Price Knowledge and Elasticity

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Abstract

Previous research indicates that consumers often exhibit surprisingly poor knowledge of product prices. The present study investigates whether price knowledge, as measured by reference price accuracy, is related to price-sensitivity as measured by the price-elasticity of demand. We hypothesize that consumers are most knowledgeable regarding the prices of goods for which demand is most price-elastic. Using a new data set containing a wide array of goods and services, we find significant correlations between price-elasticity and two measures of reference price accuracy. Additionally, price knowledge is found to be higher among teens and males than among older adults and females, respectively.

Keywords: price-elasticity, reference price, price-knowledge

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1. Introduction

In the canon of economic theory, one of the necessary conditions for a perfectly competitive market is perfect information. Consumers (and producers) are assumed to know the prices, attributes, and availability of all goods in the market (see for example, Wetzstein, 2005). Over the past five decades, however, a large empirical literature has indicated that, contrary to this stylized world, consumers often have poor knowledge of prices. Even when asked about the prices of goods they are about to purchase or have recently bought, many consumers appear unable to estimate prices accurately, and their estimation errors have tended to be surprisingly large.

Several explanations for this discrepancy have been advanced, including the role of advertising, the limitations of memory, macroeconomic factors such as price inflation, and demographic variables such as the consumer's level of education. One potentially important variable which has received limited attention in prior work is the consumer's sensitivity to price. Clearly, consumers are more sensitive to the prices of some goods than others, and it seems reasonable to suppose that this sensitivity influences their collection and retention of price information—i.e., where price matters most (least) in their purchase and consumption decisions, consumers will exhibit the greatest (least) awareness of prices.

The present paper examines the nexus between price knowledge and price sensitivity. We develop a unique data set reflecting consumer knowledge of prices in three dozen product categories and relate the mean level of knowledge to the price-elasticity of demand in each category.[1] Section II briefly reviews the prior literature and section III describes our survey. Section IV presents the results, Section V discusses our findings, and the paper ends with conclusions and caveats in section VI.

[1] The price-elasticity of demand (ε) is defined as the percentage change in the quantity demanded for a one percent increase in the good's price. A value of $\varepsilon < -1$ (elastic demand) indicates relatively strong sensitivity to price, whereas $\varepsilon > -1$ (inelastic demand) indicates relatively little price sensitivity.

2. Motivation for the Study

Since the 1960s, numerous studies have examined the accuracy of consumers' price knowledge; by the turn of the century, Estelami et al. (2001) had located 297 such analyses. Although these studies have shown substantial variation in methodologies and results (Monroe et al., 1986; Estelami & Lehmann, 2001), throughout most of this work, the general consensus has been that consumers exhibit a fairly weak knowledge of prices. As Estelami & De Maeyer (2004, p. 130) point out,

> *Since the early studies of Gabor and Granger (1961) on the topic, research has mostly converged on the disturbing fact that consumer price knowledge is relatively poor. Some researchers estimate that as much as about half of all consumers are unaware of the actual prices of items they frequently purchase (e.g., Harrell, Hutt, & Allen, 1976; Helgeson & Beatty, 1987; Le Boutillier, Le Boutillier, & Neslin, 1994). Moreover, price estimates provided by consumers are often found to be significantly different from the products' actual prices (Dickson & Sawyer, 1990; Monroe & Lee, 1999).*

A number of variables have been proposed as causal factors to explain cross-sectional or intertemporal variations in price knowledge. These include macroeconomic variables such as price inflation and economic growth (Shamir, 1985; Estelami, et al., 2001), competition among sellers (Seiders & Costley, 1994), brand loyalty and market share (Buzas & Marmorstein, 1988), advertising and the frequency with which goods are purchased (Estelami & De Maeyer, 2004), and demographic and socio-economic variables such as age, gender, education, and income (McGoldrick & Marks, 1987; Wakefield & Inman, 1993).

Importantly, a large majority of prior studies have focused on food and related grocery items (such as toothpaste and soap). For example, out of 32 studies summarized by Kenning et al. (2007), 26 were concerned with consumer knowledge of grocery store prices.[2] Relatively few studies have examined price knowledge for other categories of goods. This raises the question of whether the low price knowledge observed in most of the literature is a consequence of the particular types of products being investigated.

Because groceries are purchased quite frequently, we might expect consumers to exhibit greater price knowledge for these items than for less frequently purchased goods and services. Most empirical research shows, however, that price knowledge is no higher for groceries than it is for clothing (Kenning, et al., 2007), durables (Estelami & De Maeyer, 2004), or services (Turley & Cabaniss, 1995; Lawson &

[2] Likewise, Estelami & Lehmann (2001) reviewed 279 studies, of which 250 investigated price knowledge for frequently purchased consumer goods including groceries, and Estelami & De Maeyer (2004, p. 129) point out that there has been "an overwhelming focus on grocery products as the basis of empirical investigation" in previous research. Recent studies examining knowledge of food prices include those by Kenesei & Todd (2003), Evanschitzky et al. (2004), and Aalto-Setala et al. (2006).

Bhagat, 2002). Indeed, a direct comparison among frequently purchased goods, durables, and services by Estelami & Lehmann (2001) found no significant differences in price knowledge.

Because it occupies a unique place among consumer goods, however, there is another important difference between food and other products which may potentially offset the effect that purchase frequency has on price knowledge. While various types of foods can substitute for each other, and brand switching often occurs in response to relative price changes, there are obviously no substitutes for food in general, and for middle-income and upper-income households, groceries constitute a relatively low-budget item.[3] These two factors—a lack of substitutes and low budget-share—contribute to making the demand for food in general extremely price-inelastic. The U.S. Department of Agriculture (USDA, 2003) estimates that for the aggregate commodity group of food, beverages, and tobacco, the price elasticity of demand in the U.S. is -0.08; demand is therefore far more price-inelastic for this commodity group than for any others, such as medical care (-0.86) or recreation (-0.93). And as Table 1 indicates, similar (though slightly smaller) differentials in price-sensitivity occur in other countries; in Luxembourg, for example, food, beverages and tobacco have a price elasticity of -0.10, compared with -0.87 for medical care and -0.93 for recreation.[4] Thus, consumers in general appear to be relatively insensitive to variations in food prices, and they may therefore have little motivation to learn and remember those prices. Indeed, research by Dickson & Sawyer (1990) confirms this notion of price-insensitivity by showing that consumers often purchase groceries without bothering to check prices first.[5]

[3] Data from the 2007 Consumer Expenditure Survey indicate that four-person households with pre-tax incomes of $30,000 to $40,000 in the US spend 13.5 percent of disposable income on food, and this budget share declines to 13 percent for incomes of $40,000 to $50,000, 11 percent for incomes of $50,000 to $70,000, and 7.6 percent for those with incomes of $70,000 or more. See Table 2, Income before taxes: Average annual expenditures and characteristics, Consumer Expenditure Survey, 2007, available at http://stats.bls.gov/cex/#tables.

[4] Price elasticities for aggregate commodity groups in other countries can be viewed at the USDA website, http://www.ers.usda.gov/Data/InternationalFoodDemand/StandardReports/Priceelasticitygroups.xls .

[5] This may be especially common during periods of low inflation.

Table 1: Own-Price Elasticities for Aggregate Commodity Groups in Selected Countries*

	Canada	Denmark	Germany	Japan	Luxembg	U.K.	U.S.
Recreation	-0.95	-0.95	-0.96	-0.95	-0.93	-0.96	-0.93
Medical Care	-0.88	-0.88	-0.88	-0.88	-0.87	-0.89	-0.86
Household Operations	-0.86	-0.85	-0.86	-0.86	-0.85	-0.86	-0.85
Other	-0.83	-0.83	-0.83	-0.83	-0.81	-0.84	-0.81
Education	-0.80	-0.80	-0.80	-0.80	-0.80	-0.80	-0.80
Transport & Communicat	-0.80	-0.80	-0.81	-0.80	-0.79	-0.81	-0.79
Rent, Fuel, Power	-0.75	-0.75	-0.75	-0.75	-0.74	-0.76	-0.74
Clothes, Footwear	-0.69	-0.69	-0.69	-0.69	-0.69	-0.69	-0.69
Food, Bev & Tobacco	**-0.22**	**-0.19**	**-0.24**	**-0.22**	**-0.10**	**-0.25**	**-0.08**

**Source: USDA (2003); all figures have been rounded to two decimal places.*

Similarly, Kenning et al. (2007) found lower price-knowledge for apparel than earlier studies had found for durable goods, despite the fact that clothing is more frequently purchased. Kenning et al. (2007, p. 113) remarked, "That is particularly surprising and relevant, since most fashion apparels are medium- to high-involvement products and one would expect higher price knowledge [for clothes] than for durables." As a potential explanation of this puzzle, we note from Table 1 that the demand for clothing is also relatively price-inelastic, whereas the demand for durable goods is generally price-elastic (Parker & Neelamegham, 1997; Jain & Rao, 1990).

Such differences in price knowledge and the price-elasticity of demand across goods provide the motivation for the present study. We hypothesize that for goods which are typically purchased with little or no regard to price, price-knowledge will be relatively low; in contrast, consumers are more likely to seek, acquire, and retain information on those prices that most heavily influence consumption patterns. Accordingly, price knowledge should be correlated with price sensitivity as measured by the price-elasticity of demand. Previous empirical findings of low price knowledge may therefore have resulted from analyzing goods for which demand is relatively inelastic.

There is already some evidence in the literature to suggest that price knowledge is higher among price-sensitive individuals than others. Previous studies have demonstrated that those who deliberately seek price information (Mazumdar & Monroe, 1990) and those who engage in comparison-shopping

(Mazumdar & Monroe, 1992; Le Boutillier et al., 1994; Kenesei & Todd, 2003)—i.e., those who exhibit the greatest attention to price—tend to have more accurate price-knowledge than others. Similarly, Binkley & Bejnarowicz (2003) found that consumers having a high opportunity cost of acquiring price information (e.g., those whose time is most valuable) are less likely to undertake price comparisons and consequently have lower price knowledge than their counterparts with lower opportunity costs. And while Scriven & Ehrenberg (2004, p. 33) found no consistent relationship between price awareness and price sensitivity, they did find some evidence that demand was less elastic "among those who do not attempt to estimate a price at all when asked (and therefore perhaps do not even think about it)." [6] Our work complements such studies by investigating whether price-knowledge is higher *in the product categories* for which consumers tend to be most price-sensitive.

3. Definitions and Data

3.1 Reference Prices

Two aspects of price awareness have been distinguished in the literature: remembering (or recalling) prices and knowing prices (Monroe & Lee, 1999; Helgeson & Beatty, 1987). *Remembering* refers to having an explicit recollection of price from a recent purchase, which is stored in short-term memory. In contrast, *knowing* refers to having an accurate reference price, or price expectation, for the particular good stored in long-term memory. Goods need not have recently (or ever) been purchased in order for consumers to have developed reference prices for them; reference prices may reflect judgements based on accumulated experience with similar products. While most of the earlier studies were based on price recall (Estelami & Lehmann, 2001), a growing number of researchers have measured price knowledge by the accuracy of reference prices. Indeed, Trikka & East (2006, p. 7) demonstrate that "using a pure recall measure underestimates the level of consumer price knowledge." Some of those employing reference prices, such as Vanhuele & Dreze (2002), Evanschitzky et al. (2004), Aalto-Setala et al. (2006), Trikka & East (2006), and Kenning et al. (2007), have surveyed shoppers in stores prior to their purchases. Others have elicited reference prices entirely outside of the shopping environment: Wilkinson et al. (1980) and Urbany & Dickson (1991) interviewed individuals in their homes, Helgeson & Beatty (1987) and Lawson & Bhagat (2002) conducted classroom surveys and experiments with students, Estelami (1998) used data from game show contestants, and Manning et al. (2003) questioned riders on an urban railway.

The present study likewise measures price knowledge by the accuracy of consumers' reference prices for various goods and services. Indeed, our subjects were not engaged in shopping at the time of the survey, but rather were end-users who had received the items in question as gifts.

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[6] Non-response has also been treated as a proxy for a lack of price knowledge elsewhere in the literature; see for example Evanschitzky et al. (2004), Aalto-Setala et al. (2006), and Kenning et al. (2007).

3.2 Data Collection

To gather reference price data we conducted a survey among undergraduate students in principles of economics courses at a public college near Niagara Falls, NY during January of 2008. The survey had two stages: an in-class phase and a homework phase. For the first stage, we asked the subjects to describe several gifts they had been given in celebration of a holiday, a birthday, or another occasion.[7] Next, we asked them to estimate the price they thought the giver had paid for each gift, and explicitly instructed them to ignore any sales taxes and transportation fees.[8] The surveys were then collected and photocopied, to ensure that the subjects could not alter their initial responses during the second phase, and the price estimates were recorded in a data file.

In the following class period, the second stage was initiated: the surveys were returned to the subjects, and they were given a homework assignment to determine the actual market price of each gift they had listed. It was suggested that this could be accomplished by contacting the giver, visiting the store where the item was purchased, shopping online using the internet, or checking the price in a catalogue. When the homework assignments were submitted, the market price information was added to the data file.[9]

The survey covered 117 individuals, almost equally divided by gender: 59 males and 58 females. Their ages ranged from 18 to 53 years, with a mean of 21.6 and a median of 19. While it is not nationally representative, this sample is similar in size and nature to the undergraduates surveyed by Helgeson & Beatty (1987) and Lawson & Bhagat (2002), and comparable in size to the samples utilized by Zeithaml & Fuerst (1983), Conover (1986), McGoldrick & Marks (1987), Mazumdar & Monroe (1990), Urbany & Dickson (1991), Le Boutillier et al. (1994), and Trikka & East (2006).[10]

Collectively, the respondents reported on 539 goods and services; however, 9 of those were cash and 34 were gift cards having no fixed price. These were removed from the sample, as were two live pets. Four missing observations reduced the sample further to 490 goods and services of various kinds. The market prices ranged from $1.99 (for a coin bank) to $33,000 for a new automobile (a Chevrolet Avalanche), with a mean of $309.10 and a median of $59.99. Nearly half (47.8 percent) of the market prices were

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[7] The survey was conducted in early January so that the recollection of gifts received during the holidays would be fresh. The number of gifts reported per person was not restricted, and ranged from 1 to 8 with a median of 3.

[8] Because the subjects had not purchased the items in question, their responses were not based on price recall as defined above (though they may well have seen advertisements or even shopped for the items previously). Moreover, in contrast to prior studies which employed price *recognition* by suggesting several possible prices for a product and asking respondents to select the one that they believed to be the most accurate (e.g., Vanhuele & Dreze, 2002), we did not prompt respondents or provide any price cues. Thus, our method of eliciting price knowledge utilized neither price recognition nor price recall per se.

[9] Some subjects reported brand names during the first phase and others did not. Regardless of whether they reported brand names during the in-class phase, however, they clearly had access to the brand names of the products when they checked the market price during the homework phase.

[10] Those studies employed sample sizes of 260, 30, 160, 168, 214, 90, 59, 235, and 151, respectively. The gender balance in our sample arguably makes it slightly more representative than many earlier samples; in 84 percent of the studies surveyed by Estelami & Lehmann (2001), females comprised 75 to 100 percent of the subjects.

obtained by asking the giver, 42.8 percent were obtained from the store or the store's website, 7.1 percent were read off the purchase receipt, and the rest were obtained from a catalogue or advertisement.

3.3 Price Knowledge Measures

We calculate two price knowledge measurements that have been consistently used in the literature: the percent absolute deviation (*PAD*) and the price knowledge score (*PKS*). Both are based on the price estimation error (*PEE*), which is the percentage difference between the item's actual price (*P*) and the consumer's estimate (*E*) of the price: $PEE = (P - E)/P$. A value of $PEE > 0$ implies an under-estimate of price, and $PEE < 0$ implies an over-estimate. Averaging the *PEE* across goods or consumers will tend to diminish its magnitude, however, since positive and negative errors will offset each other (Aalto-Setala et al., 2006). It is therefore customary to calculate the percent absolute deviation (*PAD*), which is the absolute value of *PEE* for each item (Dickson & Sawyer, 1990; Mazumdar & Monroe, 1992; Estelami, 1998). The average value of *PAD* for a sample of size *n* is the mean absolute percentage error, or

$$MAPE = \frac{1}{n}\sum\left|\frac{P-E}{P}\right| .$$

Following Estelami (1998) and Vanhuele & Dreze (2002), we also calculate a related metric, the price knowledge score *PKS*. This measures the proportion of estimates which lie within 20 percent of the actual price of a good.[11] In general, *PKS* should be higher when *MAPE* is lower, reflecting greater consumer price knowledge.

4. Analysis

On the whole, the respondents demonstrated a level of price knowledge that is similar to levels found in previous investigations. Over all 490 items in the sample, the mean absolute percentage error was 0.20; that is, the average estimation error was 20 percent of the actual market price. This result is consistent with several recent studies of price knowledge and price recall which estimated *MAPE* to lie between 0.14 and 0.35 (Estelami, 1998; Estelami & Lehmann, 2001; Evanschitzky et al., 2004; Aalto-Setala et al., 2006; Kenning et al., 2007).

[11] A variety of similar measures have been utilized in prior work. For example, Kenesei & Todd (2003) calculate the proportion of consumers whose recall is within 5 percent, and Estelami & De Maeyer (2004) calculate both the proportion of estimates within 10 percent and the proportion within 25 percent of the actual price. The term "price knowledge score" for this statistic is taken from Estelami & De Maeyer (2004).

Importantly, however, as Table 2 indicates, the distribution was heavily skewed to the right, so that the mean was influenced by three outliers for which $PAD > 2$.[12] The median value of *PAD* was 0.11, and the modal value of the pricing error was zero. More than one-third of the estimates were within five percent of the correct price, a threshold used in several prior studies (e.g., Dickson & Sawyer, 1990; Kenesei & Todd, 2003) to define accuracy. Moreover, we find $PKS = 0.67$, indicating that more than two-thirds of the respondents' estimates were within 20 percent of the correct prices. This finding is at least broadly consistent with that of Vanhuele & Dreze (2002), who reported that 60.3 percent of prices recalled by consumers were within 20 percent of the correct price.

However, because nearly half of the market prices in our study were obtained by asking the giver, there is a potential source of measurement error in our price knowledge calculations. A high *MAPE* or low *PKS* may reflect the givers' poor price recall, rather than the recipients' lack of knowledge. Thus, the top panel of Table 3 tests for differences according to the source of the market price. Although estimation errors were slightly higher when the market price was obtained from the giver than when it came from other sources, the differences in the measures of price knowledge were not statistically significant.[13]

Table 2: Distribution of Percent Absolute Deviation (PAD)

PAD	**Cumulative Rel. Freq. (%)**
PAD = 0.00	14
$0.00 < PAD \leq 0.01$	27
$0.01 < PAD \leq 0.05$	34
$0.05 < PAD \leq 0.10$	48
$0.10 < PAD \leq 0.15$	57
$0.15 < PAD \leq 0.20$	67
$0.20 < PAD \leq 0.25$	73
$0.25 < PAD \leq 0.30$	78
$0.30 < PAD \leq 0.35$	85
$0.35 < PAD \leq 0.40$	87
$0.40 < PAD \leq 0.45$	89
$0.45 < PAD \leq 0.50$	91
$0.50 < PAD \leq 1.00$	98
$1.00 < PAD \leq 2.00$	99
$2.00 < PAD \leq 4.00$	100

[12] In the absence of those three outliers, the mean absolute percentage error would have been 0.18.
[13] Moreover, no significant differences in either *MAPE* or *PKS* were attributable to givers among subgroups of recipients such as males, females, teens, or older adults. Of course, some or all of the givers may have reviewed their purchase receipts rather than relying exclusively on memory when providing market prices.

Table 3 also tests for significant differences in price knowledge according to gender, age, and the magnitude of the market price. In particular, t-tests for the equality of means show that females had a somewhat higher mean estimation error (*MAPE*) than males (0.23 versus 0.17), and correspondingly, a lower price knowledge score.

Table 3: Statistical Tests for Differences in Price Knowledge*

Measures of Price Knowledge	**Groupings**		**Significance Level**
	Asked Giver n = 234	**Other Source** n = 256	
MAPE	.22 (.36)	.19 (.28)	.36
PKS	.65 (.48)	.70 (.46)	.24
	Males n = 223	**Females** n = 267	
MAPE	.17 (.22)	.23 (.38)	.06
PKS	.72 (.45)	.63 (.48)	.03
	Age < 20 n = 272	**Age ≥ 20** n = 218	
MAPE	.17 (.31)	.24 (.33)	.03
PKS	.72 (.45)	.61 (.49)	.01
	P < $60 n = 248	**P ≥ $60** n = 242	
MAPE	.23 (.39)	.17 (.23)	.04
PKS	.62 (.49)	.73 (.45)	.01

** Standard deviations are given in parentheses.*

Additionally, teenagers were significantly more knowledgeable of prices than older respondents by both measures; the superior price knowledge of younger individuals is consistent with the findings of Zeithaml & Fuerst (1983).

In addition, price estimates were significantly more accurate for items having market prices above the median than for lower-priced goods: *MAPE* was 5.8 percentage points lower, and the price knowledge score was more than 11 percentage points higher for goods priced above $60 than for those priced below $60. Of course, an estimation error of any given magnitude is a smaller percentage of a high price than a low price. But our finding of greater price knowledge for expensive goods also hints at the role of price-elasticity. The percentage change in consumption for a percentage change in price is widely accepted as a numerical measure of price sensitivity. Factors influencing the magnitude of the price-elasticity for a good include the availability of close substitutes and the proportion of the consumer's budget devoted to the good (Wetzstein, 2005). Demand is generally more price-elastic, *ceteris paribus*, for relatively

expensive goods than for inexpensive items; thus, consumers tend to be more conscious of such prices, and should therefore be more knowledgeable regarding them.

To more formally investigate this hypothesized connection between price elasticity and price knowledge, we next classified the 490 items in our sample into 36 distinct product categories for which recent and reliable price-elasticities of demand were available from the empirical literature. For each category, Table 4 reports the number of items in our sample, the mean market price of the goods, and our consumers' *MAPE* and *PKS*. Price knowledge was highest in the categories of new automobiles, household machines, textiles, glassware, and wireless internet access, for which *PKS* was 1.0 and average estimation errors were less than 6.5 percent of actual prices. Consumers were least accurate in estimating the prices of tools, furniture, flowers, household furnishings, and club memberships, for which the average errors exceeded 35 percent. [14]

[14] The diversity of goods and services displayed in Table 4 exceeds that found in most previous studies, which focused on a particular product category such as clothing, food, durables, or services, rather than a combination. The personal care category includes health and beauty products; accessories (e.g., wallets) are included among personal goods; textiles include pillows and towels; and household machines include vacuum cleaners and alarm clocks.

Table 4: Price Knowledge and Elasticity for Various Product Categories*

Category	n	Price ($)	MAPE	PKS	Elasticity	Source
Vehicle accessories	13	212.69	.27	**0.62**	**0.02**	Almon
Bicycles	3	136.00	.24	**0.67**	**-0.07**	Almon
Cameras	11	210.09	.10	**0.91**	**-0.15**	Almon
Games & Dolls	13	50.99	.16	**0.69**	**-0.17**	Almon
Tools	4	83.00	.36	**0.25**	**-0.19**	Almon
Flowers	3	23.50	.37	**0.33**	**-0.19**	Almon
Club memberships	2	61.00	.54	**0.50**	**-0.27**	Almon
Other vehicles	5	4,719.80	.16	**0.80**	**-0.27**	Almon
Tableware	5	24.99	.24	**0.60**	**-0.28**	Almon
Kitchen appliances	10	50.64	.21	**0.40**	**-0.40**	Almon
Furniture	9	165.99	.37	**0.11**	**-0.41**	Almon
Airfare	3	352.90	.27	**0.67**	**-0.48**	Almon
Telephones	4	168.50	.22	**0.25**	**-0.61**	Almon
Live entertainment	12	150.33	.05	**0.92**	**-0.70**	Nelson
Radio & TV	12	416.55	.14	**0.83**	**-0.71**	Jensen/de Boer
Computer accessories	8	61.24	.29	**0.50**	**-0.74**	Melnikov
Women's clothes	55	61.06	.20	**0.71**	**-0.74**	Kim
Furnishings	13	30.44	.46	**0.38**	**-0.75**	Almon
Jewelry & watches	41	204.95	.24	**0.61**	**-0.79**	Almon
Men's clothes	55	56.61	.22	**0.62**	**-0.80**	Kim
Education	1	1,736.00	.15	**1.00**	**-0.80**	USDA
Textiles	2	96.50	.06	**1.00**	**-0.80**	Jensen/de Boer
Sporting goods	13	195.66	.18	**0.85**	**-0.81**	Nelson
Household machines	3	47.32	.05	**1.00**	**-0.84**	Jensen/de Boer
New automobiles	3	22,443.33	.05	**1.00**	**-0.87**	McCarthy
Glassware	3	48.00	.06	**1.00**	**-0.90**	Jensen/de Boer
Soft drinks	1	4.29	.17	**1.00**	**-0.97**	Jensen/de Boer
Leisure equipment	46	197.56	.23	**0.76**	**-1.02**	Jensen/de Boer
Footwear	32	78.25	.16	**0.69**	**-1.12**	Jensen/de Boer
DVDs/CDs	35	32.32	.17	**0.63**	**-1.17**	Nelson
Personal goods	21	97.54	.14	**0.67**	**-1.23**	Jensen/de Boer
Personal care	23	44.64	.15	**0.74**	**-1.28**	Jensen/de Boer
Internet-wireless	2	214.98	.06	**1.00**	**-1.29**	Ingraham/Sidak
Books	11	41.88	.12	**0.82**	**-1.35**	Jensen/de Boer
Restaurant meals	5	70.25	.14	**0.80**	**-1.42**	Jensen/de Boer
Computers	8	704.75	.16	**0.75**	**-2.17**	Prince

** All figures have been rounded to two decimal places.*

Table 4 also identifies the relevant price-elasticity of demand for each category, along with its source. No single source could be found which reported price elasticities for each of our product categories; elasticities were therefore compiled from a variety of sources, including Almon (1997), Ingraham & Sidak (2004), Jensen & de Boer (2006),

Kim (1998), McCarthy (1996), Melnikov (2000), Nelson (2001), Prince (2008), and USDA (2003). The elasticities in Table 4 all refer to demand in the U.S. with the exception of those taken from Jensen & de Boer's (2006) study of young households in Denmark; as Table 1 indicates, however, price elasticities in Denmark are similar to those in the U.S. and other developed economies, at least at the aggregate level.[15] In some cases, multiple elasticities were available in the literature; where this occurred we applied the elasticity for the most appropriate category consistent with our classification, or the elasticity from the study focusing most clearly on the specific products. For example, because his study focused on recreation, we adopted Nelson's (2001) price-elasticity for sporting goods rather than Almon's (1997) elasticity for guns, ammunition, and sporting goods; but for non-sports-related recreational goods such as musical instruments, we applied Jensen & de Boer's (2006) price-elasticity for leisure equipment. Similarly, because his study dealt exclusively with new vehicles, we treated McCarthy's (1996) price-elasticity as the most reliable for new automobiles, but not for used cars. On the whole, the set of elasticities compiled for Table 4 seems quite reasonable, with the possible exception of the positive price-elasticity for vehicle accessories.[16, 17]

Table 4 is arranged according to the magnitude of the price-elasticity of demand for each category. A visual inspection indicates that *PKS* tends to be higher (and *MAPE* tends to be lower) among products with the most elastic demand, and several statistical analyses performed on the data confirm the connection between elasticity and price knowledge. First, when the data are divided at the median elasticity ($\varepsilon = -0.77$), we find large and significant differences in both *MAPE* and *PKS*. In particular, the mean absolute percentage errors are nearly 26 percent for the goods with the most inelastic demand, compared with only 14 percent for others. Corresponding to this difference, *PKS* is lower (0.56) among the most inelastic demands and higher (0.83) for goods with greater elasticity of demand. As shown in Table 5, the differences are both highly significant.

Table 5: Statistical Tests for Differences in Means

	n	**MAPE**	**PKS**
Elasticity ≥ -0.77	18	0.26 (0.03)	0.56 (0.06)
Elasticity < -0.77	18	0.14* (0.01)	0.83* (0.04)

** Significantly different from the preceding mean at the .001 level.*

[15] Indeed, at the micro level, the price-elasticity of demand for books and papers in Denmark (-1.35075) as reported by Jensen & de Boer (2006) is virtually identical to the price-elasticity of demand for print products in the U.S. (-1.351) as reported by Nelson (2001).

[16] A positive own-price elasticity implies that consumers will purchase a greater quantity as the price increases. However, the magnitude of the reported elasticity is near zero, implying a highly inelastic demand.

[17] The category for which it was most challenging to locate a published price-elasticity of demand was computer accessories (including, for example, the computer "mouse", printer, software, etc.). Rather than omit this category, we applied Melnikov's (2000) estimate of the price-elasticity for computer printers. Note from Table 4 that demand for computer accessories is less elastic than demand for computers: a computer may be a discretionary purchase, but once it is owned, having the accessories may be considered essential.

More generally, Pearson correlations between the price elasticity of demand and our two measures of consumer price knowledge are reported in Table 6. As the correlation matrix shows, the price-elasticities reported in Table 4 are significantly correlated with both *MAPE* and *PKS*.[18] Because greater price knowledge is indicated by a lower *MAPE* and greater sensitivity to price is indicated by a more negative price-elasticity, the positive correlation between estimation errors and elasticities indicates that price knowledge is positively related to price sensitivity. Similarly, because a larger value for *PKS* indicates greater price knowledge, the negative correlation between *PKS* and the price-elasticity of demand also indicates that knowledge and sensitivity to price are linked in the expected direction.

Table 6: Correlations between Price Knowledge and Price Elasticity*

		PKS	**Elasticity**
MAPE	1	-0.79 [.00]	0.42 [.01]
PKS	-0.79 [.00]	1	-0.37 [.03]
Elasticity	0.42 [.01]	-0.37 [.03]	1

** Two-tailed prob-values are given in square brackets below correlation coefficients.*

Finally, when we regress *MAPE* and *PKS* on market price and price-elasticity using the 36 categories of Table 4, we find

$$\underset{}{MAPE} = \underset{[.00]}{0.28} - \underset{[.06]}{(7.23E-6)P} + \underset{[.01]}{0.10\varepsilon}, \quad R^2 = .23 \quad \overline{R}^2 = .19$$

and

$$\underset{}{PKS} = \underset{[.00]}{0.54} + \underset{[.07]}{(1.52E-5)P} - \underset{[.01]}{0.19\varepsilon}, \quad R^2 = .20 \quad \overline{R}^2 = .15$$

where one-tailed prob-values are given in square brackets and $\overline{R}^2$ denotes adjusted R^2.[19] The results again indicate that absolute pricing errors are significantly lower, and price-knowledge scores higher, for more expensive goods and goods with greater (i.e., more negative) price-elasticity than for others.

Alternative specifications yielded essentially equivalent results. For example, it made little difference to the signs, magnitudes, or significance of the correlation or regression coefficients if Jensen & de Boer's

[18] *MAPE* and *PKS* are also highly correlated with one another, as we should expect.
[19] One-tailed prob-values are appropriate because our hypotheses are one-tailed; i.e., we expect price knowledge scores to be higher (and thus *MAPE* to be lower) among expensive goods and those with the most negative price-elasticities of demand.

(2006) uncompensated (Marshallian) elasticities were used in place of the compensated (Hicksian) elasticities.[20] Likewise, reformulating *PKS* as the proportion of estimates within 25 percent (rather than 20 percent) of the correct price made no substantial difference in the results.

5. Discussion

Our overall *MAPE* and *PKS* estimates are consistent with those found in the existing literature. Moreover, the finding that price estimates are significantly more accurate for items having market prices above the median than for lower-priced goods implies a link between price knowledge and elasticity. Indeed, we find a statistically significant correlation between elasticity and reference price accuracy: consumers appear to demonstrate the greatest price knowledge in those product categories for which demand exhibits the strongest price-elasticity. This result accords well with intuition: consumers are more likely to familiarize themselves with the prices to which their consumption behavior is most sensitive. Conversely, lower knowledge of prices will be evident among commodities which are typically purchased without much regard to price.

Although the consumers in the present study were not actively engaged in purchasing, reference prices themselves have behavioral implications; as Kenning et al. (2007, p. 108) note, "Price knowledge stored in long-term memory is more likely to affect a buying decision than the price knowledge stored in short-term memory." We suggest that because consumers in general are more sensitive to the prices of goods with high (absolute) price-elasticities, the respondents in the present study may have paid more attention to the advertised prices of such goods, may have examined their prices in the past, or in other ways developed more accurate reference prices for these items than for other goods.

6. Conclusion

This study examines the accuracy of reference prices held by consumers for a wide variety of goods and services spanning three dozen categories. We find evidence that price knowledge is significantly higher among teenage consumers than older adults, and higher among males than females. Price knowledge also appears to be higher for more expensive goods, and to be correlated with the price-elasticity of demand.

[20] Uncompensated, or Marsallian, own-price elasticities are calculated as the percentage change in quantity demanded for a percentage change in price, assuming that income and all other prices remain constant (while utility is allowed to vary). Compensated, or Hicksian, own-price elasticities are calculated by assuming that all other prices are held constant while income is adjusted to keep utility unchanged.

The association between price knowledge and price-elasticity has several important implications. First, it provides a potential explanation for the discrepancy between the theory of perfect information in competitive markets and the highly imperfect knowledge of price that is empirically evident among consumers in most studies. In particular, it suggests that even where price information is readily available, consumers may pay little attention to the prices of products for which their demand is most inelastic. Additionally, the results could potentially be useful to marketers in an inferential manner. Where the price-elasticities of demand for specific goods have not been estimated but measures of consumer price knowledge are available, greater knowledge of prices could be used to infer greater price-elasticity of demand.

An obvious limitation of the study is that the price-elasticities and the price-knowledge measures with which they were correlated were not derived from the behavior of the same consumers. Indeed, the price-elasticities were compiled from a variety of sources, each involving different samples and time periods. This introduces the possibility that the elasticities do not accurately capture the price-sensitivities of the respondents in the present study. Addressing these shortcomings would be a useful direction for future research.

While the results presented here should be interpreted as indicative of a possible relationship rather than as definitive, the study offers at least preliminary evidence that consumer price knowledge is associated with price sensitivity.

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