube TVs, shelf systems and walkman. As new models of camcorders or DVD players appear in the market, the market demand for the old models will decrease dramatically and many of them may never be sold in the market. To reduce their inventory costs, retailers may cut the prices for these old models, resulting in a decrease in average prices.

Our results also show that price dispersion went up with time in general, with no significant difference in the speed between MCRs and Dotcoms. Again, such an overall movement trend in price dispersion is mainly caused by the product categories of camcorders and DVD players. Our data show that the per week increment in price dispersion based on posted price was 24.3 percent for MCR camcorder, 20.7 percent for Dotcom camcorder, 13.1 percent for MCR DVD player, and 13.5 percent for Dotcom DVD player, while the price dispersion for Tube TV and other products had no significant change during the period of our study. Since some low-cost retailers may undercut rivals on the prices of the novel products, price dispersion increases more for camcorders and DVD players than for the others (Figure 2).

Our results suggest different pricing patterns in the electronics market. Economic theory tells us that market prices are determined by both demand and supply, and in a competitive market, price competition will push prices down toward marginal costs. We have discussed above that as the demand for old models of novel products decreases fast, the retailers may reduce their prices significantly. But reduction in prices is limited by marginal costs. In the electronics market, there may be different cost structures between MCRs and Dotcoms. Among the four MCRs, Best Buy and Circuit City are nationwide retailers. In addition to the retail operation, J&R reaches customers throughout the US with a huge catalogue. Abt Electronics is one of the largest single-store operations in the US, and is an authorized retailer for every major brand. These MCRs have huge inventory that may result in tremendous buying power. So they can charge lower prices than Dotcoms.

Another reason for the different pricing patterns in the electronics market may be that unlike books, CDs and DVDs, price margins for electronics products are not huge even in traditional markets. We observed that many MCRs, such as Best Buy and Circuit City, currently allow their customers to purchase online and pick up the products in local stores. These MCRs' online pricing behavior will affect demand in their physical stores. It may well be critical to keep prices same or similar in order to avoid internal competition and conflict between the two channels. So MCRs charge relatively low prices for these electronics products when they go to the Internet. In order to promote their products, the retailers may also apply different pricing strategies across the electronics products. For example, they may use cheap DVD players as an attraction. Since the electronics market is significantly different from markets of books, music, and movies, it is very interesting to further investigate the same retailers that operate in different markets and see if they behave differently in different product categories.

The findings of this study are based on our limited data sample. Ideally, one should choose both products and retailers randomly to ensure representativeness. However, price comparability requires that all the products chosen must be carried by all the retailers involved. This seems a practically infeasible task, especially for online electronics markets. Nevertheless, the 14 products and eight retailers that we had chosen did represent some major electronic products and major online retailers. Thus, our results may still shed some insights on the pricing patterns in this market, although one should be cautioned to keep in mind that our data sample size is limited.

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Notes

1 All data and detailed analysis tables are available upon request.
2 For the occasional out-of-stock situations during the effective data collection period, we used the previous week's price of the same product as the approximation.
3 The in-store pickup option provides customers with immediate access to goods. Taking into consideration of parking, getting the product and driving, the pickup costs may be higher than what we estimated here, especially for time-pressured customers. But shoppers can always choose delivery by paying shipping costs if they think that in-store pickup is more costly.
4 We are grateful to an anonymous referee for raising this point.

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Capturing the effects of coupon promotions in scanner panel choice models

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Keywords

Coupons, Brand awareness, Data handling

Abstract

The authors develop a logit modeling approach, designed for application to UPC scanner panel data, to assess the effects of coupon promotions on consumer brand choice. The effects of coupon promotions are captured via two measures: the prevailing level of availability and the prevailing face value of coupons for each brand. Both of these measures are derived from coupon redemptions of a separate sample of households. The approach captures both the advertising effect and the price discount incentive of a coupon. It also avoids drawbacks of previous choice models which have incorporated coupon effects by subtracting the value of a redeemed coupon from the price of the brand purchased. The authors illustrate their modeling approach on data for two product categories: catsup (light coupon usage) and liquid laundry detergent (heavy coupon usage). Findings are reported for coupon users and non-users as well as across latent segments.

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The effectiveness of coupons as a promotional vehicle has remained a controversial topic for at least two decades. For example, practitioners who regularly analyze coupon promotions have characterized spending on coupons as a poor investment of marketing dollars (Bucklin and Gupta, 1999). In the mid-1990s, some consumer products companies attempted to eliminate coupons, lower the face value of coupons, and shorten the time to expiration (Narisetti, 1996; Schiller, 1996). These actions proved both unpopular and, arguably, lowered profitability (Nevo and Wolfram, 2002). More recently the volume of coupons distributed has again been rising (Fetto, 2001). Furthermore, coupons have become quite ubiquitous in online shopping (Oliver and Shor, 2003). In light of the major role coupons play in the packaged goods marketing mix and the billions of dollars involved in spending, there is an ongoing need for improvements in the models available for assessing the effect of coupons on sales, share, and profitability.

One concern expressed by managers is that coupons are redeemed predominantly by loyal consumers who would have purchased the brand in any event. The conditional logit brand choice model, applied to scanner panel data (Guadagni and Little, 1983), provides a natural – and parsimonious – modeling approach to assess whether or not coupons induce brand switching. Surprisingly, there has been little explicit attention given to the problem of how best to incorporate the effects of coupon promotions into this model. Indeed, most published findings using the logit model have either omitted the effects of couponing activity or include couponing activity as part of the price variable. When the price variable is modified, which we will refer to as the NETPRICE method, the value of any coupons redeemed by a panelist is subtracted from the price of the brand chosen at that purchase occasion. Though used in a number of published studies on brand choice, the NETPRICE approach has an endogeneity problem and restricts shelf price and coupons to share the same response coefficient[1].

Another issue in capturing the effects of coupons is their potential advertising effect. Leone and Srinivasan (1996) proposed an integrated model of coupon redemption, brand sales, and coupon profitability designed to incorporate this effect. Using scanner panel data, their approach divides households into a coupon prone (CP) segment and a coupon indifferent (CI) segment, specifically incorporating the potential for an advertising effect to operate on the CI segment. While the procedure uses panel data to divide

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store-level sales into the CP and CI groups, the market response models are actually fitted to aggregate-level scanner data. As the authors acknowledge in their paper (pp. 283, 288), there is no reliable way to isolate the effect of coupons on brand switching. Thus, a disaggregate-level approach is needed to address the extent to which coupons induce switching versus simply being redeemed by loyal users.

Erdem *et al.* (1999) proposed a model to impute coupon availability using a joint estimation of choice model parameters and a coupon availability function. The procedure avoids the endogeneity that comes from using a price variable that is defined to be net of coupons redeemed. On the other hand, a limitation of the approach is that the imputed coupon availability of unchosen brands does not vary over time nor can the model capture the potential advertising effect of coupons on non-users (p. 182). Model estimation also requires sophisticated simulation techniques not generally accessible to practitioners.

The purpose of this paper is to develop and empirically test a new approach to capture the effects of coupon promotions in logit brand choice models using redemption information. Our approach includes the effects of coupon promotions in the logit model as separate predictor variables that are not confounded with price. Our goals are to overcome the difficulties with the NETPRICE approach while providing a simple, readily estimable modeling alternative (e.g. one that could be used in the growing class of so-called "marketing mix" models which are designed to assess the relative productivity of different marketing activities in consumer products).

We model the effects of coupon activity as a function of the prevailing level of coupon availability and the prevailing coupon face value. We seek to capture the effect of distribution size as well as the discount incentive offered. We compute these measures from the redemption activity reported for a separate set of households purchasing in the same market area. The modeling approach we develop is best suited for situations in which drop information and expiration dates are either unavailable (the case with most scanner panel data sets) or unable to represent the coupon availability and incentive amounts prevailing in a market area at a given time (e.g. due to multiple delivery modes such as direct mail, the Internet, and FSI's).

To be sure, this measure of coupon availability has several limitations. Consumers may have coupons which they may have clipped several weeks earlier. Consumers may also have multiple coupons available. In order to capture these and other phenomena more precisely, we would need to have a variable capturing the stock of coupons at the household level. However, the data limitations previously discussed make such an approach infeasible. We believe that our proposed approach provides a practical and robust solution to the data limitation problem[2].

We also report results for an *a priori* segmentation that divides panelists into coupon prone and coupon indifferent segments. This permits us to assess whether coupons have an advertising effect upon the coupon indifferent segment, compare coupon users and non-users, and provide a disaggregate model which fits the profitability analysis proposed by Leone and Srinivasan (1996). We also extend the *a priori* segmentation by estimating the choice model with latent classes within the coupon prone and coupon indifferent household groups. We present results for liquid laundry detergent and catsup, which are a high coupon use category and a low coupon use category, respectively.

Modeling approach

The objective of our model is to capture the effects of couponing activity on brand choice. To do this, we study the choice of shoppers whose purchases are recorded in scanner panel data. We represent purchase behavior using a probabilistic choice framework and employ a multinomial logit to model the probability that a panelist makes a brand choice. These choice decisions are modeled conditional on a product category purchase having taken place on a given store visit. Most of this basic modeling approach follows Guadagni and Little (1983).

By conditioning on the occurrence of a category purchase, the model isolates the effect of marketing activity on brand choice. Focusing on choice allows us to capture the behavior that we are primarily interested in: the effect of coupons on consumer switching across brands. Brand switching has a direct relationship to incremental sales and, hence, to profitability analysis. We note that our approach does not capture purchase timing effects (acceleration). Nor do we account for consumption effects (another potential source of incremental volume). However, consumption effects do not seem material for the categories we chose (catsup, detergent) for the empirical application (Ailawadi and Neslin, 1998).

To begin the mathematical specification of the model, we write the purchase probability for alternative i at time t, given a category purchase and store visit, as

$$P_t^h(i|\text{cat}) = \frac{\exp(U_{it}^h)}{\sum_k \exp(U_{kt}^h)} \quad (1)$$

where $P_t^h(i|\text{cat})$ is the probability panelist h selects alternative i, given a store visit and category purchase at time t and U_{it}^h is the deterministic component of utility. We specify the utility, U_{it}^h, as

$$U_{it}^h = \alpha_i + \beta_1 \text{BLOY}_i^h + \beta_2 \text{LBP}_{it}^h + \beta_3 \text{SLOY}_i^h + \beta_4 \text{LSP}_{it}^h + \beta_5 \text{PRICE}_{it} + \beta_6 \text{FEAT}_{it} + \beta_7 \text{DISP}_{it} + \beta_8 \text{COUPAV}_{it} + \beta_9 \text{COUPFV}_{it} \quad (2)$$

where BLOY_i^h is the loyalty of household h to brand of brand-size i; LBP_{it}^h is 1 if i was last brand purchased, 0 otherwise; SLOY_i^h is the loyalty of household h to size of brand-size i; LSP_{it}^h is 1 if i was last size purchased, 0 otherwise; PRICE_{it} is the actual shelf price; FEAT_{it} is 1 if brand-size i appeared in a feature ad at time t, 0 otherwise; DISP_{it} is 1 if brand-size i was specially displayed at time t, 0 otherwise. COUPAV_{it} is the index of coupon availability for brand i, time t; COUPFV_{it} is the average coupon face value for brand i, time t; $\{\alpha_i\}$ is the brand and size constants to be estimated, and $\{\beta_1,\beta_2,\ldots\beta_9\}$ is the parameters to be estimated.

The measures for loyalty (BLOY and SLOY) and last purchase (LBP and LSP) account for cross-sectional and longitudinal heterogeneity in brand and size preference, respectively. The BLOY and SLOY variables are determined from household purchases made in an initialization period and, unlike LBP and LSP, do not vary during the estimation period in the data. This formulation has appeared extensively in the marketing literature and also has been shown to have excellence in-sample and predictive fits when compared with other approaches to handling preference heterogeneity and purchase event feedback (Ailawadi *et al.*, 1999). Price is the actual price on the shelf (in cents per ounce) and feature and display are 0/1 indicator variables. The brand-size constants $\{\alpha_i\}$ follow the formulation given in Fader and Hardie (1996) in which each constant term pertains to a specific brand or a specific size. We now discuss incorporating coupon activity and our two proposed measures, COUPAV and COUPFV.

Coupon variables in the logit model

The NETPRICE approach, in which the price term becomes net of the value of a redeemed coupon, has been used by Bronnenberg and Wathieu (1996), Chintagunta *et al.* (1991), Kamakura and Russell (1989), Krishnamurthi and Raj (1988), and Papatla and Krishnamurthi (1996)[3]. It has the advantage of incorporating coupons in a simple and straightforward manner and is supported by the economic rationale that shoppers compare the prices of the available brand alternatives net of the value of any coupons redeemed. On the other hand, using contemporaneous redemption information for the same household creates a serious endogeneity problem. This occurs because the coupon affects only the price of the chosen brand. Not only are inferences about coupon effects likely to be incorrect in this procedure, but inferences about shelf prices also will be biased because coupons and shelf prices are assumed to share the same coefficient. The endogeneity problem also means that the model cannot be used for scenario evaluation, simulation or forecasting because it depends upon the revealed redemption information to produce estimates of brand choice probabilities. Lastly, the NETPRICE method cannot incorporate the advertising effect a coupon may have on coupon non-users or the incremental effect that advertising may have on coupon users over and above the economic incentive.

Mela *et al.* (1997) modeled coupon promotions from redemption data without using the NETPRICE method. In their approach, a brand coupon was deemed to be available to shoppers if the level of redemptions in that week was one standard deviation above the mean level of redemption activity for the brand. Unfortunately, the study did not report findings for the proposed coupon measure because it was combined with feature and price discount to create a variable representing promotion.

Like Mela *et al.* (1997), our proposed measures for coupons are based on redemption data. In our approach, however, coupon availability is a continuous variable (vs a 0,1 discrete variable) and face value is incorporated. Also the Mela *et al.* (1997) approach uses redemptions for the same households used for model estimation. Instead, we use redemption information from a hold-out sample of households so as to avoid introducing endogenous information. Since larger share brands are expected to have higher redemption rates (Blattberg and Neslin, 1990), we normalize (i.e. mean center and standardize) the redemption index for each brand across weeks. This procedure produces a measure of relative coupon availability for each brand in each week. We label this variable COUPAV_{it} in equation (2). We then incorporate the prevailing face value in the model with the variable COUPFV_{it}. It is defined as the average face value of coupons redeemed for the brand in week t, also computed from the hold-out set of panelists.

Because redemption rates increase with coupon face values (Blattberg and Neslin, 1990),

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high-value coupons will have more redemption activity than low-value coupons, *ceteris paribus*. Thus, an availability index based on redemption activity can be pushed upwards when face values are high and downwards when face values are low. For example, the (0, 1) coupon variable proposed by Mela *et al.* (1997) does not control for this effect. Because our approach also incorporates COUPFV_{it} in the model, we control for the potential inflation or deflation of redemption rates that can be due to higher or lower coupon face values. Thus, our two proposed measures are designed to capture the total impact of prevailing coupon availability and face value on consumers' brand choices. As in Mela *et al.* (1997), we base the coupon measures on the actual redemption activity prevailing in the market (though we use a separate set of panelists). Thus, we continue to utilize observed measures for coupons versus an econometric imputation approach (Erdem *et al.*, 1999).

The modeling approach we develop is best suited for situations in which drop information and expiration dates are either unavailable (the case with most scanner panel data sets) or unable to represent the coupon availability and incentive amounts prevailing in a market area at a given time (e.g. due to multiple delivery modes). Due to the large (and growing) number of delivery vehicles (Harmon and Hill, 2003, p. 167) now used for coupon promotions (e.g. direct mail, check-out, in-store dispensers, Internet and Web sites, and traditional FSI's), it is increasingly difficult to assemble a complete picture of coupon availability and face value without recourse to the information contained in redemption data. For these reasons, we believe that it is important to develop modeling approaches that can be implemented on redemption data alone.

Empirical application

Data

We apply our modeling approach to scanner panel data for catsup and liquid laundry detergent. Coupon usage is light to moderate in the catsup category (about 40 percent of households redeem coupons at one time or another) while it is heavy in the detergent category (about 90 percent of households redeem coupons). Both data sets are drawn from panelists shopping in Sioux Falls, SD, from 1986-1988 and were provided by ACNielsen for academic research.

In catsup, we consider the top five selling brands (sold in four sizes) and the data set comprises 823 panelists who made 4,573 purchases over a 52-week estimation period. The brands and their market shares are Heinz (71 percent), Hunt's (15 percent), Del Monte (8 percent), and two private labels (4 and 1 percent). Redemption information is based on a hold-out sample of 2,366 households who made 9,273 category purchases. In laundry detergent, we consider the top seven selling brands (five are offered in four sizes, two are offered in three sizes) and the estimation data set comprises 392 households who made 3,064 category purchases. The brands and their market shares are Tide (25 percent), Wisk (25 percent), Era (15 percent), Surf (15 percent), Cheer (8 percent), Solo (7 percent), and Bold-3 (4 percent). Redemption data are taken from a hold-out set of 1,456 households who made 5,709 purchases.

Estimation approach and segmentation

We fit the model on the estimation-sample households both with and without the coupon availability and coupon face value measures. This permits us to empirically investigate the problems of the NETPRICE approach that we detailed earlier. We then compare the results from our proposed model against those from applying the NETPRICE approach (where the value of any redeemed coupons is subtracted from the shelf price). In each of these cases, we estimate the parameters of the brand choice model (equation (2)) by maximizing the likelihood of the observed brand choices.

Our next step is to estimate our proposed model based on the *a priori* segmentation scheme introduced by Leone and Srinivasan (1996). We divide the estimation sample into coupon users and non-users and fit the choice model separately for each group. Note that in equation (2), there is potential cross-sectional heterogeneity in the response parameters of the utility function. Even though the households have been segmented according to coupon usage, additional heterogeneity in response may remain within each *a priori* segment. To accommodate this response parameter heterogeneity, we also estimate the model with latent segments (Kamakura and Russell, 1989) for both the coupon users and non-users.

In the latent segment logit model, equation (1) is modified to

$$P_t^h(i|\text{cat}) = \sum_s \pi_s P_{st}^h(i|\text{cat}) \tag{3}$$

where π_s equals the size of segment s ($0 < \pi_s < 1$) and $P_{st}^h(i|\text{cat})$ is the brand choice probability given that household h is a member of segment s. In this model, the response parameters, β, in equation (2) become segment-specific. In contrast to the *a priori* segmentation, a model selection criterion is needed to determine the appropriate number of

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latent segments to retain. We assess the predictive validity of all models using the BIC (Rust *et al.*, 1995; Schwarz, 1978).

Results

Tables I and II show the parameter estimates, model fits, and BIC values, for the base (or null) model, the full model using shelf price, and the same two models using the NETPRICE approach for catsup and liquid detergent, respectively[4]. For the shelf price full model in catsup (Table I), the coupon availability parameter is correctly signed and significant ($\beta_8 = 0.122$, $t = 4.57$) and the model fit improves significantly ($\chi^2 = 21.2$, $p < 0.01$) when compared to the base or null model. The coupon value parameter, though positively signed, is insignificant. In the detergent category (Table II), the parameters for both coupon availability ($\beta_8 = 0.211$, $t = 9.46$) and coupon value ($\beta_9 = 0.916$, $t = 3.94$) are positively signed and significant in the shelf price full model. Model fit improves quite substantially in moving from the base model to the full model (a difference of about 70 log likelihood points, $\chi^2 = 140$, $p < 0.01$). Not surprisingly, the impact of the coupon variables on choice is much stronger in the category with heavy activity (detergent) than in the category with lighter activity (catsup).

Tables I and II also present the same models but with the price variable modified according to the NETPRICE approach (i.e. the price variable is reduced by the amount of any redeemed coupons). In both categories, the results for the base model show that the magnitude of the estimated price coefficient is approximately 30 percent greater in

Table I Catsup: models with coupon users and non-users

	Shelf price		Net price	
	Base model	**Full model**	**Base model**	**Full model**
Brand loyalty	2.520 (24.181)*	2.525 (24.074)	2.539 (23.757)	2.543 (23.671)
Last brand purchased	0.592 (12.066)	0.594 (11.999)	0.582 (11.657)	0.585 (11.647)
Size loyalty	2.347 (19.502)	2.345 (19.477)	2.357 (19.322)	2.355 (19.332)
Last size purchased	0.761 (13.441)	0.760 (13.387)	0.742 (12.925)	0.742 (12.887)
Price	−0.929 (−15.4872)	−0.935 (−15.4766)	−1.172 (−24.5772)	−1.172 (−24.4033)
Feature	1.383 (23.759)	1.350 (23.036)	1.344 (23.371)	1.316 (22.625)
Display	0.595 (6.581)	0.570 (6.282)	0.601 (6.480)	0.580 (6.228)
Coupon availability		0.122 (4.569)		0.111 (4.040)
Coupon value		0.139 (0.444)		0.170 (0.536)
Log likelihood	−4855.73	−4845.14	−4633.87	−4625.57
BIC	−4914.73	−4912.56	−4692.86	−4692.99
No. of households	823	823	823	823
No. of purchases	4,573	4,573	4,573	4,573
No. of parameters	14	16	14	16

Note: **t*-values in parentheses

Table II Detergent: models with coupon users and non-users

	Shelf price		Net price	
	Base model	**Full model**	**Base model**	**Full model**
Brand loyalty	3.080 (32.556)*	3.168 (32.814)	3.096 (32.564)	3.181 (32.826)
Last brand purchased	0.907 (19.165)	0.900 (18.785)	0.903 (18.971)	0.895 (18.588)
Size loyalty	1.935 (19.355)	1.917 (19.818)	1.957 (19.441)	1.940 (19.444)
Last size purchased	0.696 (15.815)	0.700 (16.011)	0.684 (15.433)	0.688 (15.660)
Price	−0.587 (−17.1289)	−0.554 (−16.1199)	−0.771 (−22.2401)	−0.739 (−21.3223)
Feature	1.462 (18.532)	1.285 (15.773)	1.373 (17.429)	1.196 (14.657)
Display	1.305 (16.982)	1.212 (15.681)	1.249 (16.251)	1.157 (14.930)
Coupon availability		0.211 (9.457)		0.205 (9.097)
Coupon value		0.916 (3.936)		0.885 (3.778)
Log likelihood	−6169.14	−6098.80	−6060.41	−5995.87
BIC	−6233.36	−6171.04	−6124.63	−6068.12
No. of households	392	392	392	392
No. of purchases	3,064	3,064	3,064	3,064
No. of parameters	16	18	16	18

Note: **t*-values in parentheses

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the NETPRICE models than in the shelf price models. All other parameters remain essentially unchanged. Thus, including coupon activity as part of the price variable significantly alters (biases upwards) the estimated magnitude of the price coefficient. This occurs even when the coupon variables are incorporated.

We also examined the predicted choice probabilities for the items actually chosen in the catsup category. For purchase occasions in which a coupon was redeemed, the shelf price model without coupon variables has a mean predicted probability for the item actually chosen of 0.30. On the other hand, the net price model, also without coupon variables, has a corresponding mean predicted probability of 0.59. Comparing this to purchase occasions in which no coupon was redeemed, we find that the shelf price model predicts 0.39 while the net price model also predicts 0.39. In sum, our results support the concerns raised about the NETPRICE approach and indicate the need for alternative ways of incorporating coupon activity into the logit.

Segment results

Following Leone and Srinivasan (1996), those households recording one or more redemptions were placed into a coupon prone group while households recording no redemptions were placed into a coupon indifferent group. This segmentation permits us to evaluate differences in market response across the two groups and to specifically assess whether coupons have an advertising effect on the non-user group. Also, if coupons are to be effective as a price discrimination device (Narasimhan, 1984), the coupon prone group should be more sensitive to changes in price (i.e. have higher absolute price elasticities) than the coupon indifferent group. Finally, knowing the membership of each group permits an analysis of differences in demographic and purchase-pattern characteristics.

In addition to this *a priori* segmentation scheme, we use latent class analysis to accommodate potential response-parameter heterogeneity within each group[5]. Thus, our procedure combines *a priori* segmentation with *post hoc* segmentation. To do this, we estimate the choice models for both the coupon-prone and coupon-indifferent households with latent segments. For catsup, a one-segment solution is selected for the coupon user group while the two-segment model is selected for the non-user group. Following the Bayesian Information Criterion (Rust *et al.*, 1995; Schwarz, 1978) for detergent, a three-segment model is selected for the user group and a one-segment model for the non-user group[6].

Table III reports the parameter estimates and t-values for the various segments in both catsup and laundry detergent. In the catsup coupon-user segment, the coefficient for coupon availability is correctly signed and significant while neither latent segment of coupon non-users shows a significant effect for this variable. Coupon value is not significant in any of the catsup segments[7]. In detergent, coupon availability is positively signed and significant in each of the latent segments of coupon users. It is correctly signed and significant at the.10 level ($\beta_8 = 0.186$, $t = 1.79$) in the non-user segment, providing some evidence of an advertising effect of coupons among the non-user panelists. The (marginal) significance of the effect in detergent and its non-significance in catsup may be related to the extent of couponing activity in the category (Srinivasan *et al.*, 1995) – i.e. large numbers of coupons need to be dropped and redeemed for an advertising effect to be meaningful. As expected, coupon value is not significant for non-users but is significant for user segments 1 and 2 and marginally so for user segment 3.

Posterior analysis of the segments

To explore the potential cross-sectional differences among the various segments, we conducted an informal posterior analysis of the various groups. In Table IV, we report segment-level means for elasticities, loyalty indices, measures of deal proneness, and demographics for the *a priori* segmentation of users and non-users for both categories. This permits us to illustrate potential differences among panelists that come directly from whether or not they redeem the coupons[8]. In Table V, we report the same measures for each of the latent segments. Since assignment to latent segments (e.g. segment 1 or 2 of the non-coupon users in catsup) is probabilistic, the segment-level means we report are weighted by the posterior probability of a given panelist belonging to a given segment.

Turning first to Table IV, we begin with elasticities. All of the elasticities are arc elasticities computed from simulating the effect of a change in the marketing variable on the choices made by the panelists during the estimation period. Price elasticities are computed as the percentage change in choice shares given a one percent change in price. Coupon availability elasticities are computed as the percentage change in choice shares given a change in availability from the lowest level to the highest level in the estimation period. Coupon value elasticities are computed as the percentage change in choice shares given a one percent change in coupon value (this computation is made only in those cases where the variable coefficient was correctly signed).

Table III Parameter estimates for segment models

	Catsup			Detergent			
		Non coupon users		Coupon users			
	Coupon users	Segment 1	Segment 2	Segment 1	Segment 2	Segment 3	Non coupon users
Brand loyalty	2.578 (15.199)*	5.009 (8.217)	1.073 (4.762)	5.630 (20.070)	1.191 (3.681)	2.952 (14.235)	2.886 (8.990)
Last brand purchased	0.511 (7.232)	0.102 (0.500)	0.656 (6.507)	0.357 (3.224)	0.192 (1.708)	1.248 (11.528)	1.782 (9.885)
Size loyalty	1.826 (9.169)	3.752 (10.736)	0.578 (1.485)	4.174 (12.979)	1.677 (6.565)	0.464 (2.200)	1.989 (7.253)
Last size purchased	0.554 (6.593)	0.853 (5.077)	0.521 (2.752)	0.322 (3.127)	0.704 (6.349)	0.614 (6.991)	0.468 (3.105)
Price	−1.107 (−12.4915)	−0.796 (−4.0100)	−0.829 (−4.7722)	−0.733 (−9.1339)	−0.795 (−7.5348)	−0.316 (−4.2874)	−0.370 (−3.0728)
Feature	1.389 (17.131)	1.489 (6.787)	1.323 (8.574)	0.802 (3.710)	0.826 (3.901)	1.948 (10.947)	1.646 (4.994)
Display	0.484 (3.724)	0.947 (3.130)	0.462 (2.028)	1.360 (7.503)	1.030 (5.492)	1.401 (9.133)	1.382 (4.934)
Coupon availability	0.209 (5.560)	0.042 (0.382)	0.013 (0.215)	0.176 (3.846)	0.248 (5.438)	0.249 (5.461)	0.186 (1.790)
Coupon value	−0.505 (−1.1407)	1.160 (1.244)	0.710 (1.067)	1.287 (2.142)	1.151 (2.201)	0.888 (1.889)	−0.711 (−0.7342)
Segment size	n/a	0.097 (0.406)	n/a	−0.242 (−1.2538)	−0.349 (−1.6357)	n/a	n/a
		0.524	0.476	0.315	0.283	0.402	
Log likelihood	−2286.09	−2438.69		−5390.53			−447.42
BIC	−2348.00	−2566.24		−5612.83			−497.43
No. of households	327	496		350			42
No. of purchases	2,297	2,276		2,805			2,59
No. of parameters	16	33		56			18

Note: *t-values in parentheses

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Table IV Characteristics of coupon users and non-users

	Catsup		Detergent	
	Coupon users	Non coupon users	Coupon users	Non coupon users
Elasticities				
Price	−1.243	−0.978	−1.816	−0.893
Coupon availability	33.434	4.363	98.617	55.198
Coupon value	0.000	0.055	0.396	0.000
Loyalty indices				
Brand	0.743	0.767	0.551	0.740
Size	0.816	0.840	0.597	0.581
Store	0.437	0.493	0.465	0.584
Deal proneness				
Coupon propensity	32.983	0.000	63.627	0.000
Feature propensity	35.020	26.957	17.897	10.463
Display propensity	12.175	10.814	20.619	16.710
Percent savings from coupons	11.867	0.000	15.045	0.000
Demographics				
Usage (annual oz.)	242.398	153.169	628.846	525.714
Family size	3.489	3.210	3.091	3.238
Percent single/multiple family house	94.495	90.323	93.714	85.714
Percent vollege education	56.575	45.968	57.714	54.762
Percent income >30K	42.813	39.516	44.857	42.857
Percent dual employment	43.425	45.968	40.571	57.143
No. of households	327	496	350	42

Table V Segment characteristics

	Catsup			Detergent			
		Non coupon users		Coupon users			
	Coupon users	Segment 1	Segment 2	Segment 1	Segment 2	Segment 3	Non coupon users
Elasticities							
Price	−1.243	−0.652	−1.337	−2.038	−2.747	−0.904	−0.893
Coupon availability	33.434	3.845	0.065	75.477	140.657	107.987	55.198
Coupon value	0.000	0.051	0.065	0.413	0.462	0.294	0.000
Loyalty indices							
Brand	0.743	0.824	0.704	0.617	0.431	0.583	0.740
Size	0.816	0.836	0.845	0.615	0.633	0.559	0.581
Store	0.437	0.515	0.469	0.476	0.451	0.467	0.584
Deal proneness							
Coupon propensity	32.983	0.000	0.000	59.991	72.600	60.151	0.000
Feature propensity	35.020	24.749	29.391	12.423	18.330	21.888	10.463
Display propensity	12.715	10.145	11.551	16.060	21.381	23.659	16.710
Percent savings from coupons	11.867	0.000	0.000	13.753	21.148	11.754	0.000
Demographics							
Usage (annual oz.)	242.398	153.340	152.981	708.636	515.840	645.957	525.714
Family size	3.489	3.180	3.242	3.157	3.081	3.048	3.238
Percent single/multiple family house	94.495	90.728	89.875	93.338	93.115	94.432	85.714
Percent college education	56.575	52.789	53.708	57.464	55.847	59.204	54.762
Percent income >30K	42.813	39.578	39.448	47.853	43.646	43.360	42.857
Percent dual employment	43.425	45.842	46.107	47.556	34.353	39.477	57.143
No. of households	327	260	236	110	99	141	42

First, we note the difference in price elasticities across the users and non-users in both categories. Price elasticities are larger (in absolute magnitude) for coupon users than non-users. The catsup means are −1.24 and −0.98 and the detergent means are −1.82 and −0.89, respectively. These results directly corroborate Narasimhan (1984). Second, the elasticities for coupon availability suggest that large changes in share can be induced by changes in coupon activity. For example, a move from the lowest level of availability to the highest level of availability approximately doubles the choice share for a brand among coupon users in detergent while increasing it by 33 percent among coupon users in catsup. Lastly, the calculations for coupon value elasticity

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(significant only for detergent coupon users) shows an inelastic response level of about 0.4. This indicates that choice share can be expanded by 40 percent (among detergent coupon users) if coupon face value is doubled. (We address the profitability implications of this below.)

In Tables IV and V we also present indices for brand loyalty, size loyalty, and store loyalty. In general, coupon users appear to be less brand and store loyal than coupon non-users. There is relatively little difference among the segments in size loyalty. Turning to the deal proneness measures, catsup coupon users make approximately one third of their purchases with a coupon, while detergent coupon users redeem a coupon about 64 percent of the time. The proportion of items bought while on feature is also higher for coupon users and, to a lesser degree, so is the proportion of items bought while on display. Note that these proportions do not reflect response (i.e. the effect of changes in feature or display on choice) which was previously shown to be the same or higher for coupon non-users. Overall, catsup coupon users saved about 12 percent while detergent coupon users saved about 15 percent by redeeming coupons.

With respect to demographics, coupon users in both categories are, on average, heavier users than coupon non-users. One exception to this is the second latent segment of detergent coupon users. Its average usage rate is the lowest of all four detergent segments. Interestingly, this segment is both most price elastic and most responsive to coupon availability and coupon face value. Perhaps the need to buy somewhat less often in the category may enable these panelists to purchase more opportunistically than those in detergent user segments 1 or 3.

Coupon users are, on average, somewhat more likely to live in houses than apartments (Table IV). They are also better educated and have higher incomes (Harmon and Hill, 2003, p. 166). Interestingly, they also may have more time to take advantage of coupons: the percentage of coupon-using panelists with dual head-of-household employment is lower in both categories than the percentage for coupon non-users. This finding is reinforced by the pattern for the latent segments of coupon users in detergent. Again, segment 2, with the highest level of coupon elasticities, has the lowest level of dual employment (34 percent).

Cross-validation

In order to ensure that our latent segment results are stable and are not capitalizing on chance variation within the estimation sample we conducted a double cross-validation assessment for the segmentation of the coupon users in the detergent category. Using the redemption information from the calibration sample of households for the coupon variables, we also estimated the model on the hold-out sample of households ($n = 334$). The three-segment solution was also selected by the BIC and the pattern of results paralleled the three-segment solution for the coupon users in the calibration sample. To double cross validate, we then used the parameters obtained from the hold-out sample to fit the model to the calibration sample and the parameters from the calibration sample to fit the model to the hold-out sample. In both cases, the three-segment solution provided better fits to the data than the single-segment solution. For the calibration sample using hold-out parameters, the log likelihood values were -5662.8 and -5581.3 for the single- and three-segment solutions, respectively. For the hold-out sample using calibration parameters, the log likelihood values were -4936.0 and -4855.1 for the single- and three-segment solutions, respectively.

Implications for profitability assessment

The findings regarding the market response to changes in coupon availability and coupon face value have implications for the assessment of coupon profitability. In detergent, for example, share can be increased by either increasing coupon availability or by increasing face value or both. In catsup, on the other hand, share appears to respond meaningfully only to changes in availability[9]. The profitability of increasing availability depends upon the gross margin realized from new sales due to brand switching, the fixed costs of additional distribution and the variable costs of redemption. The profitability of higher face values depends upon gross margin from new sales and the variable costs of redemption.

More generally, the model can be used as an input to a decision support system for evaluating coupon profitability (e.g. as the market response component of a system like the one proposed by Leone and Srinivasan, 1996). In order to do this, the coupon availability measure will need to be scaled to the corresponding levels of coupon distribution activity. The net sales attributable to a change in availability can then be linked to the additional marketing spending that was required to produce it. The approach is similar to the notion that a given number of gross rating points (GRPs) can be directly connected to the media spending levels needed to produce them.

Conclusion

The purpose of this paper has been to develop and illustrate an approach to capture the effects of

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coupon activity in logit models of brand choice applied to scanner panel data. Methodologically, our approach is designed to take advantage of the information contained in coupon redemption data and to incorporate the effects of both coupon availability as well as coupon face value. Our model is especially suited to situations in which information on coupon distribution is either unavailable or unlikely to accurately reflect the week-to-week availability of brand coupons (e.g. due to the use of multiple delivery vehicles, overlapping drops, etc.). We measure weekly coupon availability based on normalized redemptions and face value as the average value, in each week, of all coupons redeemed for the brand by a hold-out set of households. Our approach therefore avoids the endogeneity problems in previous choice models that handle coupons by subtracting the value of any redeemed coupons from price – what we have termed the NETPRICE approach.

We present an empirical application of our modeling approach on two categories of scanner panel data, catsup and liquid laundry detergent. We show that our proposed measures of coupon activity (prevailing availability and face value) are predictive of brand choice and significantly improve the fit of the models to the data. A comparison of our model with the NETPRICE approach specifically illustrates the drawbacks of incorporating coupons via the price term in the logit. We find that the magnitude of the price coefficient is biased upwards quite substantially (about 30 percent in our data). Thus, a major limitation of the NETPRICE procedure is that it is likely to systematically overstate consumer response to changes in price.

Our estimation work in catsup and liquid laundry detergent also provides a number of substantive insights into the nature and segmentation of market response to coupons. In illustrating our modeling approach, we conduct a segment-level estimation, employing both an *a priori* division of the sample as well as a *post hoc* segmentation using latent class analysis. Following Leone and Srinivasan (1996), we estimate the model separately for coupon users and non-users. This produces the following key findings. First, price elasticities are higher for coupon users than non-users, corroborating Narasimham (1984). Second, we find evidence (at the $p < 0.10$ level) for an advertising effect of coupons on non-users in laundry detergent, though no effect in catsup. We also compute elasticities for the coupon variables which show that changes in coupon activity can lead to large changes in brand shares. Lastly, the results show coupon users to be less brand loyal, more deal prone, and demographically advantaged in having the time to take advantage of coupon promotions. Collectively, these findings suggest that coupons function much as the other short-run promotion vehicles used in packaged goods.

A limitation of our approach is that both the coupon availability and coupon face value variables are likely to be measured with error – though we do not expect this error to be systematic. The consequence of measurement error in these variables – as in most variables in the utility function – will be a bias in the parameter estimates towards zero. Thus, the true impact of coupon promotions on brand choice may be understated by this model. This limitation needs to be balanced against the drawbacks of the other extant approaches to handling coupons in logit choice models for scanner panel data.

The model and some of the substantive findings from its estimation on the two product categories should be of interest to both manufacturers and retailers. Manufacturers can use the model to obtain estimates of new sales that are truly incremental for the brand due to coupon promotions. They can also study the nature of market segmentation in coupon response and how it relates to segmentation in response to other marketing mix activity. The model can also reveal whether coupons are delivering an advertising effect in the market to coupon non-users. If significant, this effect should be incorporated into the computation of coupon promotion profitability (Leone and Srinivasan, 1996).

While the value of the model is perhaps immediately clearest for manufacturers, it should be of interest to retailers as well. Retailers incur substantial expenses in honoring and processing coupons. In many markets, competitive conditions have also prompted retailers to double the value of manufacturer coupons. Thus, coupons have an important impact on the profitability of grocery retailers. With the advent of so-called "frequent shopper clubs," retailers now have individual-level transaction data for many – if not most – of their customers. As a consequence, many retailers are now in the position to analyze the effects of coupons without relying on data analyses provided by manufacturers.

The ability to independently assess the impact of promotion activity can provide retailers with information and countervailing power that they otherwise would have lacked. For example, coupon response elasticities can be contrasted with price, feature, and display elasticities to suggest allocations of promotional spending that provide "win-win" outcomes for both manufacturer and retailer. For example, an application of the model might reveal that coupons induce little response but end-aisle displays induce large response.

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The implication is that both manufacturer and retailer could be better off if couponing were reduced and those dollars shifted into supporting increased display activity.

Notes

1. In fact, Leone and Srinivasan (1996), using data on specific coupon drops, found different effects from price cuts and coupons of the same value.
2. We thank an anonymous reviewer for suggesting that we note these limitations.
3. This list is intended to be representative and not exhaustive.
4. Our objective with this comparison is to provide a symmetric contrast of our approach with the NETPRICE approach to highlight the econometric differences. We therefore present in Tables I and II results for the shelf price and NETPRICE models both with and without the coupon measures.
5. Previous research (e.g. Andrews *et al*., 2002; Kamakura and Russell, 1989) has shown that if modelers do not account for unobserved heterogeneity when estimating disaggregate (household-level) econometric models, the estimated response parameters could be biased. In our approach we account for both observed heterogeneity via the *a priori* classification in coupon users and non-users and unobserved heterogeneity via latent class (or a finite mixture).
6. Complete model estimation and fit results are available from the first author upon request.
7. We conjecture that the (unexpected) negative sign for coupon value in the user segment may be due to the correction it can provide for overstated availability if redemptions run higher when face values increase.
8. Our exploratory analysis does not conduct the formal tests of coefficient equivalence which would be required to establish whether or not differences across segments are statistically significant.
9. This result could be due to the limitations of the natural experiment provided by the data. If there is little variation in coupon face value, it will have an insignificant effect on choice in the model.

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Iso-profit pricing for product lines

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Keywords

Breakeven analysis, Profit, Pricing, Promotional methods, Pricing policy

Abstract

When considering a price decrease in response to competitive pressures or stagnating demand, management may ask how much additional volume must be sold at the new price to match the current profit level. This "iso-profit" pricing problem has been studied extensively for single items manufactured using one resource. This paper solves three realistic extensions of the problem: when two or more items share a resource, when multiple items share multiple resources, and when resource vendors offer quantity discounts. Findings are summarized in 12 points, many of which are counterintuitive.

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Introduction

This paper presents techniques to provide additional price and volume information in situations where management must decide whether and by how much to decrease price in the face of competitive pressures or stagnating demand. This type of problem has been studied under various names, including incremental breakeven analysis (Nagle and Holden, 1987, 2002), margin arithmetic (Hoch *et al.*, 1994), and iso-profit pricing (Tabush, 2003). Hoch *et al.* state the problem as follows: "Given a particular change in everyday prices, what is the attendant change in volume necessary to maintain profits at the same level as before the price change?". We adopt the term iso-profit pricing and expand its application from the traditional single item focus to multiple items linked in a product line. Findings shed light on important pitfalls facing management using price decreases, whether to fight competition or to promote sales. Results help to fulfill Bucklin *et al.*'s (1998) vision that marketing managers "... need to link marketing decision systems with accurate, up-to-date information on costs".

Surprisingly, there are few mentions of iso-profit pricing (or margin arithmetic, or incremental breakeven pricing) in marketing or related fields, including cost accounting. Hoch *et al.* focus only on the simplest case where all operating costs are assumed to be fixed. Their formulation provides a conservative lower bound on the volume increases and cost decreases required for a price decrease to pay out for a retailer. Nagle and Holden (1987, 1995, 2002) generalize to cases where variable cost depends on price and where fixed cost can increase in discrete increments. However, they limit their analysis to one product, whereas many realistic problems involve product lines. The lack of published work in marketing, accounting, and economics is notable given the wide variety of pricing decisions that can benefit from iso-profit pricing. Iso-profit pricing has strategic implications for a single enterprise and for multiple enterprises linked in a supply chain. It operationalizes the economic principle of marginal cost equals marginal revenue in contexts where discrete cost functions and shared resources make implementing the theory a legitimate topic for deeper study.

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Illustrative examples

To clarify the kinds of practical problems we have in mind, consider the following three examples. These are progressively harder to solve but increasingly realistic. Example 1 considers a retailer deciding whether to meet a competitor's price decrease from \$2.99 to \$2.69. The retailer's sales of the item average 1,000 units per week, the time unit chosen for analysis. In this case, neither variable nor fixed costs change, but the item's contribution margin decreases. The retailer is concerned with the incremental volume needed to achieve the same profit level as at the base price of \$2.99. This volume of 1,667 units can be found using a closed form expression originally derived by Nagle and Holden (1987) and reproduced in Appendix 1 for reference. The solution (\$2.69, 1,667) is one point on an iso-profit curve. For our purposes an iso-profit price curve is defined as a collection of price (p), volume (v), and profit (π) numbers such that variable combinations of p and v yield the same profit level. The idea can be stated symbolically as $(p, v) = \pi_0$, where the symbol π_0 should be interpreted as baseline profit or, alternatively, as the starting or initial profit prior to a price decrease.

In Example 2, a more complex form of the problem arises when the resources needed to produce output are capacitated. In this example, a small firm uses four workstations to support current demand. Each workstation has a capacity of 1,000 units per month[1]. Management is considering a price decrease, necessitating higher volume to maintain the current profit level. At some point, the increased volume must be supported by an additional workstation. This increases costs and triggers a cycle where even more volume may be needed to regain the initial profit position. Finding even a single fixed, stable point $(p, v) = \pi_0$, subject to the capacity constraint and the cost of incremental resources, is more difficult than in example one.

Figure 1 shows three iso-profit curves for this problem. The precise curve depends on the cost of an additional workstation and the amount of the price decrease. To illustrate, workstation cost is varied at three levels – \$400, \$800, and \$1,200 – and a series of price decreases in 25 cent increments from the base price of \$10 down to \$8 is considered. Nagle and Holden (2002) solve this problem when a workstation costs \$800, variable cost per unit is \$4.00 and the new price is \$9.50. Their solution (\$9.50, 4,700) (refer Appendix 1) is one point (the shaded square) on the middle curve in Figure 1. The curve fit to the discrete iso-profit points in Figure 1 is derived by least squares fit. Management can read this iso-profit curve at any relevant price to get a clear idea of the volume necessary to break even with the base position (p_0,v_0). Of course, the incremental volume necessary to do so is simply (v-v_0). Later, we discuss a number of strategic takeaways from this type of analysis.

Finally, consider a third example representing the primary focus of this paper. Unlike the foregoing, assume there are multiple products in a product line, any or all of which may undergo a price decrease. Add to this the fact that several resources, each capacitated, are required to produce these items. Finally, factor in the possibility that resource vendors offer quantity discounts. This paper provides guidelines and solution techniques for this important expanded class of iso-profit pricing problems. The paper also illustrates each new development and extracts broader strategic insights in cases where solutions are counterintuitive. In the heat of a price war (Rao, 1984) or when considering aggressive pricing (Guiltinan and Gundlach, 1996), management can easily misdiagnose the consequences of a particular price decision. Unexpected, and sometimes highly undesirable, results can follow.

Organization

Because iso-profit pricing uses a supply-side perspective rather than the demand-side view emphasized in marketing and economics, the next section briefly contrasts these viewpoints. The supply-side approach is prominent in operations research and manufacturing. It emphasizes the realities of production constraints and focuses less on volume response to price than do most pricing texts (Dolan and Simon, 1996; Landsburg, 1995; Monroe, 1990). Both views have merit, and ultimately the most capable price strategists blend the two.

Subsequent sections of the paper deal with several important situations involving iso-profit pricing. As the scenarios become richer and more realistic, new issues enter the picture and new insights are gained. Table I provides a road map to the examples developed in the paper. To the author's knowledge, the extant literature only addresses row one, the case where a single resource is needed to manufacture items. For example, Nagle and Holden couch their example in terms of "workstations". Of course, "one resource" does not literally mean a single machine or a finite workforce but can include multiple resources as long as their total cost can be bundled so that cost changes are proportional to changes in overall production capacity.

Normally, several unique resources are involved in manufacturing even a single item. In this case, the analysis must explicitly address issues of how

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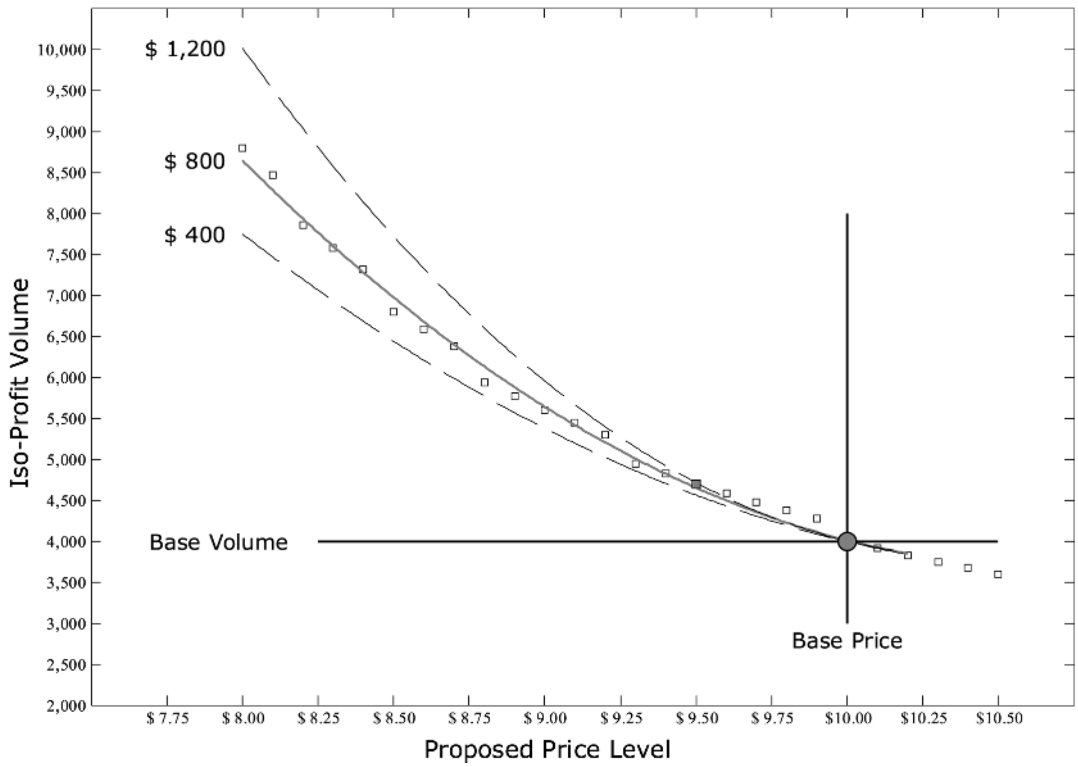
Figure 1 Resource cost and iso-profit volumes



the item's cost is apportioned among resources and, conversely, how multiple items sharing a resource share the cost of incremental units of the resource. With capacitated resources – virtually always the case – a major issue is to solve the requirements planning problem while including capacity constraints, which take the form of a production frontier for each resource. In other words, a "machine" can either make so many units of x or so many units of y or some feasible combination of both in a given time period. If price is lowered for x and differentially for y, how is the cost of an additional "resource" factored into the iso-profit pricing solution?

The other major conceptual development in this paper is captured in the columns of Table I, which correspond to additive and non-additive cost functions to obtain additional resources. Costs are non-additive if the workstation vendor offers a quantity discount so that the cost of two machines is less than two times the cost of a single machine[2]. The extant literature considers only additive cost functions. Including non-additive cost functions creates an interesting auxiliary problem referred to as the "cost slack problem". Appendix 6 structures and solves this problem for the two-item product line and provides the solution technique for the general N-item scenario.

Following the illustration of these major cases, the paper concludes with a discussion of limitations and directions for future work.
To enhance readability, technical development for all cases is relegated to appendices. The Matlab computer code used to solve the cases presented in this paper is available from the author.

Supply-side vs demand-side pricing

Most pricing textbooks focus on base rate pricing rather than pricing in the context of competitive dynamics. They typically suggest collecting price-volume-cost data for an item to estimate the item's price elasticity (Dolan and Simon, 1996; Friedman, 1990; Landsburg, 1995; Monroe, 1990). Relevant first-order conditions are used to select a profit maximizing price (or price vector) under various assumptions, e.g. the Amoroso-Robinson condition (Jensen, 1967) and category management (Zenor, 1994).

Iso-profit pricing reverses this logic by directly exploring the volume change implied to achieve a profit goal at a given price. A demand model with its attendant requirements is not necessarily specified, although astute managers blend both approaches. The supply-side view is often considered more concrete than the demand-side view. Marketing managers are apt to treat costs as accounting facts, while price elasticity, inter-item dependencies, and other demand constructs are seen as latent

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Table I Types of iso-profit cases solved

	Vendors selling resources use cost functions that are Additive	Non-additive
Base case: one-item, all costs are variable	Cost functions are additive-linear in incremental volume	Cost functions exhibit interactions, negative or positive
One resource		
One-item	Continuous case: Hoch *et al.* (1994) treat resource costs as variable Discrete case: Nagle and Holden (1987, 2002) treat resource as discrete with finite capacity	The cost of multiple resources may be less than full additive cost due to quantity discounts offered by vendors or more than full additive cost if a "third labor shift paid at an overtime rate" must be added
Two-item product line Key issue: cost sharing (confounds requirements planning and production frontier)	Items are manufactured using "one resource:tc" subject to a production frontier	Quantity discounts offered by resource vendors. (A "cost slack" problem is solved. With two items, a closed-form solution is obtained)
***N*-item product line Key issue: cost sharing**	Items are manufactured using "one resource" subject to a production frontier coupled with the resource's capacity constraint	Cost slack problem requires solving a system of linear equations subject to a cost proportionality constraint
Multiple resources		
***N*-item product line Key issues: cost sharing, requirements planning**	Each resource is capacitated and subject to unique production frontiers allocating capacity among items subject to each item's unique requirements	Cost slack problem is same as above

Notes: In each case, two solutions are offered: the limiting case where resources are infinitely divisible (the incremental cost function is continuous) and the discrete case where resources can only be purchased in whole units (the incremental cost function is a step function)

constructs that must be estimated from data and are, therefore, viewed as more speculative.

Because demand modeling is time-consuming and costly, it can shift the emphasis to price strategy when in many cases the manager needs tactical insights to respond quickly to a competitive challenge. Iso-profit pricing provides tactical insight but also forms an important link between pricing decisions and broader supply-chain considerations. Analyzed in isolation, the decision of whether to meet a competitor's price is a tactical one. However, if the firm meets a price with the goal of sustaining current profit levels, then the appropriate incremental volume will in fact have to be manufactured and delivered using scarce resources and complex scheduling. If the new units are not forthcoming, not only does the tactical move fail, but also overall operations are negatively impacted because of newly created bottlenecks in the firm's supply chain. Dealing with such bottlenecks has become a multi-million dollar industry for many companies (Camm *et al.*, 1997; Cohen and Agrawal, 1995; Lee and Billington, 1993; McHugh, 1996, Naj, 1996). This paper draws out certain risk implications of such tactical decisions and provides techniques to assess this risk more accurately.

Iso-profit fundamentals

To motivate the study of more complex cases, we review the scenario originally considered by Nagle and Holden (2002) where a firm has a finite capacity and must install new workstations to meet requirements beyond 4,000 units.
New workstations cost $800 each and increase capacity in 1,000 unit chunks. The following notation is used throughout the paper.

- p_0 – base price level
- p – new price level
- v_0 – volume at base price
- c_0 – contribution at base price
- c – contribution at new price
- Δc – change in contribution margin
- θ – capacity of an added resource
- $\$r$ – cost of an added resource
- f – incremental fixed costs
- u – unit sales

The general solution technique

Appendix 2 derives the main solution technique used for all examples presented in this paper. The technique involves a recursive relationship among unit sales (u), initial volume (v_0), the cost of incremental resources (f), resource capacity (θ), and contribution to profit at the base price level (c_0) and at the new price level (c). The relationship can take two basic forms, depending on whether new resources are assumed to be infinitely divisible or come in discrete chunks. The infinitely divisible case yields a closed-form solution that provides useful theoretical insights about the more realistic discrete case. These insights include whether a solution exists and is stable and lower bounds to iso-profit volume at a given price.

The recursive nature of the solution yields several important insights even in the case of a single item. We periodically summarize these important points and number them sequentially throughout the paper for easy reference.

P1. The general solution technique for an iso-profit pricing problem is the same whether the firm has one item and one resource or multiple items and multiple resources; the solution is found by a forward recursion seeking a fixed, equilibrium point of a dynamic system.

P2. Even with a single item, when incremental fixed costs are present, then, for a given proposed reduced price, there may *not* be an iso-profit volume.

P3. Even when an iso-profit volume exists, it may be unstable. Instability means that small variations in price from the proposed price may shift iso-profit volume dramatically, or worse, lead once again to a system with no solution.

P4. When incremental costs are "continuous" (meaning that incremental resources are infinitely divisible so that the cost of incremental resources can be treated as a variable cost), subtle differences in cost accounting assumptions lead to a solution that differs from those of Nagle and Holden (2002) and Hoch *et al.* (1994).

Points *P1-P3* are consequences of the fact that iso-profit pricing problems involve recursive systems. The system is non-linear when resources come in chunks and, as such, is subject to a variety of behaviors associated with non-linear dynamic systems. These behaviors include cases with no solution, those with unstable solutions, and chaotic behavior.

Managers who contemplate reducing price, whether to meet competition or to boost sales, should be aware that in some cases, simply because of the unique combination of costs, resource capacities, and price levels selected, the odds of being "equally profitable" at the lower price are low. Figure 1 shows that iso-profit volume increases exponentially as price decreases. Less obvious is the fact that two price levels that are nearly the same, say \$9.48 and \$9.50, can have markedly different volume implications (as illustrated in the next section) if the implied extra volume necessitates purchase of an incremental resource.

P4 is discussed further in Appendix 2. It indicates subtle differences in assumptions that lead to different numerical solutions for apparently similar cases. In particular, when a price change does not trigger a change in variable or fixed cost, Nagle and Holden (2002) find the iso-profit incremental volume from the formula $\Delta v = (-\Delta p/(c_0 + \Delta p))$ (Hoch *et al.*, 1994). In the workstation case, with a price reduction from \$10.00 to \$9.50, the resulting iso-profit volume is 1,667 units. At \$9.50 the current resource can produce the required incremental volume. Since the resource has already been purchased, it is a sunk cost, and their reasoning is perfectly legitimate from the sunk cost versus avoidable cost perspective. However, at other prices that could have been considered (say, \$9.00), the additional volume needed to break even is beyond 800 units, which implies the need for another workstation. The analyst is currently faced with the explicit need to "cost out" *all* additional units. Put another way, if the iso-profit volume is greater than zero but less than the capacity of a new workstation, then each incremental unit v-v_0 is treated as "free" in the Nagle and Holden scenario. However, assuming a resource is infinitely divisible means that no matter how many extra units of the resource are needed, they can be obtained, but at a marginal cost of $\alpha = \$r/\theta$, the total cost divided by the resource's capacity. In this view, additional units are not free. This leads to a different expression for iso-profit volume, i.e.

$$\bar{u} = \left(\frac{\Delta c}{c - \frac{\theta}{\$r}} \right) v_0$$

or 1,625 units rather than 1,667. Neither view is absolutely correct, but depends on the industry setting and management's modeling goals. Refer Cooper and Kaplan (1992) for a discussion of these different cost accounting philosophies.

Multi-product extensions when items share a resource

A firm's resources are seldom devoted solely to one item and, conversely, a given item typically requires multiple resources to produce. If the firm is considering lowering the price of one item, then the increased capacity needed for that item may have system-wide impact. We illustrate the situation, first for two items sharing one resource, then extend it to m items sharing multiple resources.

Two items sharing one resource

With two items, the vector of iso-profit volumes $(\bar{u}_1, \bar{u}_2)$ is related to total incremental fixed costs according to a recursive expression derived in Appendix 2. Several new insights are revealed by the calculation.

P5. With one resource, the system confounds two properties that subsequently must be distinguished: requirements planning and production frontiers.

P5 calls management's attention to the fact that with two items and one resource, each item requires the resource and the resource has a physical capacity constraint or production frontier that must be met in a given time period.

P6. Consequently, at each step k in the recursive solution, the items should share the purchase cost of incremental units of the resource according to a total incremental cost function of the form $f(u_1, u_2, k)$ that incorporates units of both items.

The incremental cost function can be additive,

$$f(u_1, u_2, k) = f_1(u_1, k) + f_2(u_2, k),$$

or non-additive

$$f(u_1, u_2, k) = f_1(u_1, k) + f_2(u_2, k) + f_{12}(u_1, u_2, k),$$

where the "extra piece" $f_{12}(u_1, u_2, k)$ may be negative (as in the case of a quantity discount) or positive (as in the case of adding a third shift, paid on an overtime basis). We model incremental costs as additive for the time being, but later relax this assumption to account for situations such as bundled pricing on the part of resource suppliers. In the one resource additive case, the most logical sharing rule comes from the physical capacity constraint. With two items, the production frontier is of the form:

$$u_1(k) + \phi u_2(k) = \theta,$$

where θ is the capacity of the resource. Thus, for every one unit of item 2 produced, the resource can produce ϕ units of item 1. The rate at which fixed costs increase as a function of u_1 and u_2 is, therefore,

$$f(k) = \alpha[u_1(k) + \phi u_2(k)]$$

or

$$f_1(u_1, k) = \alpha u_1(k)$$

and

$$f_2(u_2, k) = \alpha\phi u_2(k)$$

Refer Appendix 2 for additional rationale for this form.

Numerical example

We illustrate these ideas by assuming that the firm produces a second item with a base price of \$12.00 and a base contribution level of \$5.00. (Recall that item 1's base price is \$10.00, which is being reduced to \$9.50.) We further assume that the production possibility frontier is:

$$u_1(k) + 2u_2(k) = 1000;$$

i.e., a workstation can be used to make 1,000 units of item 1 (when $u_2 = 0$), 500 units of item 2 (when $u_1 = 0$) or any admissible linear combination in between, such as [800, 100] or [400, 300]. The firm is considering lowering item 2's price to \$11.50 along with the 50-cent price decrease being considered for item 1. Results for both the continuous and discrete cases are shown in Table II.

In the continuous case, the items contribute \$18,500 and \$21,105, respectively, at their new volumes of (4,625; 4,690). Total combined revenue is \$39,605 and incremental fixed costs are \$1,604, yielding \$38,001 profit as before. (Small differences in results are due to rounding error.) The discrete case yields iso-profit volumes of (630, 685), a production vector that nearly fully utilizes two additional workstations, i.e. we need $[630 + 2(685)] = 1,999$ units of additional capacity. Results yield *P7*.

P7. Unlike for a single item, with two or more items, the discrete iso-profit volumes are not uniformly higher (i.e. vectorially higher) than the continuous solution. (Note that $630 > 625$ but $685 < 690$.)

P7 holds because the firm gains some flexibility from the fact that it can schedule work at any feasible point on the production frontier. This flexibility in manufacturing can be combined intelligently with pricing to generate iso-profit solutions that require, on average, less incremental volume than would otherwise be the case. This leads to the strategic insight stated as *P8*.

P8. Even if a price decrease is precipitated by a competitor on one item, it may prove useful to drop the price on item two to a feasible point on the production frontier that generates demand that can be met using fewer rather than more incremental resources. (A similar statement holds if a price decrease is used to stimulate demand.)

Disastrous leverage

Although the continuous and discrete results shown in Table II are similar, note that if the proposed price for item 1 were just slightly lower,

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Table II Two items sharing one resource

	Baseline		Model results: Continuous case		Model results: Discrete case	
	Item 1	Item 2	Item 1	Item 2	Item 1	Item 2
Price/unit	$10.00	$12.00	$ 9.50	$11.50	$ 9.50	$11.50
Percent price change			− 5.0	− 4.2	− 5.0	− 4.2
$ Contribution/unit	$4.50	$5.00	$4.00	$4.50	$4.00	$4.50
Percent contribution	45.0	41.6	42.1	39.1	42.1	39.1
BE sales change (per cent)			+15.63	+17.25	+15.75	+17.13
BE sales change (units)			+625	+690	+630	+685
Total units	4000	4000	4,625	4,690	4,630	4,685
Item contribution	$18,000	$20,000	$18,500	$21,105	$18,520	$21,082
Category contribution						
Incremental revenue	$38,000		$39,605		$39,602	
Incremental costs[a]	$0.00		$1,604		$1,600	
Ending profit position	$38,000		$38,001		$38,002	

Notes: [a]In the continuous case, incremental costs are $1,604 = (0.8)[(625) + (2)(690)]. In the discrete case, incremental "units" are $(1\ 2) * (630\ 685)^T = 1{,}999$ which can be achieved with two machines at a cost of $800 each

$9.48 instead of $9.50, the iso-profit volumes would increase to (711, 812) because a third workstation would be needed to manufacture the combined $[711 + 2(812)] = 2,335$ equivalent incremental units. This is a 16.8 per cent increase in incremental volume in response to an extra 0.21 per cent proposed extra decrease in the price of item 1; a leverage factor of 16.8/.21 or about 80-1. In general, the discrete nature of practical problems makes solutions very sensitive to problem parameters[3]. Therefore, applying conventional wisdom such as lowering the price to a relevant psychological price point may trigger an unreasonably high iso-profit volume. Even without putting too fine a point on numerical details, it is clear that the incremental cost function is highly sensitive at certain price points that are not intuitively obvious. If we factor in other elements of the outcome, such as the time required to order, receive, and put into operation two new workstations, the potential for serious disruptions of operations becomes all the more apparent.

Multiple items, multiple resources and requirements planning

The two-item, one resource case is a useful stepping stone to the most realistic cases in which items use resources jointly as well as uniquely. When resources are used jointly, the combination depends on both the item(s) and the resources (Meester *et al.*, 1993). For example, consider the following generalization of the previous problem. The firm sells three items with regular prices of $10, $12, and $15, respectively, that contribute $4.50, $5.00, and $7.00 to profit and overhead. To counter a competitive move, management is considering lowering each price by 50 cents. Prior to finalizing the decision, the firm's marketing analyst must calculate the iso-profit volumes required at the new prices. Complicating matters, the items share seven resources when manufactured. Resources {1,4,5,7} are required to produce item 1; resources {2,4,6,7} are required to produce item 2; and resources {3,5,6,7} are required to produce item 3. Item 1 alone uses resource 1, item 2 alone uses resource 2, and item 3 alone uses resource 3. Items 1 and 2 share resource 4 in the proportions 1 : 2; items 1 and 3 share resource 5 in the proportions 1 : 3; items 2 and 3 share resource 6 in the proportions 1 : 4, and all three items use resource 7 in the proportions 1 : 2 : 1.

This set-up mimics situations typically encountered in practice and for which management intuition falters. The solution technique is outlined in detail in Appendix 3. It builds on the foundations developed to this point. Table III shows results. In this case, the continuous and discrete solutions differ considerably. The discrete solution of (1,890; 1,895; 762) requires, respectively, 47, 47 and 38 per cent more units than the continuous solution of (1,109; 1,035; 344). Overall, the discrete solution requires a total incremental sales volume that is 16 per cent above the continuous estimate and a hefty 45 per cent sales increase over base volume levels. This leads to *P9*.

P9. The discrete nature of most resources can dramatically increase iso-profit volume. In problems with multiple items sharing multiple resources subject to complicated production frontiers, management's intuition is undependable and should be replaced by formal analysis.

The requirement of increasing sales 4,547 units above a base volume of 10,000 units would likely

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Table III Three-item example with shared resources

	Baseline			Model results: Continuous case			Model results: Discrete case		
	Item 1	Item 2	Item 3	Item 1	Item 2	Item 3	Item 1	Item 2	Item 3
Price/unit	$10.00	$12.00	$15.00	$ 9.50	$11.50	$14.50	$ 9.50	$11.50	$14.50
Percent price change				− 5.0	− 4.2	− 3.3	− 5.0	− 4.2	− 3.3
$ Contribution/Unit	$4.50	$5.00	$7.00	$4.00	$4.50	$6.50	$4.00	$4.50	$6.50
Percent contribution	45.0	41.6	46.7	42.1	39.1	44.8	42.1	39.1	44.8
BE sales change (per cent)				+27.73	+25.88	+17.20	+47.25	+47.38	+38.05
BE sales change (units)				+1,109	+1,035	+344	+1,890	+1,895	+762
Total units	4,000	4,000	2,000	5,109	5,035	2,344	5,890	5,895	2,762
Item contribution	$18,000	$20,000	$14,000	$20,436	$22,657	$15,236	$23,560	$26,528	$17,953
Category contribution									
Incremental revenue	$52,000			$58,329			$68,041		
Incremental costs[a]	$0.00			$6,334			$16,034		
Ending profit position	$52,000			$51,995			$52,007		

Notes: [a]It may be shown that total incremental costs are given by $\mathbf{F} = \text{diag}(\boldsymbol{\alpha}) \cdot \mathbf{R}^{T} \cdot \mathbf{u}$, where $\mathbf{u} = [665\ 725\ 293\ 2{,}226\ 1{,}821\ 440\ 164]^{T}$ for total incremental costs of $6,334. In the discrete case, the incremental resources required are: (2 2 1 2 2 2 1) at costs (600 700 850 1,728 2,550 624 1,050) for total incremental costs of $16,034

push management to reconsider the proposed price cuts if this number were correctly anticipated. However, we suspect that major planning misjudgments would be made in this case because the problem does not lend itself to intuitive insight or a simple solution. Psychological processing biases of the sort reviewed by Thaler and Johnson (1990) may play a role in the situation. Certainly the instinctive "we have to fight back" attitude prevalent among managers will be triggered as it has been in prominent price wars during the past decade. Cases include the airlines, breakfast cereals, cigarettes, long distance service providers, internet service providers, paper, fast food, newspapers, and personal computers. (See Rao, 1984. A separate list of citations about price wars is available from the author.) Although the evidence is anecdotal, misjudgments about required incremental volumes and unanticipated supply-chain effects may have played a major role in the negative and at times disastrous results in these industries.

Non-additive incremental cost functions

It is important to consider one more generalization of the problem because it most closely parallels real-world conditions. The incremental cost function $f(u,k)$ must be increasing in units of each component item but may not be additive as previously assumed. The most likely case is that f decreases in joint output due to production interdependencies and/or volume discounts when purchasing resources. An example for two items is the bilinear incremental fixed cost function shown below.

$$f(k) = \alpha[u_1(k) + \phi u_2(k)] + \eta(\gamma_1 + \gamma_2)u_1(k)u_2(k)$$

When the parameter η is negative, total incremental fixed cost is less than its additive counterpart. The weights $\gamma_1 + \gamma_2 = 1$ apportion savings (or cost premiums) between the items.

In practice, firms face a discrete analogue of the continuous function shown above. The real-world counterpart of $\eta < 0$ occurs when a firm can achieve a quantity discount if it purchases more than one additional resource (workstation) at a time. Because this case yields several new insights, The author solves both the continuous and discrete versions in Appendix 4 and illustrates solutions numerically here in the main text. For simplicity, we assume that the vendor's price for the mth workstation in an order of M workstations is given by $(1-d)^{m-1} \times$ full price, where the discount parameter lies between 0 and 1. With this schedule, the vendor charges full price for the first workstation and a sliding scale for additional workstations purchased in the same order. For example, with $d = 0.10$, three workstations cost $2,168 rather than $2,400.

Points derived from the continuous case

Using the same price decreases as in the two item example, but with $\eta = -0.001$, we find that the incremental break-even volumes decrease from their previous levels of (625, 690) to (569, 628), a 9 per cent reduction for each item. Results are shown in Table IV.

P10. When resource vendors offer quantity discounts, iso-profit volumes are lower – as expected – than in the absence of such discounts, and much lower in some cases.

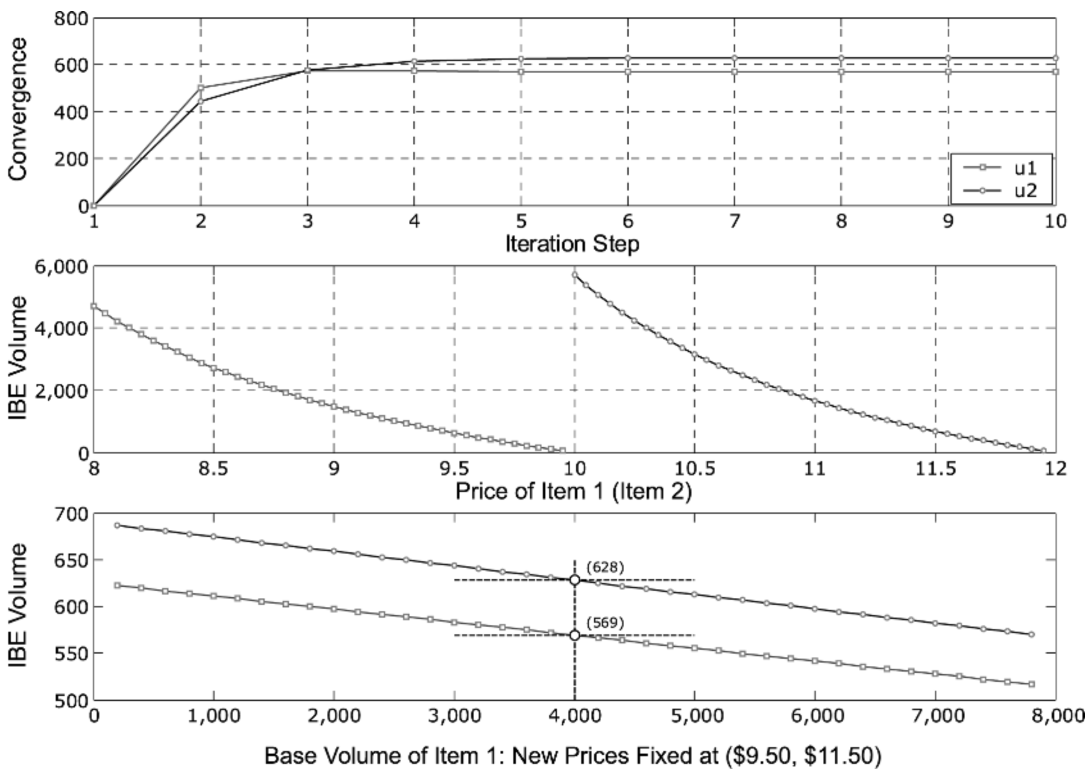
Note, however, that the properties of a nonlinear system are less intuitive than those of a linear system. Figure 2 shows how quickly the system converges to the equilibrium (top panel), how

Table IV Two-item example with non-additive incremental costs

	Baseline (a)		Model results (b) Continuous cases: Additive costs		Non-additive costs		(c) Discrete case: Non-additive costs	
	Item 1	Item 2	Item 1	Item 2	Item 1	Item 2	Item 2	Item 3
Price/Unit	$10.00	$12.00	$ 9.50	$11.50	$ 9.50	$11.50	$ 9.50	$11.50
Percent price change			− 5.0	− 4.2	− 5.0	− 4.2	− 5.0	− 4.2
$ Contribution/Unit	$4.50	$5.00	$4.00	$4.50	$4.00	$4.50	$4.00	$4.50
Percent contribution	45.0	41.6	42.1	39.1	42.1	39.1	42.1	39.1
BE sales change (per cent)			+15.63	+17.25	+14.23	+15.70	+14.45	+17.83
BE sales change (units)			+625	+690	+569	+628	+578	+713
Total units	4000	4000	4,625	4,690	4,569	4,628	4,578	4,713
Item contribution	$18,000	$20,000	$18,500	$21,105	$18,276	$20,827	$18,312	$21,208
Category contribution								
Incremental revenue	$38,000		$39,605		$39,103		$39,520	
Incremental costs[a]	$0.00		$1,604		$1,103		$1,520	
Ending profit position	$38,000		$38,001		$38,000		$38,000	

Notes: [a]Incremental costs are, respectively, $1,604 = (0.8)[(625) + (2)(690)] and $1,103 = (0.8)[(569) + (2)(628)] − (0.001)(569·628). For the non-additive case, two machines are required at a cost of $1,520 according to the price discounting policy of the resource vendor. Refer Appendix 6 for details

Figure 2 Equilibrium volumes with non-additive incremental fixed costs



iso-profit volumes relate to price decreases (middle panel), and how baseline volumes relate to incremental volumes (bottom panel).

For example, the top panel shows the trajectory of the system when it is initialized at $u = [0\,0]$. The system reaches its equilibrium value [569 628] in five steps. (Appendix 5 shows that this equilibrium is asymptotically stable.)

To form the mid panel, price changes were varied independently for items 1 and 2 from $0 to $2 in five-cent increments. In other words, item 1's price ranged from its baseline of $10.00 down to a low of $8.00 and item 2's price ranged from its baseline of $12.00 to a low of $10.00. Results show that iso-profit volumes grow exponentially as a function of the depth of the price cut. For example,

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the iso-profit volume needed to cover a price decrease from \$10.00 to \$9.50 for item 1 is 625 units while item 2's price is held constant at baseline. To cover twice the price decrease to \$9.00 requires $(1585/625) = 2.536$ times the incremental volume.

For the bottom panel of Figure 2, proposed prices were fixed at \$9.50 and \$11.50 and base volumes were varied from the combination (200, 7,800) to the combination (7,800, 200) in increments of 200 units while holding total baseline volume constant at 8,000. The relationship is linear in units but highly nonlinear when the resulting incremental volumes are expressed as a percent of their respective baselines. For example, the iso-profit incremental volume for item 1 is 569 units or 14.2 per cent of the original 4,000 unit baseline. Incremental volume is 583 units or 19.4 per cent when the baseline is 3,000 units, a relatively inelastic effect. However, incremental volume grows to 622 units or a whopping 311 per cent of baseline when item 1's baseline is 200 units.

The author performed a variety of numerical experiments with incremental costs decreasing at the margin (e.g. quantity discounts) versus where incremental costs increased at the margin (e.g. adding a third shift paid at an overtime rate.). These experiments yield the following conclusion.

P11. Although iso-profit volume solutions typically exist under both scenarios (decreasing or increasing marginal costs), increasing marginal costs more often lead to situations with no solution or chaotic behavior (Kelley and Peterson, 1991). Chaotic behavior means that the system contains irresolvable tensions. In such cases, management's efforts to control costs will be met with stiff resistance, *not* due to external forces, such as competition, but due to the natural economic laws of motion of the system.

In summary, certain combinations of price decreases, combined with cost interdependencies and capacity limits can exert severe pressures on a firm and its supply chain. Although system dynamics alone do not necessarily cause corporate failures, this phenomenon should be investigated further as a possible contributor to firms' unanticipated woes during price wars. Perhaps even more disturbing is the fact that these kinds of problems can arise during periods of proactive price discounting.

The discrete counterpart and the cost slack problem

Table IV, section c illustrates outcomes when $d = 0.10$. In this case, the workstations cost, respectively, \$800, \$720, and \$648 in an order of three machines. Solving this case by forward recursion requires that the discounted cost of incremental resources be factored in at each step. To do so requires solving a constrained optimization problem to adjust (downward) the volume vector at each step since fewer units are actually required to cover the (discounted) cost relative to the full (additive) cost. We refer to this as the "cost slack" problem. The solution is provided in Appendix 6.

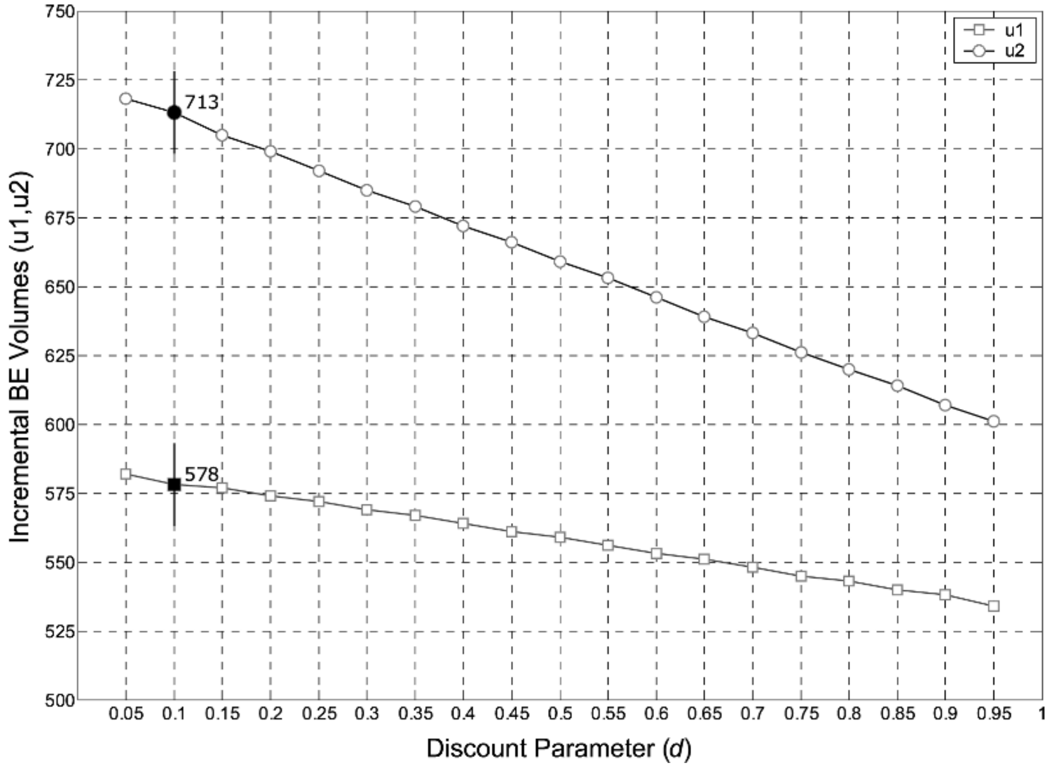
Table IV, section c, shows that the iso-profit volumes in the discrete case are slightly higher than those for the continuous case. This follows the expected pattern, i.e. because the firm must purchase the incremental resource in chunks, costly unused capacity increases the required incremental volume. However, it is also clear that these volume increases are a function of the discounting policy of the vendor(s) who supply resources. In the present case, the discounting policy is very liberal, declining exponentially. We expect iso-profit volume to decline less rapidly than price. The reasoning: even though fewer units are required at any given step in the recursion, the result does not take advantage of the price discount until it "bumps forward", requiring another machine. More generally, the author suggests that with price discounts, *P12* usually holds.

P12. Even though the costs of incremental resources decline exponentially, iso-profit (incremental) volumes decline linearly.

To illustrate *P12*, iso-profit volumes were calculated for the two-item case, letting d range from 0.05 to 0.95 in increments of 0.05. As d increases, the discounted cost of an order of M workstations declines rapidly relative to the full cost. For example, when $d = 0.10$, three machines cost \$2,400 at full price, but only \$2,168 (90.3 per cent) at the discounted price. When $d = 0.5$, the costs are \$2,400 vs \$1,400, a 58.3 per cent discount.

Figure 3 shows results from the sensitivity test. Results, when $d = 0.10$, are marked to reference case c in Table IV. In Figure 3, all cases shown require two extra machines because the vendor price discounts outpace the increase in units to break even; a third machine is never required. The iso-profit volumes decline to reflect the fact that fewer units are required to cover the cost of these two machines. However, if at some point three machines were required, the line graphs in Figure 3 would step upward, then decline linearly again. With resource costs increasing at a decreasing rate, whether this happens or not depends on the tension between the increases in units needed to break even and the decreases in cumulative cost needed to supply those units. These tensions depend, of course, on the properties of each given problem faced in practice.

Figure 3 Resource cost discounts and IBE-volume



Limitations and directions for future research

This paper extends published work on iso-profit pricing to cases involving more than one item. The paper illustrates solution techniques for three major new cases and outlines a number of implications for pricing practice. Although the present results add to the body of knowledge in this neglected area, the interesting and potentially very important problem of agile resources and their effect on iso-profit volumes requires further attention.

An agile resource can perform multiple functions. Human resources are *a fortiori* agile, while many modern machine tools can be reconfigured to perform more than one function on a single item or separate functions on different items. Although details would take us too far afield, it is clear that for any given required vector of items, **u**, available resources can be optimally scheduled to produce **u**, subject to capacity and agility constraints. The author developed an optimal scheduling algorithm and experimented with it in the context of the iso-profit pricing. Results are mixed, primarily because this case couples features of discrete optimization with features of a dynamic system. This coupling leads to difficult new problems. In brief, if resources are optimally rescheduled at each step of the solution recursion, the dynamic system is continually reinitialized and sent on a new trajectory.

In other words, the optimal resource schedule at step k represents an exogenous shock to the dynamic system. Often, but not always, this leads to a non-convergent trajectory. The other coupling strategy; i.e. find the system equilibrium, $\bar{\boldsymbol{u}}$ then optimally schedule resources at the terminal step, clearly misleads the recursion since fewer resources are required at step k than are represented in the system. In sum, the most general version of the iso-profit pricing problem remains unsolved and represents a valid arena for further research.

Conclusion

The present work, despite its limitations, suggests that important benefits accrue from research that blends considerations from marketing science and cost accounting. Bucklin *et al.* (1998) emphasize this need in their "2020 vision for marketing": "Focusing on profits also requires accurate information on costs. Marketing managers who have historically focused on sales and market share may pay little attention to costs, or be satisfied with rough approximations. Marketing engineers building decision automation systems will need to link marketing decision systems with accurate, up-to-date information on costs".

Notes

1 Example 2 was originally explored by Nagle and Holden (2002). It is used as a reference point from which more complex examples are built.
2 The paper focuses primarily on non-additive cost functions where the "non-additive" component reduces cost, mimicking quantity discounts for additional units of a resource. Note, however, that price premium interactions can also occur, particularly in labor markets where adding an additional shift may necessitate overtime. The solution techniques are neutral with respect to the nature, positive or negative, of the non-additive cost components.
3 Typically constraints are not as "hard" as those portrayed, but unless the firm faces a kinked demand curve, i.e. it has to sell at a lower price or lose all demand (rare for any differentiated product) fairly rigid limits do exist.

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Appendix 1. Published formulas

All costs variable

Nagle and Holden (1987, 2002, Appendix 3A) and Hoch *et al.* (1994, p. 27) derive the same result when a price change does not trigger a change in costs. These derivations are provided here for completeness. In this case, the iso-profit volume requires that the following equality hold.

$$\pi_{p_0} \equiv (p_0 - c_0)v_0 = (p_0 + \Delta p - c_0)(v_0 + \Delta v) \equiv \pi_p$$

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Expanding and simplifying gives $0 = \Delta p v_0 + p_0 \Delta v + \Delta p \Delta v - c_0 \Delta v$. Solving yields the iso-profit incremental volume

$$\Delta v = \left(\frac{-\Delta p v_0}{p_0 + \Delta p - c_0}\right).$$

Dividing both sides by v_0 expresses the result as a percentage of baseline quantity, i.e.

$$\frac{\Delta v}{v_0} = \frac{-\Delta p}{p_0 + \Delta p - c_0}.$$

This is identical to Hoch *et al.*'s (1994) result $\phi = -\delta/(\pi + \delta)$. To see this, note that if the right-hand side is expressed in price percentage terms, the numerator is $-\Delta p/p_0$ (which is $-\delta$ in Hoch *et al.*'s notation) and the denominator is

$$\frac{p_0 + \Delta p - c_0}{p_0} = \frac{p_0 - c_0}{p_0} + \frac{\Delta p}{p_0}.$$

But $\pi = (p_0 - c_0)/p_0$ is gross profit margin in Hoch *et al.*'s notation, so the denominator is $\pi + \delta$ as required.

With incremental fixed costs

Nagle, Holden, and Smith (Chapter 3, p. 42 in Nagle and Holden, 2002) state: "The breakeven sales change for a price change with incremental fixed costs is the basic breakeven sales change plus the sales change necessary to cover the incremental fixed costs". The basic breakeven sales change is found by solving $c_0 v_0 = cv = c(v_0 - \Delta v)$ for Δv. The result is $(-\Delta c/c)v_0$. The sales change necessary to over any incremental fixed costs is f/c, these costs divided by the contribution at the new price. Thus, the unit iso-profit (incremental) volume is

$$u = \left(\frac{-\Delta c}{c}\right)v_0 + \left(\frac{1}{c}\right)f$$

as stated in the main text.

Appendix 2. Derivation of main results

Single item case

To understand the structure of the iso-profit problem, closed form expressions are found when resources are infinitely divisible. This structure is then used as the basis for numerical solutions to the discrete cases found in practice. The closed form expressions also signal certain important requirements for solutions to exist and be stable.

At a given new price, Appendix 1 indicates that the iso-profit (incremental) units needed are a linear function of base volume and incremental fixed costs

$$u = \left(\frac{-\Delta c}{c}\right)v_0 + \left(\frac{1}{c}\right)f.$$

If the resource were continuously divisible, the cost per unit of added capacity would be

$$\alpha = \left(\frac{\$r}{\theta}\right).$$

Therefore, incremental fixed costs $f = \alpha u$ are a function of incremental units. The relations $u = g(f)$ and $f = h(u)$ are recursive. We express the recursion as a dynamic system on the step index k.

$$\begin{aligned} u(k+1) &= \left(\frac{-\Delta c}{c}\right)v_0 + \left(\frac{1}{c}\right)f \\ f(k) &= \alpha u(k) \end{aligned} \qquad (1)$$

Eliminating $f(k)$ by substituting into the top equation of (1) and making the change of variables $a = \alpha(1/c)$ and $b = (-\Delta c/c)v_0$ yields the linear difference equation

$$u(k+1) = au(k) + b.$$

An iso-profit (incremental) volume is a fixed point $\bar{u}$ of this system, i.e. it yields the identity $\bar{u} = a\bar{u} + b$. Solving, we have

$$\bar{u} = \left(\frac{b}{1-a}\right)$$

and resubstituting the original notation reveals the general expression for the equilibrium value $\bar{u}$ for a single item and an infinitely divisible resource

$$\bar{u} = \left(\frac{\Delta c}{c - \frac{\theta}{\$r}}\right)v_0.$$

This result differs from those in Appendix 1 because it places an explicit cost on every additional unit whether or not that unit is manufactured with "unused capacity". Cooper and Kaplan (1992) discuss this view.

The solution $\bar{u}$ exists if and only if $|a| < 1$. In the iso-profit pricing context this means that

$$\left|\left(\frac{\$r}{\theta}\right)\left(\frac{1}{c}\right)\right| < 1.$$

Thus we have the following basic principle: $\bar{u}$ exists if and only if the cost per unit of additional capacity is less than the item's contribution at the new price – this is known as the unit root property of the solution, the multivariate counterpart of which is described shortly.

Discrete solutions: the general technique

When resources come in discrete chunks, the iso-profit volume must be found numerically. The Matlab program written for this purpose implements the recursion (1) until a fixed point is found. More specifically, the procedure involves the following steps.

1 Initialize key values {base price, base volume, base contribution, etc.}
2 Define change relationships, e.g.
   2.1 New contribution margin = base margin + change
   2.2 New price = base price + change
3 Initialize iso-profit (incremental) volume according to the top equation in (1)
4 Enter the recursive cycle at a given (new) price point
   4.1 Calculate iso-profit incremental volume prior to adjusting for incremental fixed costs
   4.2 Adjust the result for incremental fixed costs using the bottom equation in (1)
   4.3 If step 4.2 alters incremental iso-profit volume, cycle through steps 4.1 and 4.2 until they converge to the same value.
5 Exit the recursive cycle and store results for this price
6 Return to 4 to try another price if desired
7 Output results for all prices tried

Matlab code implementing the solutions presented in the main text is available from the author. Excel's solver is based on the logic of forward recursion and a competent Excel programmer should be able to implement solutions using Solver.

Two items sharing one resource

With two items, each item's incremental iso-profit volume is related to total incremental fixed costs according to a bivariate generalization of equation (1), where v_{i0} is the base volume for item $i = 1, 2$.

$$\begin{aligned} u_1(k+1) &= \left(\frac{-\Delta c_1}{c_1}\right) v_{10} + \left(\frac{1}{c_1}\right) f_1(u_1, k) \\ u_2(k+1) &= \left(\frac{-\Delta c_2}{c_2}\right) v_{20} + \left(\frac{1}{c_2}\right) f_2(u_2, k) \end{aligned} \quad (2)$$

The cost function for two-items sharing one resource, subject to a production frontier, is

$$f(k) = \alpha[u_1(k) + \phi u_2(k)],$$

where $\alpha = \$r/\theta$. (We drop the step index, k, for simplicity.) This follows from the fact that if the resource is devoted entirely to item 1, the cost per unit is $\alpha_1 = \$r/\theta$. If it is devoted entirely to item 2, the cost per unit is

$$\alpha_2 = \frac{\$r}{(\theta/\phi)} = \frac{\$r\phi}{\theta}.$$

Thus, at any point $[u_1, u_2]$ on the production frontier we have

$$\left(\frac{\$r}{\theta}\right) u_1 + \left(\frac{\$r\phi}{\theta}\right) u_2 = \left(\frac{\$r}{\theta}\right)(u_1 + \phi u_2) \text{ or }$$
$$\alpha(u_1 + \phi u_2).$$

The rate at which incremental fixed costs increase as a function of u_1 and u_2 is, therefore

$$f_1(u_1, k) = \alpha u_1(k) \text{ and } f_2(u_2, k) = \alpha\phi u_2(k).$$

Substituting these expressions into equation (2) and grouping coefficients yields equation (3).

$$\begin{aligned} u_1(k+1) &= \left(\frac{-\Delta c_1}{c_1}\right) v_{10} + \left(\frac{\alpha}{c_1}\right) u_1(k) \\ u_2(k+1) &= \left(\frac{-\Delta c_2}{c_2}\right) v_{20} + \left(\frac{\alpha\phi}{c_2}\right) u_2(k) \end{aligned} \quad (3)$$

The system (3) can be expressed using matrix notation as $\mathbf{u}(k+1) = \mathbf{A}\mathbf{u}(k) + \mathbf{b}$.
Equation (4) shows the corresponding arrays where the coefficients are given by the substitutions $a_{11} = (\alpha/c_1)$, $a_{22} = (\alpha\phi/c_2)$, and $b_{i0} = (-\Delta c_i/c_i)v_{i0}$.

$$\begin{pmatrix} u_1(k+1) \\ u_2(k+1) \end{pmatrix} = \begin{bmatrix} a_{11} & 0 \\ 0 & a_{22} \end{bmatrix} \cdot \begin{pmatrix} u_1(k) \\ u_2(k) \end{pmatrix} + \begin{pmatrix} b_{10} \\ b_{20} \end{pmatrix} \quad (4)$$

Equation (4) is the two-item analogue of the single item case, and immediately generalizes to any number of items sharing a single resource.

An equilibrium point of the system must satisfy equation (5), which is a direct extension of equation (1). Equation (5) is the closed-form solution for any number of items sharing a single resource when the resource is infinitely divisible.

$$\bar{\mathbf{u}} = \mathbf{A}\bar{\mathbf{u}} + \mathbf{b} \quad \text{or solving} \quad \bar{\mathbf{u}} = (\mathbf{I} - \mathbf{A})^{-1}\mathbf{b} \quad (5)$$

Equation (5) will be satisfied if unity is not an eigenvalue of **A**, otherwise the matrix **I** − **A** is singular and the inverse will not exist (Bronson, 1991). Further, a necessary and sufficient condition for the iso-profit volumes to be asymptotically stable is that the eigenvalues of **A** have magnitude less than 1. This is the multivariate analogue of the unit root condition mentioned earlier (Luenberger, 1979, p. 157; Brogan, 1991, Chapter 10). In the additive cost case, the coefficient matrix, **A**, is diagonal. The eigenvalues of a diagonal matrix are the diagonal elements. Thus, in the multi-item, one resource case, for iso-profit volumes to exist, the cost per unit of added capacity – calculated as if the resource were fully devoted to each item – must be less than the contribution of the item at its new price.

Appendix 3. The three-item seven-resource problem

The following scalar, vector, and matrix quantities are necessary to solve multiple item, multiple resource problems. The following notation is used.

- r – (1×1) number of resources needed
- $f(k)$ – (1×1) total incremental fixed costs (all items) step k
- $f_g(k)$ – (1×1) incremental fixed cost for subgroup $g \in G$
- C – $(m \times m)$ diagonal matrix with $(1/c_i)$ as entry (i,i)
- α – $(r \times 1)$ vector of (continuous) costs/unit by resource
- $\mathbf{R}$ – $(m \times r)$ resource allocation matrix
- $a = \mathbf{R} \cdot \boldsymbol{\alpha}$ – $(m \times 1)$ vector of resource use
- θ – $(r \times 1)$ vector of capacities, by resource
- $\$r$ – $(r \times 1)$ vector of costs to purchase one additional resource
- $\mathbf{1}$ – $(r \times 1)$ vector of ones
- $\mathbf{F}(k)$ – $(r \times 1)$ vector of incremental cost by subgroup

To illustrate the notation, consider the three-item group used in the main text. Resources are needed according to the resource requirement matrix $\mathbf{R}$ shown in equation (6), where the rows of $\mathbf{R}$ are the resources and the columns are the items. The example in the main text uses $\rho_{42} = 2$, $\rho_{53} = 3$, $\rho_{63} = 4$, $\rho_{72} = 2$, and $\rho_{73} = 1$.

$$\mathbf{R} = \{\rho_{ij}\} = \begin{array}{cccc} & \textit{item1} & \textit{item2} & \textit{item3} \\ \textit{res}1 & 1 & 0 & 0 \\ \textit{res}2 & 0 & 1 & 0 \\ \textit{res}3 & 0 & 0 & 1 \\ \textit{res}4 & 1 & \rho_{42} & 0 \\ \textit{res}5 & 1 & 0 & \rho_{53} \\ \textit{res}6 & 0 & 1 & \rho_{63} \\ \textit{res}7 & 1 & \rho_{72} & \rho_{73} \end{array} \tag{6}$$

Note that $\mathbf{R}$ indicates resource requirements, not production frontiers. Production frontiers complicate the problem because resources should be efficiently scheduled. Certain ramifications of this extension are discussed in the limitations section of this paper. However, the technical elements of the required optimization programs (Fernandez *et al.* 2000; Gavish and Pirkul, 1991) and the behavior of dynamic systems, when subjected to exogenous shocks, render detailed analysis of this extension the subject of future research.

The limiting continuous costs per unit of resource used, by item, are given in the vector $\boldsymbol{\alpha} = (\alpha_1, \alpha_2, \alpha_3, \alpha_{12}, \alpha_{13}, \alpha_{23}, \alpha_{123})$. For example, resource 1 contributes α_1 to the total incremental cost of producing item 1. Resources 4, 5, and 7 are also needed to produce item 1 and the respective (overall) cost rates of these resources are α_1, α_{12}, α_{13}, α_{123}. A resource producing the items in a given product subgroup g is costed at a rate per "equivalent unit" according to the required proportions constraining the rates at which a resource must be used to produce a given item.

The vector $\mathbf{a} = \mathbf{R} \cdot \boldsymbol{\alpha}$ is used to form the state matrix in the state-space representation of the system according to the relation $\mathbf{A} = \mathbf{C} \cdot \text{diag}(\mathbf{a}) = \mathbf{C} \cdot \text{diag}(\mathbf{R} \cdot \boldsymbol{\alpha})$. Further, it may be shown that the $(r \times 1)$ vector, $\mathbf{F}(k)$, of total subgroup costs per resource at step k is given by

$$\mathbf{F}(k) = \text{diag}(\boldsymbol{\alpha}) \cdot \mathbf{R}^{\mathrm{T}} \cdot \mathbf{u}.$$

Total incremental fixed cost at step k in the recursion is, therefore, given by $f(k) = \mathbf{1}^{\mathrm{T}} \cdot \mathbf{F}(k)$ which also holds at the solution or terminal value of k.

Appendix 4. Solutions with non-additive incremental cost functions

We select $\gamma_1 = 1/(1+\phi)$ to reflect resource use but other allocations are possible. The non-additive cost function given in the main text implies that the dynamic system (4) must be rewritten as:

$$\begin{aligned} u_1(k+1) &= \left(\frac{-\Delta c_1}{c_1}\right) v_{10} + \left(\frac{1}{c_1}\right) \\ &\quad \times [\alpha + \eta\gamma_1 u_2(k)] u_1(k) \\ u_2(k+1) &= \left(\frac{-\Delta c_2}{c_2}\right) v_{20} + \left(\frac{1}{c_2}\right) \\ &\quad \times [\alpha\phi + \eta\gamma_2 u_1(k)] u_2(k) \end{aligned} \tag{7}$$

or rearranging

$$\begin{aligned} u_1(k+1) &= \left(\frac{-\Delta c_1}{c_1}\right) v_{10} + \left(\frac{\alpha}{c_1}\right) u_1(k) \\ &\quad + \left(\frac{\eta\gamma_1}{c_1}\right) u_1(k) u_2(k) \\ u_2(k+1) &= \left(\frac{-\Delta c_2}{c_2}\right) v_{20} + \left(\frac{\alpha\phi}{c_2}\right) u_2(k) \\ &\quad + \left(\frac{\eta\gamma_2}{c_2}\right) u_1(k) u_2(k) \end{aligned} \tag{8}$$

At equilibrium, the system must satisfy the nonlinear equations in equation (9) where we have substituted for the coefficients in equation (8) in an obvious way. The bilinear system (9) can be represented in matrix notation as

$$\mathbf{u}(k+1) = \mathbf{M} \cdot \mathbf{u}(k) + \mathbf{b}$$

where the matrix $\mathbf{M}$ is diagonal with entries $a_{11} + a_{12}u_2(k)$ and $a_{21} + a_{22}u_1(k)$. Thus, at equilibrium we have,

$$\begin{aligned} \bar{u}_1 &= b_1 + a_{11}\bar{u}_1 + a_{12}\bar{u}_1 \cdot \bar{u}_2 \\ \bar{u}_2 &= b_2 + a_{21}\bar{u}_2 + a_{22}\bar{u}_1 \cdot \bar{u}_2 \end{aligned} \tag{9}$$

Solving for $\bar{u}_2$ in the bottom line of equation (9), substituting into the top line, and simplifying yields a quadratic equation in the unknown $\bar{u}_1$, shown as equation (10).

$$\begin{aligned} &[(a_{11} - 1)a_{22}]\bar{u}_1^2 + (1 + a_{11}a_{21} + a_{22}b_1 \\ &\quad - a_{11} - a_{21} - a_{12}b_2)\bar{u}_1 + (a_{21} - 1)b_1 \end{aligned} \tag{10}$$

Equation (10) is solved using the quadratic formula and the positive, real solution is selected. Systems with three or more items can be solved numerically.

Appendix 5. Solution stability with non-additive costs

The nonlinear system $\mathbf{x}(k+1) = s(\mathbf{x}(k), k)$ with equilibrium points $\bar{\mathbf{x}} = s(\bar{\mathbf{x}})$ may be linearized at an equilibrium point using Liapunov's first method (Brogan, 1991, p. 349). This method perturbs the system at the equilibrium point using a vector of small deviations $\mathbf{y}$ or $s(\bar{\mathbf{x}} + \mathbf{y}) = s(\bar{\mathbf{x}}) + \mathbf{J}(\mathbf{y})$. $\mathbf{J}$ is the Jacobian matrix of the system with general entry $(\partial s_i / \partial x_j)$. The linearized version of the system is found by substituting $\mathbf{x}(k) = \bar{\mathbf{x}} + \mathbf{y}(k)$ into $\mathbf{x}(k+1) = \mathbf{s}(\mathbf{x}(k), k)$ and using $s(\bar{\mathbf{x}} + \mathbf{y}) = s(\bar{\mathbf{x}}) + \mathbf{J}(\mathbf{y})$, yielding

$$\bar{\mathbf{x}} + \mathbf{y}(k+1) \cong \mathbf{s}(\bar{\mathbf{x}}) + \mathbf{J}\mathbf{y}(k) \Rightarrow \mathbf{y}(k+1) = \mathbf{J}\mathbf{y}(k).$$

Note that this last expression is itself a linear system in $\mathbf{y}$ with coefficient matrix $\mathbf{J}$. The nonlinear system is, therefore, stable in the y-region of $\bar{\mathbf{x}}$ if the Jacobian matrix $\mathbf{J}$ satisfies the unit root property.

With the non-additive system in the main text, we find that

$$\mathbf{J} = \begin{bmatrix} a_{11} + a_{12}\bar{u}_2 & a_{12}\bar{u}_1 \\ a_{22}\bar{u}_2 & a_{21} + a_{22}\bar{u}_1 \end{bmatrix}_{\bar{\mathbf{u}}=(569,628)} \tag{11}$$

Evaluating this matrix at $\bar{\mathbf{u}} = [569, 628]$, yields

$$\mathbf{J} = \begin{bmatrix} 0.1215 & -0.0711 \\ -0.0698 & 0.2923 \end{bmatrix}$$

with eigenvalues [0.0962 0.3176]. Hence, the system is stable at this equilibrium point.

Appendix 6. The cost slack adjustment problem

On iteration k, the cost to manufacture the iso-profit volume vector, $\mathbf{u}_{(k)} = (u_{1k} \quad u_{2k})^{\mathrm{T}}$, must reflect the price discount offered by the resource vendor. It may be shown that the incremental contribution of the new units at step k is

$$\Delta c_{(k)} = \mathbf{v}_0^{\mathrm{T}} \cdot (\mathbf{c} - \mathbf{c}_0) + \mathbf{u}_{(k)}^{\mathrm{T}} \cdot \mathbf{c}.$$

Note that contrary to intuition, the last term $\mathbf{u}_{(k)}^{\mathrm{T}} \cdot \mathbf{c}$; i.e. incremental volume times the contribution at the new price, is not the incremental contribution of the incremental units. The goal is to adjust the iso-profit volumes $\mathbf{u}(k)$ to reflect the vendor discount for however many machines are implied by these volumes at this step. The cost slack, $s(k)$, is the difference between full costed and discounted costed machines. The problem, therefore, is to find a solution vector,

$$\mathbf{x}_{(k)} = (x_{1k} \quad x_{2k})^{\mathrm{T}},$$

such that

$$(\mathbf{u}_{(k)} - \mathbf{x}_{(k)})^{\mathrm{T}} \cdot \mathbf{c} = \mathbf{u}_{(k)}^{\mathrm{T}} \cdot \mathbf{c} - s.$$

But since

$$(\mathbf{u}_{(k)} - \mathbf{x}_{(k)})^{\mathrm{T}} \cdot \mathbf{c} = \mathbf{u}_{(k)}^{\mathrm{T}} \cdot \mathbf{c} - \mathbf{x}_{(k)}^{\mathrm{T}} \cdot \mathbf{c},$$

it follows that $\mathbf{x}_{(k)}^{\mathrm{T}} \cdot \mathbf{c} = s$. We also want the adjusted iso-profit incremental volumes to be proportional to their use of the resource

$$p(k) = \frac{u_1(k)}{u_2(k)}$$

at this step. In the two-item case, therefore, the solution is straightforward. Expand $\mathbf{x}_{(k)}^{\mathrm{T}} \cdot \mathbf{c} = s$ and substitute for x_{2k} in terms of the relation $p(k)$ to yield

$$c_1 x_1 + c_2 \frac{x_{1k}}{p(k)} = s(k).$$

Therefore,

$$x_{1k} = \frac{s(k)}{\left(c_1 + \dfrac{c_2}{p(k)}\right)}$$

and

$$x_{2k} = \frac{x_{1k}}{p(k)}$$

In the general case, we must solve a system of equations, subject to the proportionality constraint. This can be accomplished using the method of Lagrange multipliers.

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Resources for understanding product liability

The *Journal of Product & Brand Management* continues to investigate companies and online initiatives that have a product focus. Usually, we cover aspects of product development or product management. We have not yet devoted space to the consideration of product liability. Liability is one of those concepts that most new product developers' wish did not exist. Most new products currently undergo significant product defect testing to minimize unforeseen accidents that might occur in use. Despite extensive efforts, not everything can be anticipated.

Recently, the popular press has devoted considerable attention to a product category with inherent dangers, cigarettes. Stakeholders and liberal reformers have done battle against the cigarette companies to force a patchwork of state laws that take aim against cigarette smoking. Some of the laws prohibit smoking in restaurants, hospitals and non-smoking areas in public places. Others are more draconian and prohibit smoking in any public place including outdoor sporting arenas or privately owned buildings that the public might visit.

Many actions aim at increasing taxes on the product to increase its price in an attempt to reduce consumption. Data from the US from 1980 to 2000 show an increase in the per pack price from $1.20 to $3.20. Consumption data from the same period show a decrease from 30,000,000,000 packs to 21,000,000,000. The numbers are still staggeringly high but they have decreased. Several studies have shown the clear link between higher price per pack and lower consumption level, especially among younger people.

The liberal, public-spirited guardians of the nation's welfare have become emboldened by early successes and have tried other strategies. Upset by the acknowledged high public health costs of cigarette smoking, they sought other ways of reducing the habit than taxation. One major initiative was to portray cigarettes as a drug dispensing system, injecting nicotine into patients. That effort bore some success. The legal import is that the US Food and Drug Administration retains widespread powers to regulate or even prohibit the sales of drugs. The hope was that if cigarettes' addictive ingredient, nicotine were declared a drug, it could be regulated and only dispensed with a physician's prescription. The effect would be to make all over the counter sales illegal and keep cigarettes out of the hands of children and teenagers.

The cigarette industry faces a series of difficult challenges. The latest onslaught is unfolding state by state. One of the dangers of cigarettes is the damage they cause when a smoker falls asleep. Smoldering cigarettes can cause deadly fires killing the smoker and others who live in the same building. New York City is one of the most densely populated cities in the US and experiences a large portion of cigarette-induced fires. New York state legislators from city districts helped to push "fire-safe cigarette" standards that cigarette products sold in the state must meet. To meet the standards, a lit cigarette must extinguish itself if it has not been puffed after a small time period. The idea is that if a smoker falls asleep, the cigarette will not continue to burn, posing a hazard. Despite protests from the cigarette industry that the goal was technologically impossible, such cigarettes have been produced. So, to be legal to sell in New York City and state, all cigarettes must be certified as "fire-safe" every three years. So, should product developers and marketers feel relief when their new formulations pass the test? The answer is no. The change to a "new cigarette" will have some anticipated but difficult to quantify consequences. New York City and its environs are the most populated parts of the state. The area borders the states of Connecticut, and New Jersey and is not far from Pennsylvania and Massachusetts. New York City's taxes are already higher that New York state's, and higher than bordering states. Already there is a healthy traffic in bootleg cigarettes that are purchased in neighboring states with lower taxes. Since a carton of 20 can cost upwards of $60, there is a significant incentive to save some money buying out of state.

The fire-safe cigarette's safety feature may prove annoying to the smoker during the day. If it self-extinguishes when one is working on a computer, it would have to be relit for another puff. If smokers are forced to relight continuously the product will be annoying to use versus the "classic" style. That single benefit would be enough to boost cross border purchases, impacting New York retailers.

The effects reported above may be minor annoyance to the tobacco companies. The real problem may be that making and selling a "fire-safe" cigarette is an admission that the old style is dangerous. Big tobacco has no plans to introduce the safe style in areas where it is not mandated. The admission will become costly when the old style causes a fire. That event is predictable and leaves manufacturers open to the charge that

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they knowingly sold a "fire-unsafe" cigarette, even though they also sold a "fire-safe" version.

Cigarettes are currently an obvious product under pressure. That pressure is mounting and legal onslaughts may take very unexpected forms with danger, like the heads of the Hydra, coming from multiple sources. The lesson is that even straightforward looking cases can contain a legal pitfall that might spell significant financial loss for a producer. Since few marketers are also attorneys, there seems to be a need for some source that can provide information about product liability in an understandable way for the layman.

The Internet has several Web sites which provide legal information about current product liability cases. That information will not be helpful to the companies currently enduring litigation. However, it might be a valuable warning about what kinds of actions to avoid. In this issue, we very briefly look at two of them.

Australian Competition and Consumer Commission

[www.accc.gov.au/content/index.phtml/itemId/268708]

The Australian Competition and Consumer Commission maintains an extensive Web site of regulations and their description as well as basic consumer information pertaining to product liability. The Web site provides information about product liability provisions of the Australian Trade Practices Act. The act allows "persons who suffer injury or loss as the result of a defective product to take legal action for compensation against the supplier of that product". The act pertains only to goods supplied after 9 July 1992. The material will be of help to Australian residents.

Tort law product liability resource center

[http://resource.lawlinks.com/Content/Legal_Subject_Index/Tort_Law_Product_Liability/product_liability.htm]

This Web site will be of interest to US and international marketers faced with guarding against product liability issues in the US. When visited, we found ten major liability categories as well as a group of documents. The documents include: "Introductory Articles", which focuses on rather general liability concepts and issues. There are also, "In-depth Articles", which treats individual topics in great detail. One example gives advice to technical writers to protect themselves from documentation-based liability suits. Others are similarly focused. There is also another major selection of "Legal Codes and Regulations" links that cover chapter and verse of the underlying liability regulations.

Each of the major liability categories covers very pertinent material. For example, one category, Asbestos, contains several introductory articles, several selected court cases, and a group of asbestos specific regulations.

Overall, the Web site contains enough information to educate a marketer about the basics of numerous product liability areas. It also provides enough real-life evidence in the form of court cases to alert the businessperson to the perils of litigation. With no tongue in cheek humor, it acts as the liability attorney's sales aid. The information can be chilling to some marketers, and prompt a legal consultation.

Overall comments

Product liability is a sad aspect of new product development. As new product teams implement six-sigma processes to improve their underlying quality, one goal may be to exhaust the possibilities of a product related injury. It is an another worthy goal of six-sigma.

In our next issue, we will investigate other informative sites and invite readers to submit their favorite Internet sites for our consideration.

Reader requests

Please forward all requests to review innovative Internet sites to: Dr Dennis Pitta, University of Baltimore, 1420 North Charles Street, Baltimore, MD 21201-5779, USA. Alternatively, please send E-mail to: pitta@comcast.net for prompt attention.