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4 **PRICE DISPERSION, PRODUCT**
5 **CHARACTERISTICS, AND FIRMS’**
6 **BEHAVIORS: STYLIZED FACTS**
7 **FROM SHOPPER.COM**
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14 Jihui Chen and Patrick Scholten
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17 **ABSTRACT**
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19 *We study how price dispersion varies with product characteristics at a popular*
20 *online price comparison site – Shopper.com. Our primary finding suggests*
21 *that price dispersion in online markets varies with product characteristics and*
22 *firm behavior. We also find evidence that the level of dispersion varies with*
23 *the percent of firms listing price information in multiple categories. When the*
24 *percent of firms listing prices in multiple categories is relatively high (low),*
25 *price dispersion is low (high).*
26

27 **1. INTRODUCTION**
28

29 This paper explores the extent to which price dispersion varies across categories
30 of products in online markets. The existing literature on price dispersion in online
31 markets focuses either on explaining the observed dispersion for products in similar
32 categories – like books and CDs – or explains observed dispersion at the aggregate
33 level across many product categories. The casual evidence from this study suggests
34 that certain product categories tend to exhibit more price dispersion than others.
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37 **Organizing the New Industrial Economy**
38 **Advances in Applied Microeconomics, Volume 12, 143–164**
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ISSN: 0278-0984/doi:10.1016/S0278-0984(03)12006-8

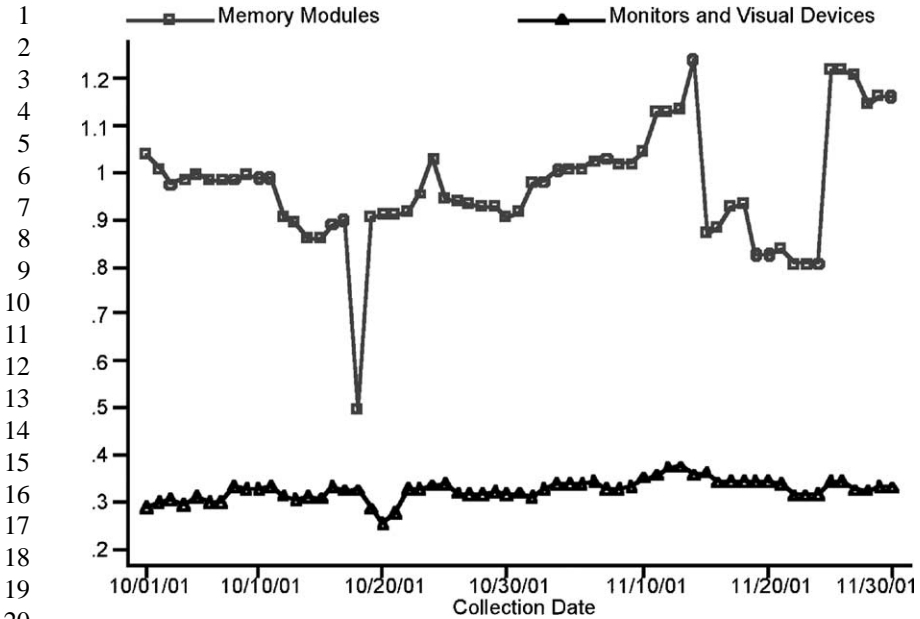


Fig. 1. Percent Range for Two Shopper.com Product Categories.

Moreover, there appears to be an association between firms' behaviors and price dispersion across product categories.

Figure 1 provides the primary motivation for this paper. This figure charts one measure of price dispersion – the average range in prices as a percent of the lowest price – for two product categories at [Shopper.com](#): computer memory modules and computer monitors and visual devices. Two features are immediately apparent from Fig. 1. First, there is a dramatic difference in the average percent price range between the two categories. The average price range for the computer memory modules category is remarkably high at about 90%. In contrast, computer monitors and visual devices tend to have a relatively low price range; averaging about 30%. A second distinguishing feature of Fig. 1 is the fluctuations in the average percent range experienced by the two product categories. While the average range is relatively stable for computer monitors and visual devices, the computer memory modules category experiences large fluctuations. In particular, notice that on October 18, 2001, the average percent range for the computer memory modules category dramatically fell. While one might be inclined to dismiss this event as a pricing error made by a specific firm, such fluctuations are commonly observed at sites like [Shopper.com](#).¹ A careful look at the data reveals that the dramatic drop in the average price range is driven by a single firm's behavior in the

1 market for a specific 256 MB memory module. Specifically, prior to October 18,
2 [Computer4Sure.com](#) listed a relatively high price for this product, chose not to
3 list a price on October 18, and re-posted the same high price after October 18 for
4 the remainder of the sample period. Thus, the decision by [Computer4Sure.com](#)
5 not to list a price on October 18 is the factor responsible for the large fall in the
6 average price range for the computer memory modules category.

7 Other studies documenting price dispersion in online markets are of the
8 magnitude observed in [Fig. 1](#). For instance, [Brynjolffson and Smith \(2000\)](#) find
9 price ranges in online book and CD markets of 33% and 25%, respectively.²
10 Similarly, [Clay, Krishnan and Wolf \(2001\)](#) find percentage ranges of 60% to 73%
11 for hardcover and paperback books on the best-seller list, respectively. Averaging
12 across many products and product categories, [Baye, Morgan and Scholten \(2004\)](#)
13 also find price ranges of about 57% at [Shopper.com](#). This paper deviates from these
14 previous studies by examining how dispersion varies across product categories.

15 Using data from [Shopper.com](#)'s 12 product categories we find that, consistent
16 with [Fig. 1](#), there is considerable variation in the average price ranges across
17 categories. This observation suggests an association may exist between firms'
18 behaviors and the average percent range across product categories. Indeed, we
19 find there is a negative correlation between the average price range and the
20 percentage of firms that list price information in multiple categories and for
21 multiple products. When the percent of firms listing prices in multiple categories
22 and products is high (low), the average percent range in price is low (high). In
23 addition, the weighted average percent range in prices varies with the number of
24 firms displaying its company logo. When the number of firms with a company
25 logo is below the median, the weighted range averages about 35%, but is only
26 16% when this number is above the median number of firms with company logos.

27 The remainder of the paper proceeds as follows. [Section 2](#) discusses the
28 [Shopper.com](#) environment and provides an overview of the data. [Section 3](#)
29 examines how price dispersion at [Shopper.com](#) varies across each of the 12
30 product categories and looks at how product life cycles affect price dispersion.
31 [Section 4](#) examines the extent to which firms' behaviors impact price dispersion.
32 [Section 5](#) concludes.

33 34 35 **2. INSTITUTIONAL FEATURES OF SHOPPER.COM** 36 **AND OF THE DATA**

37 38 *2.1. The Shopper.com Environment*

39
40 [Shopper.com](#) is an Internet price comparison service, which provides consumers
with lists of prices charged by firms selling physically identical products.³ One

1 way to obtain price information for, say, a KDS Rad-5 flat panel monitor is to
2 directly enter the product name into [Shopper.com](#)'s search engine. Alternatively,
3 a consumer could click on [Shopper.com](#)'s "monitor" category and sift through the
4 various brands and models of computer monitors and click "check latest prices"
5 once the KDS Rad-5 was identified. Using either method on October 10, 2001
6 would result in the list of prices in [Fig. 2](#). Notice, each of the 10 firms lists a
7 unique price ranging from \$346.96 to \$375.85, or about 8% of the minimum price.
8 Compared to other studies, the dispersion observed in [Fig. 2](#) is relatively low. We
9 explore whether this is an artifact of being associated with a particular product
10 category, as would be consistent with the observation in [Fig. 1](#).

11 Accessing [Shopper.com](#)'s database of more than 200,000 computer and
12 consumer electronics products is costless to consumers with Internet access. In
13 contrast, firms listing price information at [Shopper.com](#) pay⁴ for the privilege to
14 do so. In addition to deciding what price to list each day, firms must also decide
15 how frequently and for which products to list information. These decisions can
16 be updated up to two times each day. To ensure accuracy, firms are responsible
17 for directly inputting and uploading this information to the [Shopper.com](#) servers.
18 The institutional features at [Shopper.com](#) have important implications for firms
19 competing in this online environment. In particular, [Baye-Morgan \(2001\)](#) show
20 that firms competing in a [Shopper.com](#)-style environment will randomize both
21 the frequency with which price information is advertised and the price charged.
22 By randomizing both the price and advertising frequency, firms can avoid the
23 deleterious outcome associated with classical Bertrand-style price competition.
24 We explore whether some of the stylized facts at [Shopper.com](#) are consistent with
25 the predictions of Baye-Morgan.


28 *2.2. Data Description and Summary Statistics*

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30 To examine the relationship between the level of price dispersion and product
31 categories, we assemble a data set consisting of daily price observations listed at
32 [Shopper.com](#) spanning the two-month period October 1, 2001 to November 30,
33 2001. In total, 193,159 observations were collected for 219 products in 12 product
34 categories. These categories are defined using exactly the same scheme employed
35 at [Shopper.com](#), which we use to examine the across category differences in price
36 dispersion.

37 [Table 1](#) shows the summary statistics of the daily price data for the 12
38 [Shopper.com](#) product categories over the sample period. As illustrated in [Table 1](#),
39 the number of observations and number of products vary across categories. For
40 example, the computer memory modules category consists of the smallest number

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KDS Rad-5



Review

List Price: \$429.00
Lowest Price: \$346.95 [Price drop alert](#)
Manufacturer: Korea Data Systems U.S.A.
Part Number: RA05
My Shopping List: [Add it to my list](#) | [View my list](#)

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[offices](#)
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Updated	Store	Crèmez BusinessDeal	Price	State	Phone	Shipping	In Stock	Shop
10/30/2001	buy.com The Newest Superstore Compare prices Buy now	★★★	<u>\$346.95</u>	CA	N/A	See Site	Check	Buy info
10/30/2001	TheMedia.com Compare prices Buy now	★★★	<u>\$347.59</u>	FL	1-888...	29.95	100	Buy info
10/30/2001	Compu America Compare prices Buy now	No rating	<u>\$349.00</u>	CA	1-800...	33.25	YES	Buy info
10/29/2001	PCNation.com Compare prices Buy now	★★★	<u>\$349.44</u>	IL	1-800...	9.95	Y	Buy info
10/28/2001	Micro Pro, Inc. Compare prices Buy now	★★☆	<u>\$355.00</u>	OH	1-888...	\$17 - \$29	Yes	Buy info
10/30/2001	L.A. Computer Center Compare prices Buy now	No rating	<u>\$359.00</u>	CA	1-800...	30	YES	Buy info
10/30/2001	ASURE At Office Depot Company Compare prices Buy now	★★★	<u>\$369.99</u>	CT	1-888...	11.00	Yes	Buy info
10/30/2001	Half.com Compare prices Buy now	No rating	<u>\$371.88</u>	PA	N/A	see site	208	Buy info
10/30/2001	MEDIA EXPRESS Compare prices Buy now	★★☆	<u>\$379.00</u>	IN	1-888...	\$16.00 - 31.00	274	Buy info
10/29/2001	2Burst.com Compare prices Buy now	No rating	<u>\$379.85</u>	FL	1-888...	Free Shipping	Yes	Buy info

Fig. 2. Screenshot from Shopper.com.

Table 1. Summary Statistics by Category.

Product Category	Number of Observations	Number of Products	Average Price	Average Minimum Price	Average Maximum Price	Average Shopper.com Product Rank
Notebook computers	671	11	\$1,876.65	\$1,660.19	\$2,312.61	315.1
Computer monitors & visual devices	2013	33	902.40	803.21	1101.08	370.4
Digital cameras	1586	27	500.46	409.61	600.57	351.8
Computer printers & supplies	1647	27	482.09	409.87	555.98	383.9
Handheld PDAs	854	15	292.78	238.25	361.92	352.8
Computer software titles	2013	33	226.09	198.00	260.31	375.5
MP3 players	671	11	192.00	158.92	251.48	299.8
Computer storage devices	610	10	186.63	160.87	226.40	354.4
Networking hardwares	732	12	169.33	144.55	202.75	397.2
Computer graphics	915	15	150.85	132.86	174.49	408.7
Computer hardware components	1159	18	146.72	122.13	194.34	326.1
Computer memory modules	488	8	75.88	54.35	111.54	321.8

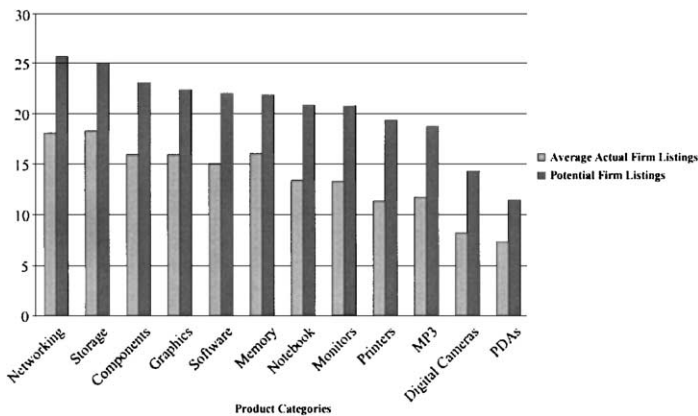
of products, eight in total. In contrast, the categories consisting of computer software titles and computer monitors and visual devices each have 33 products; the category with the largest number of products among the 12 categories. [Table 1](#) also provides the average price for each of the 12 product categories.⁵ Notice, the categories are fairly well divided into relatively expensive and inexpensive products: six categories have average prices less than \$200 and six greater than \$200. The computer memory modules category is the cheapest among the 12 categories, with an average price of \$75.88. The notebook computers category, in contrast, has the highest average price of \$1,876.65. [Table 1](#) also reports the average [Shopper.com](#) product rank. Based on the number of unique consumer “click throughs,” each day [Shopper.com](#) assigns a product rank between one and 1000 to each product. Thus, the [Shopper.com](#) product rank is a relative measure of product popularity (also a proxy for relative demand), where a rank of one indicates the

1 most popular product and that of 1000 being the least popular. For the 12 categories
 2 in our sample, the average [Shopper.com](#) product ranking across categories is
 3 between 300 and 409. This suggests that products in our sample are relatively
 4 popular; although, products do tend to go through identifiable life cycles – an
 5 issue further explored later in this paper.

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2.3. Market Structure at Shopper.com

10 Given that firms can change their decisions to list prices on a given product date,
 11 the number of actual firms listing price information can be viewed as a random
 12 variable. Accordingly, a distinction exists between the number of *potential* firm
 13 listing prices and the number of *actual* firms listing prices for a product date. Given
 14 the relatively short time horizon of this study, one way to measure the number of
 15 potential rivals is to use the total number of distinct firms that list price information
 16 for a given product. That is, as long as a firm listed a price for a given product
 17 over the two-month sample period, this firm is considered a potential rival.⁶

18 Using this as the number of potential firms for a given product, [Fig. 3](#) charts
 19 the average number of actual firms listing prices and the average number of
 20 potential firms for each of the 12 product categories. Notice, the average number
 21 of potential firms is up to eight firms higher than the average number of actual
 22 firms listing prices. This suggests that firms do not advertise price information
 23 for each product date. More importantly, when making daily pricing decisions the
 24 number of potential firms is relevant. Thus, firms paying to list price information
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Fig. 3. Actual vs. Potential Number of Firms Listing Prices.

1 at [Shopper.com](#) for the average product date in our sample tend to face a large
2 number of potential firm.

3 [Baye-Morgan \(2001\)](#) show how firms can avoid the deleterious outcome of
4 classical Bertrand competition when firms compete in an environment similar
5 to [Shopper.com](#). Equilibrium in the Baye-Morgan model consists of firms'
6 symmetrically advertising price information with propensity less than one and a
7 distribution of prices where the identity of the low-price firm changes with each
8 random draw (for instance, each day). The idea behind these strategies is that in
9 equilibrium, firms will be unable to systematically undercut each others' prices.
10 Moreover, consumers will be unable to learn the identity of the low-price firm
11 without visiting the price comparison site. In expectation, firms pursuing this
12 strategy can earn positive expected profits.

13 Using the ratio of the average number of actual firms listings to average
14 potential number of firms as a measure of advertising propensity, [Fig. 3](#) provides
15 casual evidence that advertising propensities are strictly less than unity; a result
16 consistent with [Baye-Morgan \(2001\)](#). Further evidence that firms' propensity to
17 advertise at [Shopper.com](#) is presented in [Section 4](#).

18 19 20 **3. PRICE DISPERSION AND PRODUCT** 21 **CHARACTERISTICS AT SHOPPER.COM** 22

23 Price dispersion at [Shopper.com](#) and other online retail markets has been well doc-
24 umented (cf. [Baye, Morgan and Scholten \(2002, 2004\)](#); [Brynjolfsson and Smith](#)
25 [\(2000\)](#); [Morton, Zettelmeyer and Silva-Risso \(2001\)](#) and [Scholten and Smith](#)
26 [\(2002\)](#)).⁷ The source and nature of price dispersion remains an important and
27 interesting debate in the literature. These studies focus on either reporting price
28 dispersion in relatively few products categories with similar product characteristics
29 – like books and CDs – or present price dispersion statistics aggregated over many
30 product categories. Two competing explanations for the observed dispersion in
31 these idealized markets have emerged. One view, expressed by [Brynjolfsson and](#)
32 [Smith \(2000\)](#), attributes observed dispersion in the online markets for books and
33 CDs to heterogeneities – like branding, trust, and reputation – among retailers.
34 According to this view, branded retailers charge relatively high prices to its loyal
35 consumer. Other firms must charge low prices to attract more price sensitive
36 consumers. Given the [Shopper.com](#) environment where consumers can costlessly
37 observe price lists for identical products, any price dispersion owing to branding
38 or other firm heterogeneities should dissipate over time since consumers can
39 easily identify the low-price seller. In contrast, [Baye, Morgan and Scholten \(2002\)](#)
40 find evidence that price dispersion is remarkably stable over what is perhaps

1 the most turbulent eight-month period in e-commerce's short history; a result
2 that, as they note, is consistent with several clearinghouse models of equilibrium
3 price dispersion. How does one reconcile these seemingly contradictory results?
4 Given that Brynjolfsson and Smith examine price dispersion for books and CDs
5 and Baye, Morgan and Scholten examine computer products and consumer
6 electronics products, one explanation is that the nature of price dispersion varies
7 across product categories. That is, the nature of the price dispersion is somehow
8 fundamentally distinct for products in different categories or with varying
9 characteristics.⁸

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12 *3.1. Measures of Price Dispersion*

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14 Price dispersion in traditional and online retail markets have been measured
15 in several ways. The most commonly used measure is the range in prices (the
16 difference between the maximum and minimum price).⁹ Carlson and Pescatrice
17 (1980) and Sorensen (2000) have used the coefficient of variation (σ/μ) to measure
18 price dispersion, which has the benefit of allowing for direct comparisons between
19 product categories with different price levels. Both of these measures of price
20 dispersion are zero when the "law of one price" holds. Baye, Morgan and Scholten
21 (2002), however, have recently proposed a new measure of price dispersion called
22 the "gap." They argue that, if firms are viewed as classical Bertrand competitors,
23 observed price distributions can be consistent with the competitive pricing even
24 when the price range and coefficient of variation are strictly positive. For this to
25 be true, the two lowest prices in the markets must coincide, or in the language of
26 Baye, Morgan and Scholten, the "gap" between the two lowest prices in the market
27 must be zero.

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"Sorensen (2000)"
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28 For each product category, Table 2 presents three measures of price dispersion
29 averaged across each product date; the average price range as a percent of the
30 minimum price, the average gap as a percent of the minimum price, and the
31 coefficient of variation. Converting the range and gap to percentages allows
32 for easy comparisons across product categories. Notice that independent of the
33 way price dispersion is measured, each of the product categories in our sample
34 exhibits considerable dispersion. For the typical product category in our sample,
35 the average price range is 51%, the average gap (between the two lowest prices)
36 is 7% and the average coefficient of variation measures 13%.

37 While it is certainly remarkable to observe price dispersion of such magnitude
38 in this environment, it is also important to note that each of these measures
39 result in similar order rankings. That is, ranking each of these measures from
40 highest to lowest results in a similar order ranks for each product category. Prices

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Table 2. Comparison of Price Dispersion Measures by Product Category.^a

Product Category	Number of Observations	Average Percent Range ^b	Range Order Rank	Average Percent Gap ^b	Gap Order Rank	Average Coefficient of Variation ^b	Coefficient of Variation Order Rank
Computer memory modules	488	0.91 (0.86)	1	0.12 (0.42)	2	0.25 (0.23)	1
MP3 players	671	0.67 (0.47)	2	0.09 (0.19)	3	0.16 (0.09)	2
Handheld PDAs	854	0.59 (0.48)	3	0.14 (0.47)	1	0.15 (0.10)	4
Computer hardware components	1159	0.58 (0.71)	4	0.05 (0.12)	8	0.15 (0.14)	3
Computer printers & supplies	1647	0.52 (0.55)	5	0.06 (0.13)	7	0.13 (0.10)	6
Digital cameras	1586	0.50 (0.21)	6	0.08 (0.12)	4	0.14 (0.06)	5
Computer storage devices	610	0.43 (0.16)	7	0.06 (0.09)	6	0.11 (0.04)	8
Notebook computers	671	0.41 (0.46)	8	0.02 (0.05)	11	0.12 (0.10)	7
Networking hardware	732	0.41 (0.25)	9	0.04 (0.06)	9	0.10 (0.06)	9
Computer graphics	915	0.39 (0.27)	10	0.07 (0.14)	5	0.09 (0.04)	11
Computer software titles	2013	0.38 (0.34)	11	0.04 (0.11)	10	0.09 (0.07)	10
Computer monitors & visual devices	2013	0.35 (0.21)	12	0.01 (0.03)	12	0.08 (0.04)	12
Average		0.51		0.07		0.13	

^aStandard deviation in parenthesis.

^bCalculation based on observations with multiple firms listing prices.

1 for computer memory modules tend to exhibit the most dispersion (Range and
2 Coefficient Order Rank = 1 and Gap Order Rank = 2). While prices are least
3 dispersed in the computer monitor and visual devices category; an order rank of 12
4 for each measure of price dispersion. Despite having the lowest order rank, price
5 dispersion for computer monitors and visual devices remains remarkably high; the
6 average price range is 35%, the average gap is 1% and the average coefficient of
7 variation is 8%.

8 The consistent order ranking of these three measures of price dispersion is not,
9 however, a general property of the data or of the measures of price dispersion.
10 Indeed, [Table 3](#) reveals that this property fails to hold at the product-level in the
11 computer monitors and visual devices category. The order ranks of the percent
12 range and coefficient of variation for the LT150 XGA Portable Projector are 33,
13 indicating the highest level of price dispersion within this category. The average
14 percent gap, however, indicates very little relative dispersion with an order rank
15 of four. Thus, these measures of dispersion tell completely different stories
16 suggesting that it is important to measure price dispersion in different ways before
17 making general statements about market performance.

18 Based on the evidence presented in [Table 2](#), it is clear that price dispersion varies
19 across product categories. In particular, some categories tend to exhibit relatively
20 low levels of price dispersion, while others exhibit very high dispersion. The
21 remainder of this paper examines factors that may contribute to the differences in
22 price dispersion across product categories.

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3.2. Product Life-Cycle

27 [Tables 2 and 3](#) report three measures of price dispersion averaged across the product
28 date for each category ignoring the possibility that products are at different stages
29 of their life cycle. The behavior of prices (and price dispersion) may, however,
30 vary with product life cycle. Early in a product's life cycle the minimum price
31 charged may be relatively high. As a product becomes more popular competitive
32 forces may drive the minimum price down. To examine this relationship, we use
33 the product rank [Shopper.com](#) assigns to the most popular 1000 products in its
34 database – measured by the number of unique consumer requests for product and
35 price information. Popular products have low [Shopper.com](#) product ranks, while
36 relatively unpopular products have high product ranks. To the extent that across-
37 category differences in price dispersion are, at least partially, attributable to life
38 cycle effects, one might expect to observe a product's minimum price to vary with
39 [Shopper.com](#)'s product ranking.

40 The evidence presented in [Table 4](#) suggests that the average minimum price for a
product varies with [Shopper.com](#)'s product rank. We use the median [Shopper.com](#)

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Table 3. Comparison of Price Dispersion for the Products in the Computer Monitors and Visual Devices Category.

Product in Computer Monitor and Visual Device Category	Average Percent Range	Range Rank Ordering	Average Percent Gap	Gap Rank Ordering	Average Percent Coefficient of Variation	Coefficient of Variation Rank Ordering
LT150 XGA PORTABLE PROJECTOR	1.049	33	0.001	4	0.265	33
ViewSonic VG 175	0.753	32	0.004	11	0.124	29
19" Sony Multiscan CPD-G400 Trinitron	0.684	31	0.007	17	0.126	31
ViewSonic PF790	0.561	30	0.010	24	0.126	30
Sony VPL-CX1 Superlite LCD Projector	0.529	29	0.003	7	0.142	32
ULTRALIGHT X350 XGA PROJECTOR	0.466	28	0.020	29	0.101	26
Samsung Syncmaster 950P	0.397	27	0.008	21	0.110	27
ViewSonic E70f	0.368	26	0.003	8	0.078	20
Samsung SyncMaster 753 DF	0.362	25	0.008	20	0.081	22
Samsung Electronics Co. Ltd. SyncMaster	0.353	24	0.008	19	0.082	23
Hitachi CM771 (Ergo Flat)	0.353	23	0.061	32	0.123	28
Samsung SyncMaster 700NF	0.334	22	0.002	5	0.076	17
LG Electronics Flatron 795FT Plus	0.333	21	0.046	31	0.079	21
ViewSonic VE 150	0.329	20	0.004	13	0.062	8
Samsung SyncMaster 570v	0.328	19	0.002	6	0.075	16
Samsung Electronics Co. Ltd. SyncMaster	0.325	18	0.003	9	0.074	15
Samsung SyncMaster 150T	0.319	17	0.005	16	0.073	12
ViewSonic GS 790	0.316	16	0.003	10	0.092	25
Samsung SyncMaster 955DF	0.308	15	0.000	1	0.077	19
Samsung SyncMaster 900NF	0.303	14	0.011	25	0.066	11
Samsung SyncMaster 170 MP	0.297	13	0.009	22	0.073	13
Sony Multiscan LCD Display SDM-M81	0.296	12	0.009	23	0.077	18
NEC MultiSync LCD1530V	0.292	11	0.007	18	0.063	10
Samsung SyncMaster 770 TFT	0.270	10	0.000	2	0.074	14
ViewSonic Optiquest Q95	0.254	9	0.001	3	0.083	24
Samsung SyncMaster 170 T	0.247	8	0.016	28	0.060	6
KDS Rad-5	0.242	7	0.013	26	0.061	7
MP2800 MICRO PROJECTOR	0.236	6	0.016	27	0.063	9
Philips Professional Brilliance 180P	0.193	5	0.005	15	0.056	5
Samsung SyncMaster 150 Mp	0.187	4	0.004	14	0.048	3
NEC MultiSync LCD1800	0.098	3	0.088	33	0.054	4
22" Apple Cinema Flat Panel Display	0.068	2	0.004	12	0.027	2
Apple Studio Display	0.043	1	0.026	30	0.021	1

Table 4. Average Minimum Price and Product Life Cycle.

Shopper.com Product Rank	Computer Software Titles	Computer Storage Devices	Networking Hardware	Computer Memory Modules	Computer Graphics	Computer Hardware Components	Notebook Computers	Computer Monitors & Visual Devices	MP3 Players	Computer Printers & Supplies	Digital Cameras	Handheld PDAs	Average
Average minimum price for low rank ^a	\$162.52	\$162.13	\$120.25	\$32.09	\$142.87	\$134.16	\$1,605.39	\$642.70	\$154.46	\$339.93	\$474.32	\$277.41	\$354.02
Percent of products with low rank	0.80	0.83	0.63	0.80	0.68	0.82	0.73	0.79	0.73	0.70	0.81	0.79	0.76
Number of observations	1007	305	367	244	459	583	336	1013	337	825	793	427	
Average minimum price for high rank ^b	\$233.52	\$159.61	\$168.98	\$76.61	\$122.80	\$109.95	\$1,715.16	\$965.82	\$163.41	\$480.07	\$344.91	\$199.10	\$394.99
Percent of products with high rank	0.80	0.75	0.75	0.80	0.74	0.70	0.73	0.82	0.73	0.81	0.65	0.71	0.75
Number of observations	1006	305	365	244	456	576	335	1000	334	822	793	427	

^aCalculated by averaging the minimum price for a product-date if the product popularity rank is less than (or equal to) the median rank.

^bCalculated by averaging the minimum price for a product-date if the product popularity rank is greater than the median rank.

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1 product rank to divide observations in each product category into low rank
2 and high rank groups. Based on these groups, [Table 4](#) summarizes the average
3 minimum price for each product category. Across all categories, the average
4 minimum price for low-rank products is \$354.02 and that for high-rank products
5 is \$394.99. Notice, the percent of products in low-rank and high-rank groups is
6 relatively high. On average, 76% of products have a low rank at some point in
7 the sample and 75% have a high rank. The considerable overlap in the percent of
8 products in the low-rank and high-rank groups suggests that the products in our
9 two-month sample have relatively short life cycles at [Shopper.com](#).

10 Furthermore, for seven out of the 12 product categories, the average minimum
11 price for products with ranks at or below the median rank (low rank) is lower than
12 the average minimum price for ranks above the median rank (high rank). While
13 only about 60% of the categories exhibit this expected behavior, the 20–40% of
14 the product that are not common to both low and high rank over the two-month
15 sample may be driving the imperfect result. Taken together, the evidence suggests
16 that, on average, products with low (high) ranks tend to have low (high) minimum
17 prices. That is, there is a positive relationship between a [Shopper.com](#)'s product
18 rank and a product's minimum price; however, more systematic approach is
19 necessary to make a conclusive determination.

20 21 22 **4. FIRM BEHAVIOR** 23

24 From the above analysis, we find that price dispersion varies across product
25 categories and that some of the variation across categories may be attributable to
26 products being at different stages in their life cycle. In what follows, we explore
27 other explanations to why price dispersion varies across product categories that
28 rely on differences in firms' behaviors.

29 30 31 *4.1. Product Breadth and Frequency of Listing Prices* 32

33 Recall that in subsection 2.1, firms pay to list price information at [Shopper.com](#) and
34 must decide: (1) which products to list at [Shopper.com](#); (2) how frequently to list
35 price information for the products they do sell; and (3) what price to list. Viewed in
36 this way, the nature of price dispersion across product categories may stem from
37 differences in firms' behaviors. For instance, based on product characteristics,
38 some of the 141 firms in the sample may choose to specialize in selling products in
39 a particular category (or even a particular product). [Table 5](#) shows that only about
40 29% of firms in the sample specialize in listing prices in a single category, while

Table 5. Advertising Frequency, Specialization and Product Breadth.

Firm Type	Percent of Firms	Average Percent of Days Listing Prices	Minimum Percent of Days	Maximum Percent of Days
Single-category firms	0.29	0.67	0.03	1.00
Multiple-category firms	0.71	0.63	0.02	1.00
Single-product firms	0.09	0.73	0.16	1.00
Multiple-product firms	0.91	0.64	0.02	1.00

the remaining 71% list prices in multiple categories. Similarly, only 9% of firms our sample list price information for a single product, while 91% list prices for multiple products.

Despite whether firms list prices in single or multiple categories (products), on average, firms only list price information about 66% of the time; a result consistent with Baye-Morgan. Interestingly, the Baye-Morgan model suggests that firms will symmetrically advertise with propensity strictly less than unity. At the aggregate level, there appears to be some support for this idea: single and multi-category firms list price information with roughly the same frequency. However, more thorough empirical work is needed to formally test this hypothesis.

Table 6 illustrates the degree to which firms specialize in listing price information for certain product categories (and products) and the resulting price dispersion. Column 2 of Table 6 indicates that no firms specialize in listing prices for computer memory modules, computer hardware components or computer

Table 6. Price Dispersion, Specialization and Breadth by Product Category.

Product Category	Percentage of Firms		Percentage Range	Percentage of Firms	
	Single Category	Multiple Categories		Single Product	Multiple Products
Computer memory modules	0.00	0.27	0.91	0.00	0.27
MP3 players	0.01	0.38	0.67	0.01	0.38
Handheld PDAs	0.02	0.41	0.59	0.01	0.42
Computer hardware components	0.00	0.29	0.58	0.00	0.29
Computer printers & supplies	0.03	0.40	0.52	0.01	0.42
Digital cameras	0.06	0.49	0.50	0.01	0.54
Computer storage devices	0.01	0.37	0.43	0.01	0.38
Notebook computers	0.03	0.31	0.41	0.01	0.34
Networking hardware	0.01	0.29	0.41	0.00	0.30
Computer graphics	0.00	0.36	0.39	0.00	0.36
Computer software titles	0.06	0.29	0.38	0.00	0.35
Computer monitors & visual devices	0.05	0.49	0.35	0.03	0.51

1 graphics categories. One potential explanation for this observation is that comple-
2 mentarities may exist to selling products in these categories. For instance, consider
3 a consumer wanting a build computer. In this case sellers, presumably, do better by
4 offering a diverse selection of product across categories in an attempt to being the
5 low-price on a bundle of products.¹⁰ In contrast, approximately 6% of firms in our
6 sample list prices for only digital camera and another 6% list prices for software
7 titles. A similar pattern is observed for firms specializing in listing prices for
8 single products.

9 [Table 6](#) also computes the percent of firms selling in multiple product categories.
10 That is, conditional on listing price information for each particular category, what
11 fraction of firms also list price information in at least one other category? [Table 6](#)
12 indicates that 27% of the firms that list prices for computer memory modules also
13 list prices in at least one other product category. This figure is 49% in the digital
14 camera and computer monitors and visual devices categories. A similar obser-
15 vation exists for multiple-product firms. Interestingly, the correlation coefficient
16 for firms selling products in multiple categories and the percentage price range is
17 -0.25 ; suggesting that a high percentage of firms listing prices in multiple cate-
18 gories is associated with lower price dispersion (measured by the percentage price
19 range). Similarly, the correlation coefficient is -0.34 between the percentage of
20 multiple-product firms and the percentage price range across categories.

21 While there appears to be little systematic differences between the frequencies
22 with which single- and multi-category firms' list price information, [Table 7](#)
23 shows that the average minimum price for firms listing price information in a
24 single category is higher than for multi-category firms. Specifically, for seven out
25 of the nine categories that have firms listing prices in both single and multiple
26 categories, the average minimum price is higher for firms listing in a single
27 category. Similarly, the average minimum price for single-product firms is higher
28 than that of multi-product firms for five of seven categories where both single-
29 and multi-product firms are present.

30 Taken together, this casual evidence suggests that an important line of future
31 research is to explore the behavior of single and multi-product firms and the
32 impact of their presence in online markets; an area of research largely left
33 unexplored in online markets.

34 35 36 *4.2. Firm Logos and Differentiation* 37

38 Online retail markets have been touted as the new example of perfectly efficient
39 markets; an idealized environment in which to observe the "law of one price." As
40 mentioned a great deal of research provides evidence to the contrary and provides

Table 7. Average Minimum Price by Product Category.

Product Category	Average Minimum Price for Single-Category Firms	Average Minimum Price for Multiple-Category Firms	Difference	Average Minimum Price for Single-Product Firms	Average Minimum Price for Multiple-Product Firms	Difference
Notebook computers	1948.45	1662.54	285.91	1590.72	1709.41	-118.69
Computer printers & supplies	571.07	412.79	158.28	21.49	560.58	-539.09
Networking hardware	251.02	144.55	106.47	-	133.91	-
MP3 players	199.95	163.25	36.70	199.95	160.13	39.82
Digital cameras	441.17	414.95	26.22	706.19	421.09	285.10
Handheld PDAs	261.53	238.49	23.04	325.15	245.09	80.06
Computer monitors & visual devices	825.13	803.22	21.91	2455.14	824.40	1630.74
Computer storage devices	161.51	161.60	-0.10	170.95	162.09	8.86
Computer software titles	182.70	201.41	-18.71	-	210.20	-
Computer memory modules	-	54.35	-	-	49.85	-
Computer graphics	-	132.86	-	-	138.20	-
Computer hardware components	-	122.13	-	-	124.64	-

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1 competing explanations for the dispersion observed in online markets. [Section 4.1](#)
 2 provides some evidence that firms may randomize their decisions to list price
 3 information; a result that is consistent with Baye-Morgan. In the remainder of the
 4 paper we explore how firms' observable attempts to differentiate themselves from
 5 rival impacts price dispersion.

6 One way firms at [Shopper.com](#) attempt to distinguish themselves from their
 7 rivals is by paying to display their company logo next to their name. Since
 8 displaying a firm logo is costly, there must be a strategic benefit from doing
 9 so. Specifically, a firm displaying its logo may be attempting to build a loyal
 10 consumer to earn higher profit. To the extent that such a strategy is successful, one
 11 might expect the level of price dispersion observed in these markets to increase,
 12 depending on the number of other firms in the market displaying a logo.

13 Of the 141 firms in our sample only 10 displayed their firm's logo. [Table 8](#)
 14 reports the number of categories and products for which firms displaying logos list
 15 price information. Interestingly, half of the firms with a logo list price information
 16 for over 100 products in each of [Shopper.com](#)'s 12 product categories. Three
 17 out of the 10 firms with a logo list prices in more than three categories but less
 18 than nine, and for between eight and 19 products. This suggests that 80% of the
 19 firms displaying a logo receive exposure from at least two product categories and
 20 all of these firms sell multiple products. That is, firms with logos may receive
 21 across category and product benefit. Furthermore, all logo firms sell more than
 22 one product. These observations make sense since logo firms selling in multiple
 23 products in several categories can, presumably, spread the added cost of displaying
 24 a logo over many products and reach more consumers.

25
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 27 **Table 8.** Number of Product Categories and Products where Firms
 28 Display Logos.

29 Firm names	Number of Product Categories	Number of Products
30 Buy.com	12	157
31 Computers4SURE.com	12	149
32 CDW	12	148
33 Amazon.com	12	119
34 Gateway.com	12	112
35 AtomicPark.com	8	17
36 Toshiba	6	18
37 Circuit city	4	9
38 800.com	1	29
39 Handspring Inc	1	6
40 Average	8	76.4

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Table 9. Weighted Average Percentage Range & Firms with Logos by Category.^{a,b}

	Computer Software Titles	Networking Hardware	Computer Monitors & Visual Devices	MP3 Players	Handheld PDAs	Computer Storage Devices	Computer Printers & Supplies	Computer Graphics	Computer Hardware Components	Notebook Computers	Computer Memory Modules	Digital Cameras	Average
Weighted average percentage range (of the minimum price) when the number of firm logos is below the median	0.22	0.37	0.28	0.44	0.59	0.23	0.31	0.21	0.33	0.18	0.70	0.33	0.35
Number of observations below the Median	1023	654	1643	403	853	342	859	574	909	403	312	1037	
Weighted average percentage range (of the minimum price) when the number of firm logos is above the median	0.15	0.04	0.07	0.22	0.00	0.20	0.19	0.16	0.22	0.23	0.22	0.17	0.16
Number of observations above the median	990	78	370	268	1	268	752	341	250	268	176	549	
Median number of firm logos	5	5	4	4	4	3	3	3	1	1	1	1	2.92

^aWeighted by the number of observations for each product-date.

^bThe large discrepancy between the number of observation above and below the median reflects a mass point of observations at the median.

1 The presence (or lack) of firms with logos appears to impact the level of price
2 dispersion observed in markets. To reach this conclusion, we calculate the median
3 number of firms displaying logos within each product category and report the
4 weighted average percent price range. The results, presented in [Table 9](#), suggest
5 that when the number of firms displaying logos is below the median, the average
6 percent range is higher than when the number of logo firms is above the median.
7 On average, when the number of firms with a logo is below the median, the range
8 is about 35%, and falls to 16% when the number of firms with logos is above
9 the median.

10 Interestingly, the categories with the largest median number of firm logos –
11 software titles, networking hardware, and monitors and visual devices – tend to
12 have the smaller percent price ranges, as shown in [Table 9](#). In contrast, the median
13 number of firms with logos is the lowest for the computer memory modules
14 category, which also has the highest percent price range.¹¹ This suggests that the
15 characteristics of products are likely to influence whether firms incur the cost asso-
16 ciated with displaying a logo, which in turn impacts the level of price dispersion in
17 a market.

18 Based on the evidence presented in [Table 9](#), price dispersion varies with the
19 number of firms that pay to display a logo. Specifically, characteristics of some
20 product categories make it more attractive for firms to differentiate themselves
21 from rivals by displaying a logo. This, in turn, appears to impact the level of price
22 dispersion observed in the market. This suggests that premia accrue to firms with
23 logos, but that the size of the premia depends on the number of other firms that
24 display logos. A more systematic study is required to determine the magnitude of
25 these premia under various competitive conditions.

26 27 28 **5. CONCLUSION** 29

30 This paper offers some new stylized facts about the nature of price dispersion
31 in online retail markets. Specifically, we find that price dispersion varies across
32 product category. While some of the difference is likely to be the result of
33 products being at different stages of their life cycle, we find casual evidence that
34 the price dispersion varies with the percent of firms listing price information in
35 multiple categories or for multiple products. Specifically, conditional on listing
36 price information in a particular category, when the fraction of firms selling in
37 multiple categories is high (low), price dispersion will be low (high). Furthermore,
38 price dispersion varies with the number of firms displaying their company logos.
39 When the number of logo firms is below the median, the weighted-average price
40 range is about 35%, and is 16% when the number of logo firms is below its

1 median value. This suggests that firms' behaviors in markets varies with product
2 characteristics, which influences price dispersion.

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5 **NOTES**
6

- 7 1. For examples see <http://nash-equilibrium.com>
8 2. The ranges reported in Brynjolfsson and Smith are a percent of the average price, not
9 the minimum price. Therefore, the ranges reported in this study are not directly comparable
10 with Brynjolfsson and Smith.
11 3. Shopper.com's database technology relies on member firms' to input price infor-
12 mation. In contrast, "shopbot" technology – programs written to automatically retrieve
13 price information from firms' web sites – is used by competing Internet price comparison
14 services like MySimon.com and Pricescan.com.
15 4. Firms must pay a one-time, set-up fee plus a fixed monthly fee provided the number of
16 qualified leads does not exceed a threshold, where qualified lead occurs when a consumer
17 "clicks through" from a Shopper.com web page to a firm's web page. If this threshold is
18 exceeded, firms must pay an additional fee for each qualified lead.
19 5. The average price for each category is obtained by giving equal weight to each
20 product and date in the category, or a "product-date." For example, the average price for
21 computer memory modules is the average of eight different products over a 61-day period,
22 or the simple average of each product-date in the category.
23 6. Measuring the number of potential competitors in this way is consistent with an
24 ML estimator. There are, of course, alternative ways to measure the number of potential
25 competitors. For instance, one could also take the number of actual price listing on the
26 previous day for a given product (consistent with an AR1 estimator) or use a moving
27 average process of several days.
28 7. Various measures of price dispersion in online retail markets are available at
29 <http://www.nash-equilibrium.com>
30 8. Another potential explanation is the methodology used in each study. See the
31 respective papers for the details.
32 9. The price range is typically expressed as a percent of either the low price or average
33 price. For examples, see Pratt, Wise and Zeckhauser (1979); Brynjolfsson and Smith
34 (2000) Baye, Morgan and Scholten (2004).
35 10. Generally, one might not expect consumers to purchase bundles of products from
36 shopper given the averages prices are relatively high. See Baye, Morgan and Scholten
37 (2002) for additional arguments.
38 11. See Table 2.

39
40 **ACKNOWLEDGMENT**

38 We would like to thank Michael Baye for his valuable comments. All errors and
39 omissions remain ours.

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