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James C. Cooper

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Price Levels and Dispersion in Online and Offline Markets for Contact Lenses

James C. Cooper*

Federal Trade Commission
600 Pennsylvania Ave., N.W.
Washington, D.C. 20580
202-326-3367 (phone)
202-326-3548 (fax)
jcooper1@ftc.gov

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Abstract: I examine online and offline prices for popular disposable contact lenses. Idiosyncratic features of this market make it likely that offline firms set prices on the assumption that most of their customers are unaware of online prices. Consistent with lower online search costs, offline prices are more dispersed and approximately 11 percent higher than online prices when controlling for differentiated retail services. I also find that the Internet has had a smaller effect on the prices of widely-advertised lenses. Overall, the results suggest that contact lens consumers still are relatively uninformed about their options.

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Key Words: Contact Lenses, Price Dispersion, Search Costs, Internet, E-commerce

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1. Introduction

Theory predicts that price dispersion and margins should be positively related to consumer search costs.[1] In most models of consumer search, given search costs and knowledge of the price distribution, a consumer determines how many stores to visit and purchases from the lowest price firm observed; he or she will visit an additional store only if the expected gain (from a price lower than the lowest one observed to date) is greater than the cost of search. When consumers face no costs to obtain an additional price quote, stores must set their prices on the assumption that anyone visiting their store already knows – or will soon discover – the lowest price offered. Conversely, when search is costly, consumers visit fewer stores. Because consumers with positive search costs do not learn the entire price distribution, they are more likely to buy from a store that does not offer the lowest price.

It is reasonable to assume that consumers can shop among competing online merchants more cheaply than offline merchants.[2] Recently, several economists have taken advantage of this "natural experiment" to test the predictions of search theory by comparing online and offline price distributions of commodity goods.[3] This line of

[1] *See* Stahl (1989); Burdett & Judd (1983); Carlson & McAfee (1983); Salop & Stiglitz (1976).

[2] Visiting an online merchant's Web site to find a price almost certainly takes less time than visiting or even calling an offline merchant for the same information. Additionally, "shopbot" Web sites like Shopping.com or BizRate.com allow consumers to compare large numbers of online competitors' prices with the click of a mouse. The online firm, then, must set its prices on the assumption that anyone visiting its Website has seen – or will see – the lowest online price offered. Accordingly, we would expect to see online prices for homogeneous goods to be lower and less dispersed than those offline; indeed, in the limiting case where all online consumers are perfectly informed about competitors' prices and view all online vendors as perfect substitutes, a zero-profit Bertrand equilibrium obtains. *See* Bakos (1997) who catalogues several claims by commentators has to how the internet would bring about "frictionless" markets, where prices are driven to marginal cost.

[3] *See*, *e.g.*, Clay et al. (2002); Clemons, Hann, and Hitt (2002); Lee and Gosain (2002); Clay, Krishnan, and Wolff (CKW) (2001); Brynjolfsson and Smith (2000); Bailey (1998). Several economists have found

research, however, has arrived at no consensus that online prices are lower or less dispersed than offline prices. Further, and perhaps not unexpectedly, no studies have found levels of online price dispersion at levels low enough to suggest online firms selling homogenous goods are Bertrand competitors (*see*, *e.g*., Brynjolfsson and Smith 2000; Clay, Krishnan, and Wolff (CKW) 2001; Clay et al. 2002; Clemons, Hann, and Hitt 2002).[4]

In this paper, I examine the online and offline prices of disposable contact lenses. Overall, the data indicate that search costs play an important role in stores' pricing decisions and that online markets are more efficient that their offline counterparts. Specifically, I find that using various measures and controlling for differentiation among outlets, online prices are significantly less dispersed that offline prices. I also find that controlling for business model differences that are likely to be associated with differences in the provision of costly retail services, online prices are on average 11 percent lower than offline prices. Although the data are consistent with online markets functioning more efficiently than their offline counterparts, however, like other studies of online pricing, I find that the online market for contact lenses still exhibits levels of dispersion greater than what we would expect to see in Bertrand competition. I also take advantage of variation in advertising, using widely-advertised lenses as a control group in a difference-in-difference approach to measure the effect of Internet availability on online and offline price dispersion and level. I find that the difference between most measures

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empirical support for this prediction by identifying other proxies for consumers' knowledge of price distributions. *See* Dahlby & West (1986), Van Hoomiseen (1988), Sorensen (2000).

[4] Indeed, recent research by Baye et al. (2004) presents compelling evidence that persistent dispersion in prices listed at a price comparison site is an equilibrium phenomenon.

of online and offline price dispersion for widely-advertised lenses is only about half that for the remainder of the lenses in the sample. Further, average online and offline prices of widely-advertised lenses are statistically equivalent in contrast to non-advertised lenses. These results suggest that online markets have had less of an impact on the pricing for widely-advertised lenses than other lenses.

This study improves on previous work comparing online and offline prices to test search theory in two ways. First, one assumption implicit in previous studies of online and offline pricing is that offline stores set prices based on expectations of their patrons' knowledge of other offline firms' prices, not online prices.[5] It is more expensive to compare among offline than online firms. But, for those consumers with Internet access, comparing an offline price to an online price should be no more expensive than comparing among offline firms. Once online, moreover, it is extraordinarily cheap to gain additional price quotes from online merchants. For instance, if a consumer with Internet access already knows the price that Borders charges for a particular CD, it appears that it would be equally costly to phone Barnes & Noble for a price quote or to go online and search several merchant's prices.

Although it is reasonable to assume that those who shop at one online outlet are likely to obtain many additional online quotes, there is no *a priori* reason to believe that – apart from those consumers who either do not have Internet access or who are unwilling to purchase goods online due to idiosyncratic reasons – a large proportion of those who shop offline obtain only offline quotes. If this is the case, offline sellers of books and CDs are likely to take into account online pricing when setting their prices. This may be

[5] That is, most of those who shop at Barnes & Noble base their purchase decision on their knowledge of Borders', Crown's, and Wal-Mart's prices for the same book, not on Amazon.com's price.

one reason why studies of these goods have arrived at no consensus that online and offline prices are statistically different.

A variety of factors likely have caused many consumers to remain unaware of their full range of options beyond their prescribing eye care professional (ECP). For example, prescribing ECPs in all states were not required to release contact lens prescriptions to their patients until 2004.[6] Prior to the Fairness to Contact Lens Consumers Act (FCLCA), several states' laws made it difficult for consumers to receive a copy of their contact lens prescription, which is necessary to purchase lenses from someone other than a prescribing ECP.[7] Further, there is anecdotal evidence that prescribing ECPs are hesitant to let their patients know that their prescriptions are portable (*See* 1-800 Contacts 2005b, pp. 18-30).[8]

When consumers do not know the distribution of prices and have difficulty determining what individual merchants charge, they are more likely to purchase from the first store they visit, which, in the case of contact lenses, always will be their prescribing ECP.[9] Given the relative youth of the replacement contact lens market, state regulatory

[6] 15 U.S.C. § 7601; 16 C.F.R. § 315.3. FCLCA prohibits ECPs from tying contact lens sales to eye examinations and requires ECPs to release their patients' prescriptions.

[7] *See*, *e.g.*, *Hardy v. City Optical, Inc.*, 39 F.3d 765 (7th Cir. 1994), a case in which an ECP claimed that Indiana law prevented him from releasing contact lens prescriptions to patients who wanted to purchase lenses at cheaper outlets. Additionally, FTC (2004, p.23-25) discusses anecdotal evidence that even in states that explicitly allowed prescription release before FCLCA, some prescribers refused to release contact lens prescriptions to their patients.

[8] The FTC, which is in charge of enforcing the prescription release requirements of FCLCA, recently reported violations involving prescribing ECPs not releasing prescriptions to their patients. *See* FYI on The Contact Lens Rule and the Eyeglass Rule (Oct. 24, 2004) *at* http://www.ftc.gov/opa/2004/10/contactlens.htm.

[9] This is because the decision to engage in additional search is a positive function of the probability of finding a lower price. If costs of search are high, the expected benefit from additional search (savings*probability a lower price is found) must be sufficiently high to justify additional search. If a consumer over-estimates the lower bound of the price distribution, she necessarily will under-estimate the probability of find a lower price with additional search.

impediments, lack of consumer knowledge of their right to their prescription, and reported reluctance on the part of some prescribers to release prescriptions, it is probably reasonable to assume that many contact lens consumers do not routinely search for prices lower than the one their prescribing ECP offers.[10] Because prescribing ECPs can be affiliated only with offline sellers, in contrast with goods previously studied, there are strong prior reasons to believe that a large proportion of offline contact lens sellers' customers are unaware of online pricing.

A second improvement on previous work is that unlike previous studies in this area, I take advantage of the variation in offline business models to control for the provision of costly retail services that consumers may value. Search theory relates margins, not prices, to consumer search costs; unless it is reasonable to assume that online and offline merchants have similar costs, a comparison of prices alone is not likely to provide much information about search costs. Although I find that offline prices are on average higher than online prices, I also find that the magnitude and significance of this result depends on the composition of the offline sample. When controls are added for features specific to certain offline vendors, the average difference between online and offline prices falls dramatically. These results suggest that absent data on costs, the choice of offline comparison group will influence measured price differences and thus inferences regarding search costs.

[10] Indeed, data indicate substantial inertia toward purchasing from prescribing ECPs; independent ECPs perform over 60 percent of all adult eye examinations and, despite charging the highest prices of any retail channel, sell a similar proportion of all contact lenses.

The remainder of this paper is organized as follows. Section 2 provides a brief overview of the contact lens industry. Section 3 describes the data and Section 4 presents the main results. Section 5 discusses some implications of these results and concludes.

2. Overview of the Contact Lens Industry

The FDA approved soft contact lenses in 1971, but in the early stages of development, they were manufactured in a way that did not always accurately reproduce the original prescription. Because each lens required a great deal of ECP effort to fit, consumers generally purchased lens from their ECP after an exam and replaced them infrequently. The evolution in contact lens manufacturing technology now allows the sale of lenses to be unbundled from the fitting exam. Technological improvements have solved standardization problems; the replacement lens a consumer purchases pursuant to a prescription that specifies a brand will be identical, regardless of where it is purchased. These advances have transformed contact lenses of the same brand and prescription into commodities.[11] Now, a consumer with a valid prescription can purchase contact lenses from an array of merchants, including optical chains, independent ECPs, warehouse clubs, mass merchandisers, and online vendors.

A consumer needs a prescription from an ECP to purchase contact lenses, which will specify a brand name typically will last between one and two years.[12] Data indicate

[11] Contact lenses – like books and CDs – are differentiated products and specific brands compete against one another. Once a consumer has been prescribed a certain brand of lens, however, that lens can be treated as a commodity because it is the same regardless of where it is purchased. For example, a Focus Toric lens of a certain prescription is identical at every location it is sold; a consumer will treat the lens as a commodity, and if retailers are undifferentiated as well, she will be purchase the lens from the seller with the lowest price.

[12] Under FCLCA, unless there are special health-related circumstances, a contact lens prescription must last at least one year. 15 U.S.C. § 7604(a). Under some state laws, a prescription can last for as long as two years.

that 70-80% of contact lens wears purchase less than a year's supply at a time, so most will purchase lenses at least twice during the length of their prescription.[13] Under FCLCA, contact lens prescriptions are portable; despite some prior contradictory state law and industry practice, ECPs must provide patients with a copy of their contact lens prescription to allow them to purchase their lenses from whomever they wish. According to public data, independent ECPs (both optometrists and ophthalmologists) account for approximately 68 percent of sales, with the remaining offline channels, such as optical chains, mass merchandisers, warehouse clubs, accounting for between 18 and 25 percent of sales.[14] The same data has online and mail order outlets accounting for between 8 and 13 percent of sales.

Contact lenses are classified in two major categories—spherical and specialty. Spherical lenses contain a single refractive power and are by far the most commonly prescribed lens. Varieties of specialty lenses include toric (to correct astigmatism), multifocal (to correct near and far-sightedness simultaneously), cosmetic tint, and extended wear. According to industry data, spherical lenses accounted for 70 percent of dispensing visits and 57 percent of total soft lens sales in 2003.[15] Within the specialty

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[13] According to this data, in 2004, surveyed ECPs reported that after the exam 64% of patients purchased a six-month supply, 20% purchased a year's supply, and 6% purchased a three-month supply. Additional data provided to the FTC also suggests that consumers purchase less than a year's supply of contact lenses, showing that only 12% of consumers from a national survey purchased a year's supply at once, whereas 31% purchased lenses two times a year, and 43% purchased 3 - 4 times a year. *See* FTC (2005, pp. 5-6).

[14] *See* FTC (2005, p. 11).

[15] Optistock (2003) reports that clear spherical accounted for approximately 70% of patient visits where a lens was dispensed for the first three quarters of 2003). Similarly, CooperVision (2003, p.21) notes that specialty lenses account for 43 percent of U.S. soft lens market sales. The disparity in data for sales and lenses dispensed may reflect the fact that specialty lenses typically are more expensive than spherical lenses.

segment in 2003, toric, cosmetic tint, and multifocal lenses accounted respectively for 16 percent, 9 percent, and 5 percent of patient visits when contacts lenses were dispensed.[16] Most consumers wear lenses that are taken out every night and disposed of according to a replacement schedule. Lenses requiring replacement every two weeks are the most popular option, followed by lenses that are replaced on a monthly basis.[17]

There are four major contact lens manufacturers (Bausch & Lomb, CooperVision/Ocular Sciences,[18] Ciba Vision, and Vistakon). According to Census Bureau (2004) data U.S. shipments of all contact lenses were valued at $1.9 billion in 2002,[19] and estimates place annual U.S. soft contact lens sales somewhere between $1.4 and $1.8 billion.[20] Recent data indicate that 36 million Americans—almost 13 percent of the population—wear contact lenses (FTC 2005).

3. Data

During the week of November 29 – December 5, 2004, price information was collected for a six-month supply of ten of the most widely-worn contact lenses from 20 online and 14 offline retailers. A six-month supply was chosen based on public data that suggest this to be the most commonly purchased quantity of lenses.[21] Six spherical

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[16] *Id.*

[17] Optistock (2003) reports that for first three quarters of 2003, two-week and monthly replacement lenses account for 64% and 20% of new contact lens fits, respectively. FTN Midwest Research (2004, p.7) reports that 62% and 22% of ECPs surveyed responded that two-week and monthly disposables were the most common lenses prescribed, respectively).

[18] CooperVision acquired Ocular Sciences in 2005.

[19] This estimate is consistent with private research, which projected U.S. sales of contact lenses in 2003 to reach $1.92 billion, or 11.8% of total U.S. retail optical sales. *See The State of The Optical Market*, 20/20 MAGAZINE (2003), *at* http://www.2020mag.com/index.asp?page=3_190.htm; Jobson Optical Research, *The State of the Optical Market*, 2nd Quarter, 2003, *at* http://optistock.com/jobson-som-2003-06.pdf.

[20] CooperVision (2003) reports that total U.S. sales of soft lenses are $1.4 billion. The 2002 Census data lists U.S. soft contact lens sales at $1.8 billion.

[21] *See* note 15, *supra*.

lenses (Acuvue, Acuvue2, Acuvue Advance, Frequency55, Biomedics55, Proclear Compatable), three toric lenses (Frequency55 Toric, Softlens66 Toric, Focus Toric), and one multifocal lens (Softlens Multifocal) were selected for the study. The mixture of spherical and specialty lenses is roughly consistent with consumer purchasing patterns.

No publicly available data exists on market shares of individual lenses, but the lenses sampled were chosen to be among the most frequently purchased and are thus likely to capture a large proportion of actual consumer purchasing patterns. For example, Vistakon is the leading contact lens manufacturer and its Acuvue brand contact lenses are the world's leading selling brand of spherical lens.[22] Additionally, Proclear Compatibles, Biomedics55, and Frequency55 are the leading brands of CooperVision, which due to its recent acquisition of Ocular Sciences is among the top four contact lens sellers in terms of sales.[23] Trade press and company reports suggest that CooperVision, Bausch & Lomb, and Ciba Vision account for the most of toric lens prescriptions, thus the inclusion of CooperVision's Frequency55 Toric, CibaVision's Focus Toric, and Bausch & Lomb's Softlens66 Toric are likely to capture a large proportion of actual consumer purchases of toric lenses.[24] Finally, Bausch & Lomb's Softlens Multifocal is the leading multifocal lens.[25]

Of the online retailers (listed in the first column of Table 1), 16 are pure online sellers—those with no offline presence—and 4 are hybrids, meaning that they have both online and offline sales. Pure online sellers were selected based on the results of a search

[22] *See* Vistakon's website statement at http://www.jnjvision.com/about_vistakon.htm; OSI (2004, p. 6).

[23] *See* CooperVision (2003). OSI (2004, p. 29) refers to its Biomedics brand as its "flagship product."

[24] Bausch & Lomb (2003, p. 2); FTN Midwest Research (2004, p.10); Optistock (2003, p.3).

[25] *See* Bausch & Lomb Annual Report; FTN Midwest Research (2004).

for “contact lenses” at shopping.com, a price comparison search engine.[26] Hybrid sellers were selected by determining whether well-known offline outlets also had a Web site.

The offline retailers sampled (listed in the second column of Table 1) were all located in the Northern Virginia Area (primarily Alexandria and Arlington) and fell into one of four channels: wholesale clubs, mass merchandisers, optical chains, and independent ECPs. Sam’s and BJ’s were sampled to represent wholesale clubs and Target and Wal-Mart were sampled to represent mass merchandisers. With the exception of Costco, which would not give price quotations for contact lenses over the phone, the sample of mass merchandisers and wholesale clubs is likely to comprise almost the entire population for the geographic area.[27] LensCrafters, Pearle Vision, Hour Eyes, and Sears Optical were sampled to represent optical chains.

The independent ECPs in the sample were chosen by first searching for “optometrists” in the Yahoo yellow pages for the zip code 22301 (Alexandria, Virginia), which produced a list of 21 independent ECPs. To assure reliability, this list was cross-referenced with another list of independent ECPs from the area to arrive at 13 ECPs who appeared on both lists. From this list, six were chosen at random. Although resource constraints prevented sampling a greater number of optical chains and independent ECPs, the sample is likely to be representative of the population. For example, each of the optical chains sampled belong to one of the two largest grossing optical retailing groups

[26] This methodology for determining a sample of online merchants has been employed by Clay *et al*. (2002), Zoonky and Gosain (2002), Clay *et al*. (2001); Brynjolfsson and Smith (2000).

[27] Although K-Mart would be another potential mass merchandiser competitor to Wal-Mart and Target, according to K-Mart’s Web site it does not offer optical services at its local stores.

(Luxottica and Eye Care Centers of America).[28] Further, the sample is likely to include a substantial proportion of the largest independent ECP practices in the market area.

For online merchants, researchers visited each Web site and gathered the price of each lens and the standard shipping option. Researchers posing as potential customers collected prices quotes from offline merchants over the phone.[29] For every outlet sampled, researchers collected information on manufacturer and retailer rebates. No online site offered rebates on a six-month supply of lenses (most rebate offers only cover a year's supply of lenses), and very few offline merchants offered rebates.[30] Because it is unclear whether the clerks surveyed at these stores were providing accurate information regarding rebates on six-month supplies or how frequently consumers follow-through with mail-in rebates, rebate information is not included in the data.

As seen in Table 1, almost all outlets carried at least 80 percent of the lenses in the sample. A store reported a lens as unavailable in only 8.5 percent of the potential 340 observations, leaving a total of 311 observations. Online and offline stores carried on average 88.5 percent and 95.7 percent of the lenses studied, respectively. Taken as a whole, online and offline availability are approximately equal. A majority of online and offline stores carried all lenses (55 and 57 percent, respectively). The lower online average is reflective of very low carriage rates from two sellers; when these two sellers are dropped from the sample, the average percentage of lenses carried by online retailers rises to 93.9 percent. Further, if hybrid Web sites are eliminated from the sample to

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[28] *See* FTC (2005, p. 10).

[29] Virginia does not tax contact lens sales to consumers.

[30] Specifically, Wal-Mart offered manufacturer rebates on five spherical lenses ranging from $12-15, Target offered a retailer rebate ranging from $15.99 to $19.96 on three different lenses, and LensCrafters offered an $8.80 rebate on one lens.

focus on only pure online merchants, the average percentage of lenses carried rises to 97.9 percent. More of the missing observations are for CooperVision's Proclear Compatible lens than any other lens, presumably because the manufacturer has a policy to limit this lens' distribution.

Table 2 presents summary statistics of price information collected. For online observations, prices that include shipping and handling are presented in parentheses. Online prices for all lens types are less than offline prices taken together, but warehouse clubs offer the lowest average prices of any channel. Further, hybrid pricing is substantially higher than that for pure online merchants. In fact, a closer examination of the data reveals that with the exception of Wal-Mart online, hybrid sites' pricing reflects the pricing of their offline counterparts. Accordingly, comparisons of online and offline channels for the remainder of the paper focus only on pure online merchants.

4. Empirical Results

4.1 Price Dispersion

As discussed above, one hypothesis that follows from search theory is that prices should be less dispersed online than offline. Table 3 presents various measures of online and offline price dispersion (standard deviation, coefficient of variation, range, and range as a percentage of the average price).[31] All measures of dispersion are calculated at the individual lens level and then averaged across lenses.[32] Overall, offline prices are about twice as dispersed as online prices. For example, the average range of offline prices is $67.32 compared to $33.33 online and the average offline standard deviation is $19.77

[31] Because online firms can compete on shipping costs but offline firms can compete with regard to proximity to consumers only in the long run, I include shipping and handling costs in online merchants' prices, but do not include transportation costs for offline stores.

[32] *See* Appendix for details of how dispersion measures are calculated.

compared with $8.53 online. A Wilcoxon rank-sign test shows all differences are significant at standard levels.[33]

Because consumer purchases are not uniformly distributed across outlets, giving each price observation equal weight may distort comparisons of online and offline prices. For example, if consumers tend to purchase more from relatively higher (lower) priced outlets, equal weighting will tend to bias average prices downward (upward). Further, if outlets that charge outlier prices receive little business, equal weighting will overstate price dispersion. To remedy this potential problem, I construct weights for online and offline observations that proxy for shares of sales.[34]

As seen in Table 4, weighting observations by a proxy for share does not significantly alter either online or offline price dispersion, and differences remain statistically significant. It also is important to note that the relatively larger level of price dispersion offline is not driven by the inclusion of warehouse clubs in the sample. The third columns of Tables 3 and 4 show that although excluding warehouse clubs from the offline sample does reduce offline standard deviation and range, online dispersion is still less than offline dispersion, and that these differences remain mostly significant.

[33] Given the relatively small sample for these comparisons (N=20) and doubt that the small-sample distribution of these variables justifies an assumption of normality, I used the non-parametric Wilcoxon rank-sign test. Additionally, an *F*-test for equality of variances for each lens (not reported) shows that online prices for all but two lenses (Proclear and Softlens 66 Toric) are statistically significantly more dispersed than offline prices for the same lenses.

[34] There is no publicly available information on online shares, but data indicate that online contact lens sales are around $200 million. Using this as a denominator, I calculated online shares for 1-800 Contacts, Vision Direct, and Coastal Contact from publicly available revenue information ($93.5 million, $40 million, and $28 million, respectively). I divided the remaining 19 percent equally among the remaining 13 online firms for which no revenue information is available. With regard to offline weighting, again there is no publicly available share information for specific outlets, but public data provided to the FTC indicate the following shares of total offline sales for each offline channel: 74.4 percent for ECPs; 10.4 percent for optical chains; and 15.2 percent for mass merchandisers and warehouse clubs combined. I construct weights for each outlet sampled by dividing channel shares equally among all firms within a channel. As a result of this process, each independent ECP is assigned a 12.4 percent share of offline purchases, each optical chain outlet is assigned a 2.6 percent share of offline purchases, and each warehouse club and retail outlet is assigned a 3.8 percent share of offline purchases.

Because online and offline channels differ significantly in a variety of important ways, one cannot ignore the role that factors beyond search costs may be playing in the data. Most significantly, offline stores clearly are more differentiated than their offline counterparts. Although disposable contacts of the same brand and prescription are themselves identical regardless of where a consumer purchases them, there are likely to be differences in service and convenience among offline outlets. For example, if the wait is longer and the staff less knowledgeable at a warehouse club than an independent ECP's office, some consumers may be willing to pay more for the same contacts at the latter outlet. Further, bricks-and-mortar merchants are geographically dispersed and utilize a wide array of business models; independent ECPs and optical chains operate in professional offices and malls and specialize in selling optical goods, while mass merchandisers and warehouse clubs operate in large free-standing stores in which optical goods comprise only a tiny proportion of all sales. Online sellers' business models, by contrast, are relatively homogeneous and all share the same "location" from consumers' perspectives.[35]

Table 5 indicates that offline stores are more easily categorized into high or low-priced outlets than online outlets. For example, the warehouse clubs sampled offered one of the four lowest prices for 90 percent and 70 percent of the lenses, respectively, and independent ECPs and optical chains appear consistently to charge among the highest

[35] Several studies comparing online and offline pricing of books and CDs have found online price dispersion and price levels to be at least as large as that offline. It is likely to be the case, however, that offline book and CD sellers sampled in those studies are less-differentiated than offline contact lens sellers. For instance Clay et al. (2002) collect offline book prices from stores with similar business models (Barnes & Noble and Borders) and Lee & Gosain (2002) collect offline CD prices exclusively from stores where record sales comprise a major portion of their business (Barnes & Noble, Borders, Sam Goody, Tower, and Virgin). Bynjolffson and Smith (2001) have a slightly more diverse sample of offline merchants, which Clay et al. (2002) point out may, in part, be driving their price level results because the smaller stores that they sampled tend to have higher prices than larger chains. Further, the more diverse sample also may play a role in the finding of a significant difference between online and offline price dispersion.

prices for the lenses sampled. Although three online firms appear consistently to offer among the highest online prices (1-800 Contacts, LensesforLess, and 1-Save-on-Lens) and two appear to offer among the lowest online prices on most lenses (Coastal Contacts and Contact Lens Discount), the overall pattern of pricing from Table 5 suggests that online firms are not as easily classified into high and low-price outlets as their offline counterparts. Thus, it seems plausible that at least some proportion of offline price dispersion is a result of relatively more differentiated stores rather than higher search costs.

To control for heterogeneity across outlets that may be driving price dispersion, I regressed lens price on store and lens-fixed effects:[36]

$$p_{ij} = C + \alpha_i + \delta_j + e_{ij}, \qquad (1)$$

where p_{ij} is the price of lens i at outlet j, α_i is a lens fixed effect, and δ_j is a store fixed effect. The goal is for δ_j to sweep away the effects of firm-specific pricing strategies that may be related to idiosyncratic cost or demand parameters. Table 6 shows measures of price dispersion for the residuals from this regression (e_{ij}), which proxy for prices that have been adjusted for interstore differentiation.[37] Consistent with offline firms being more differentiated than their online counterparts, these results suggest that interstore heterogeneity is responsible for almost twice as much of the observed offline dispersion compared to online dispersion. The online standard deviation and range do not differ

[36] As noted earlier, the most important component of online differentiation is likely to be consumers' willingness to trust that a transaction will be completed. Ideally, I would have a direct measure for trust, but store fixed-effects are likely to serve as a good proxy. Pan et al. (2002) and Clay et al. (2002) find that in price regressions proxies for online store attributes have little explanatory power, and Clay et al. specifically find that such proxies have no explanatory power when store fixed-effects are included.

[37] The R^2 from this regression is 0.90, compared to 0.74 for a regression with only lens-specific effects and 0.81– 0.89 for the price regressions reported in Tables 8-10. This suggests that store-specific effects are an important source of price variance.

significantly from those reported in Table 4: \$8.40 versus \$7.09 and \$33.33 versus \$30.44, respectively (a decrease of only 17% and 9%). By contrast, controlling for interstore heterogeneity reduces offline standard deviation and range by 30% and 31%, respectively. Even so, after controlling for interfirm differentiation online prices still are statistically significantly less dispersed than their offline counterparts, which suggests that consumers who shop online for contact lenses enjoy lower search costs.[38]

Although online price dispersion appears to be lower than that offline, it is still at higher levels than would be expected in a model of Bertrand competition. Clearly the law of one price has not obtained: the coefficient of variation is 0.10 for all lenses and the range of online prices as a percentage of the average online price is 0.37 for all lenses.[39] These data are consistent with consumers viewing the package of services that online sellers bundle with the lenses as a differentiated product. A review of Web sites does not reveal important differences in the shopping experience among online vendors,[40] but one important dimension of differentiation is likely to be trustworthiness, which may be especially important with regard to a medical product like contact lenses. As B&S (2000, p.578) note:

> While the importance of factors such as search costs may be reduced on the Internet, factors such as trust may play an enhanced role because of the spatial and temporal separation between buyer, seller, and the product on the Internet. Most consumers have little history or physical contact with Internet retailers and

[38] To check for whether lens availability affected the results, all dispersion tests also were run on a subset of lenses that were the most widely available (Acuvue2, Biomedics55, Frequency55, Softlens66 Toric, and Frequency55 Toric), defined missing from no more that two merchants (only Softlens66 Toric was available at all outlets). Offline dispersion rises, but results are qualitatively nearly identical.

[39] These levels of dispersion, in general, are slightly lower, but within the range of those that Clay et al. (2002) and CKW (2002) report for online book prices. The coefficient of variation is very similar to that reported by Baye et al. (2005), while they report a lower range as a percentage of average price.

[40] In addition, a review of ratings at BizRate.com reveals that of those online sellers rated, all have roughly similar customer ratings.

> they must be wary of falling prey to a site that posts low prices but is proficient only in charging credit cards, not delivering the goods.[41]

Thus, consumers may enjoy lower search costs online, but choose to forego lower prices in return for greater assurances that their transaction will be completed without a hitch. This may explain why 1-800 Contacts—the best-known online seller—is able to command higher prices than less-well known sellers.[42] These results also are consistent with those of Smith and Brynjolfsson (2001), who find that the most heavily branded online retailers charge higher prices than less well-known online retailers.

Another contributing factor to online dispersion is that although price comparisons for contact lenses are easier online than offline, they are not costless. It is likely that consumers are aware of only one or two online contact lens vendors from advertising and may not feel it worth their while to search for others. Indeed, finding sizable online dispersion even after controlling for firm-specific effects suggests that online consumers—although better informed than their offline counterparts—still are not perfectly informed with respect to the distribution of prices. This finding is consistent with Sorensen (2000) and Pan et al. (2002b), who use similar techniques to conclude that interfirm heterogeneity is not the key driver of price dispersion.

4.2 Price Levels

Another prediction of search theory is that average margins should fall with search costs. In support of this hypothesis, Table 2 shows that average online prices are lower than average offline prices. I also estimate the following equation:

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[41] Similarly, Pan et al. (2002b, p.58) conclude with respect to their finding that hybrid sellers charge more than pure online sellers, "improving trust and entering online markets early might result in greater traffic and possibly higher prices."

[42] This is also consistent with hybrid sites charging higher prices. Having an offline presence may offer an assurance of trustworthiness to consumers, and hybrids may be able to charge for this.

$$\log p_{ij} = C + \alpha_i + \beta_1 OFFLINE_j + e_{ij}\,, \qquad (2)$$

where p_{ij} is the price of lens i at outlet j, *OFFLINE* is a dummy variable equal to 1 if outlet j is an offline outlet and α_i is a lens-specific effect to capture unobserved cost and demand factors specific to each lens that may affect prices. I estimate (2) in the semi-log form so that coefficients may be more readily interpreted as percentage differences in prices.[43] The first column of Table 7 reports results of this baseline regression and, as expected the estimated coefficient of *OFFLINE* is positive and significant, showing that offline outlets sampled set prices that are on average 25 percent higher than those online.[44]

Although finding that higher average offline prices is consistent with lower online search costs, it also may reflect offline firms' provision of costly services for which consumers are willing to pay.[45] If offline outlets charge more because consumers value the additional services they provide, then $\hat{\beta}_1$ would be biased upward because it would include the premium that consumers are willing to pay for these services. That is, online and offline firms may charge different prices for different price/quality packages, but

[43] Results of a linear specification are qualitatively and statistically unchanged.

[44] To the extent that offline prices in Northern Virginia are higher than those in other localities, the online and offline differences would be biased upward. A review of locality adjustments in pay for government employees shows that Washington D.C. metropolitan area upward adjustment is similar to that in other major urban area. For example, the locality pay adjustment for D.C. is 17.5%, compared with 15.1% for Atlanta, 19.9% for Boston; 21.15% for Chicago, 23.1% for Los Angeles; 17.8% for Miami, 18.4% for Philadelphia, 22.9% for New York; 15.5% for Raleigh-Durham; 17.9% for Seattle, and 28.6% for San Francisco. Thus, it would be reasonable to assume that these results would be likely to hold for major segments of the population. Further, the ranking of prices charged by channels is similar to those found in other public data submitted to the FTC (available from author upon request). Future research, however, would include offline samples from both urban and rural areas.

[45] As part of a settlement to an antitrust suit, Vistakon, Cibavision, and Bausch & Lomb each agreed to sell to online and offline channels on non-discriminatory terms. *See In re Disposable Contact Lens Antitrust Litigation*, MDL 1030 (M.D. Fla. 2001). Thus, it may be reasonable to assume that all channels enjoy similar wholesale prices, although large national offline chains may still be able to negotiate volume discounts that small online sellers cannot.

have similar margins. Because models of price dispersion relate search costs to margins, it is impossible to know if lower online prices reflect more intense competition without detailed cost data, which is unavailable.

To control for retail service heterogeneity that may be driving the observed online-offline price difference, I include *EYESONLY* and *INDEP* as independent variables in (2). *EYESONLY* is equal to 1 if offline outlet *j* carries only ophthalmic goods. These outlets (optical chains and independent ECPs) typically provide attentive sales assistance and operate in small settings, located primarily in professional offices and malls, which are likely to be substantially more expensive locations than most online operations. *INDEP* is equal to 1 if offline outlet *j* is not affiliated with a national chain. Past empirical research into the effect of state-imposed restrictions on the commercial practice of optometry has suggested that chains may enjoy lower costs of operation than independent ECPs.[46]

The second column of Table 7 reports regressions including *EYESONLY* and *INDEP*, and shows that when these business model differences are taken into account the price differential remains significant but falls to 11.4%. The estimated coefficient on *EYESONLY* is significant and shows that offline stores selling only ophthalmic goods charge an average of 18 percent more for their lenses than other offline sellers. This result is consistent both with multiproduct retailers enjoying economies of scope and scale and with consumers placing additional value on the retail package that stores specializing in ophthalmic goods offer. The estimated coefficient on *INDEP* is positive, but insignificant, suggesting that (at least in Northern Virginia) independent and

[46] *See* Haas-Wilson (1986, 1987); FTC (1980, 1983).

commercial sellers of ophthalmic goods enjoy similar costs.[47] If the *EYESONLY* price premium primarily reflects a cost disadvantage associated with a business model that consumers do not value, then the fact that optical chains and independent ECPs can pass this extra expense and still retain at least 70 percent of sales suggests that many consumers in this market remain unaware of many prices beyond those quoted by their prescribing ECP.

Columns 4 and 5 of Table 7 report the same regressions as columns 1 and 2, but weight observations by share using the method reported in the previous section. When observations are weighted, both online and offline average prices increase; online prices increase because 1-800 Contacts' prices – which are on average the highest of all the online merchants sampled – are much more important in the data, and average offline prices increase because ECPs and optical chains—the most expensive channels—take on greater importance. The results indicate that the increase in online prices due to greater weight being put on more expensive sellers overwhelms the similar effect in the offline data. Although the baseline regression (reported in column 4) shows that offline prices are 23 percent higher than online prices, when business model differences are controlled for, the difference falls to only 6 percent, and is statistically insignificant.

With the inclusion of *EYESONLY* and *INDEP*, the offline control group with which online prices are compared is an average of warehouse club and mass merchandiser pricing. However, this average masks the fact that mass merchandisers in the sample charge significantly higher prices than warehouse clubs and that warehouse

[47] That independent ECPs and optical chains offer statistically equivalent pricing may be an artifact of Virginia's regulation prohibiting commercial optical goods sellers from employing an ECP directly. According to discussions with some industry representatives, in instances where the ECP is not an employee of the optical chain, the optical chain may allow the ECP to sell all replacement lenses as part of the compensation scheme.

club and online prices are statistically equivalent. The results in columns 3 and 6 of Table 7 show that mass merchandiser pricing is much closer to that of optical chain and independent ECP pricing is driving the sign and significance $\hat{\beta}_1$; when a dummy variable equal to 1 if outlet j is a mass merchandiser is added (which causes $\hat{\beta}_1$ to represent the average difference between online and warehouse club prices), $\hat{\beta}_1$ becomes much smaller (negative in three of the four specifications) and highly insignificant. At the same time, mass merchandisers charge prices 28% higher than average prices offered by warehouse clubs and online sellers, and the coefficient on *EYESONLY* almost doubles and is statistically indistinguishable from that on *MASS MERCHANDISER* because the comparison group's average prices are lower.

A key question is whether mass merchandisers charge higher prices than warehouse clubs because their customers are aware of online and warehouse club pricing, but prefer the mass merchandiser price/quality combination, or because their consumers are less informed about prices than those who shop online or at warehouse clubs. That is, is there some uncontrolled-for variable that distinguishes warehouse clubs from mass merchandisers in consumers' eyes and that explains the price differential between these two outlets. For example, it may be that consumers are willing to pay a premium to mass merchandisers because they provide more service, have shorter lines, and have more numerous and convenient locations than warehouse clubs. This would imply that, despite major business model differences, consumers place a similar value on the mass merchandiser retail package and those offered by optical chains and independent ECPs. If the difference between warehouse club and mass merchandiser pricing is wholly based on differentiation, then observed price differences across retail channels merely reflect different price/quality combinations; consumers may willingly pay around 30 percent more to purchase lenses from optical chains, mass merchandisers, and independent ECPs because these outlets offer a higher quality retail experience or have some other locational or reputational advantage over online sellers and warehouse clubs.[48]

An alternative explanation consistent with lower online search costs is that mass merchandisers charge a premium over warehouse clubs because they primarily serve consumers who are unlikely to have knowledge of online or warehouse club pricing. Consumers who shop at warehouse clubs – perhaps due to lower opportunity costs of time – may be expected to have greater knowledge of both online and offline prices. Rather than there being separate online and offline markets for contact lenses, it may be more precise to view online and offline merchants of part of one market in which warehouse clubs and online vendors compete for informed customers, and the remaining offline sellers concentrate on making sales to their share of uninformed customers. Thus, warehouse clubs – like online outlets – set prices on the assumption that most of their patrons know what other online and offline stores charge. High-price offline outlets, on the other hand, set their prices on the assumption that their customers have very little knowledge of actual prices.

These results demonstrate the sensitivity of online and offline price comparisons to the offline control group. Previous studies have either sampled only one type of offline retailer [*e.g.*, Clay et al. 2002] or sampled different types of offline retailers, but failed to control for business model differences [*e.g.*, Brynjolfsson & Smith 2000]. As

[48] The relative price for independent ECPs, mass merchandisers, and optical chains may be biased upwards to the extent that consumers purchasing from these channels tend to receive discounts due to managed vision plans in greater proportions than do consumers purchasing from other channels.

seen above, unless there is a sound reason to assume that online and offline retailers face similar costs and provide consumers with similar retail packages, this approach is likely to overstate the differences between online and offline prices. Because search theory links margins – not prices – to search costs, caution must be taken when inferring anything about relative search costs from comparing online and offline prices.

4.3 Variation in Advertising and Pricing

Another method to test whether consumers face lower search costs online is to use the variation in consumer knowledge of prices across lenses. Acuvue brand lenses are the most widely worn, and casual empiricism suggests that they are the most heavily advertised of those lenses sampled.[49] Because price advertising and word of mouth on what various outlets charge for Acuvue lenses (which is likely to be a positive function of the number of people who purchase Acuvue lenses) reduce consumers' search costs, we would expect consumers to be relatively more informed about the price distribution of Acuvue brand lenses than other brands.[50] If this is the case, the marginal impact of the Internet on consumer search costs should be greater for non-Acuvue than for Acuvue lenses.

The last two panels of Tables 3, 4, and 6 show measures of dispersion for Acuvue and non-Acuvue lenses. First, it is important to note that even for Acuvue lenses online price dispersion is less than that offline. Indeed, that after controlling for interfirm differentiation, measures of dispersion for the most heavily advertised lenses still are

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[49] For example, an informal sampling of advertisements the Sunday Washington Post during 2005 finds that the price of Acuvue lenses often accompanies circulars from optical stores and other outlets, whereas advertisements for other lenses in the sample are never seen. Further, OSI (2004, p.30) notes that it rarely advertises directly to consumers.

[50] Kwoka (1983), Feldman & Begun (1978), and Benham (1972), show a negative relationship between price levels and advertising in optical goods markets.

larger offline than online, is strong evidence that consumers in online markets for contact lenses enjoy lower search costs. Consistent with the hypothesis that consumers are relatively more informed about the distribution of Acuvue prices, however, intrachannel comparisons reveal that all measures of price dispersion for Acuvue brand lenses are less than non-Acuvue lenses. Because the average price of non-Acuvue lenses is higher than Acuvue lenses, we would expect the range and standard deviation to be larger for the former category. However, even when normalized by average price, these measures are largest for non-Acuvue lenses in both online and offline channels.

A comparison of residual dispersion measures in Table 6 with those in Tables 3 and 4 indicates that differentiation is an important source of dispersion only for non-Acuvue lenses sold offline. Controlling for store-specific attributes has a very slight negative effect on measures of dispersion for all online prices and offline prices for Acuvue lenses, but has a much larger negative effect on offline prices for non-Acuvue lenses. This is consistent with purchasers of Acuvue lenses viewing retailers as more fungible than non-Acuvue customers.

This variation in consumer knowledge across lenses can be used to further test the hypothesis that search costs are lower online. Specifically, I use a difference-in-difference approach, with Acuvue prices serving as a control group and non-Acuvue lenses serving as the treatment group to compare online and offline measures of dispersion. I use the data from Tables 3, 4, and 6 to calculate:

$$\Delta = \left(\frac{1}{N_{NAV}} \sum_{i=1}^{N_{NAV}} (d_i^{Off} - d_i^{On}) \right) - \left(\frac{1}{N_{AV}} \sum_{i=1}^{N_{AV}} (d_i^{Off} - d_i^{On}) \right) \qquad (3)$$

where d_i is the relevant measure of dispersion (standard deviation, coefficient of variation, range, and normalized range) for a specific lens and channel, subscripts *NAV* and *AV* denote non-Acuvue and Acuvue brand lenses, respectively, and superscripts *On* and *Off* denote on and offline, respectively. If online and offline consumers are similarly informed about the price distribution in each respective channel for Acuvue lenses, and consumers shopping online for non-Acuvue contact lenses enjoy lower costs for comparing lens prices than those shopping offline, then Δ should be positive.

The results shown in Table 8 are supportive of the lower search cost hypothesis. All measures of Δ are positive and almost half are statistically significant at standard levels using a Wilcoxon rank-sum test.[51] Further, these results generally are robust to weighting and the exclusion of warehouse stores from the offline sample, although differences-in-differences for residual measures are positive, but not significant. Taken as a whole, the results are consistent with search theory: The marginal impact of lower search costs online does appear to be largest for consumers of non-Acuvue lenses.

The price dispersion results suggest that due to advertising online and offline consumers may face similar search costs for Acuvue brand lenses. If this is true, it should be the case that the difference between online and offline prices for Acuvue lenses is smaller than those for other lenses in the sample. Table 9 reports estimations of equation (2) including an interaction dummy equal to 1 if lens *i* is an Acuvue brand lens and outlet *j* is an offline seller, allowing Acuvue lenses to act as the control group and other lenses as the treatment group. I expect the estimated coefficient on the Acuvue interaction dummy to be negative.

[51] Given the small number of observations the lack of knowledge of small sample distributions of the measures of dispersion, I used the Wilcoxon rank-sum test, which does not rely on distributional assumptions.

Consistent with search theory, the data suggest that the Internet has had the largest impact on the prices of lenses for which offline consumers have the least information. The difference between online and offline prices for Acuvue brand lenses is about 14 percentage points less than for other lenses. When business model differences are controlled for, online and offline prices for Acuvue lenses are roughly equivalent, and the coefficient on *OFFLINE* rises by about 4 percentage points. As shown in columns 3 and 4 of Table 9, these results are robust to weighting for intrachannel share.[52] It appears that advertising has informed consumers about offline prices for Acuvue brand prices, causing offline firms to set prices for Acuvue brand lenses on the assumption that a relatively large proportion of consumers with prescriptions for Acuvue lenses know the competitors' prices.

4.4 Transportation Costs

So far, the estimates of differences in online and offline prices have not taken into account consumers' costs of obtaining the good, and thus may not provide a realistic picture of the actual trade-offs that consumers face. To purchase contacts offline, a consumer must incur the cost of physically traveling to the outlet, and although online shopping eliminates the need for consumers to travel to a store, the consumer pays the online outlet for delivery.[53] Table 10 shows the results of a regression of total price – list price with shipping and handling fees for the standard delivery option added to online

[52] As an additional robustness check, I ran the regressions reported in Tables 8 and 9 on a subset of lenses that were the most widely available, defined as missing from no more that two merchants (only one lens was available at all outlets). The lenses in the limited sample were Acuvue2, Biomedics55, Frequency55, Softlens66 Toric, and Frequency55 Toric. The results (not reported) are nearly identical in magnitude and statistical significance to those from the full sample.

[53] This price may be explicit in the form of a shipping and handling fee, or may be built in to the price of the lens in cases where online outlets offer free shipping.

prices – on *OFFLINE* and business model controls.[54] The estimated coefficient of *OFFLINE* shows that when travel costs associated with purchasing a lens offline are not included, lenses purchased offline are on average \$6.20, or 7 percent more expensive than those purchased online. When we control for Acuvue lenses in column 2, the results show that with shipping and handling costs included, non-Acuvue lenses are \$10.89, or 12 percent more expensive online and that Acuvue lenses are less expensive offline, although this difference is not statistically significant.

Although many trips may be undertaken for the sole purpose of purchasing contact lenses, in some circumstances it is appropriate to assume that consumers can spread the fixed cost of travel over other shopping activities (e.g., grocery shopping while at Wal-Mart, clothes shopping while at the mall, running errands adjacent to an eye doctor's office or receiving an eye examination). Assuming a ten-mile round trip to an offline store takes one hour, and using the government reimbursement rate of \$0.38/mile to proxy for direct costs (e.g., gas, depreciation) and \$6.75 as the hourly opportunity cost of time,[55] Table 11 shows the offline premium under various assumptions of how the costs of travel should be allocated to the purchase of lenses.[56] The results show that regardless of how offline travel costs are allocated, lenses are less expensive online. For cases where a trip is solely for purchasing lenses – as may be more likely when purchasing from an independent ECP –lenses offline are on average 19 percent more

[54] The dependent variable is in dollar, rather than log, form for ease in calculating total offline costs.

[55] Henscher (1997) has estimated that the value of transit time for leisure trips (including shopping) is between 26 and 42 percent of the average wage. Small (1992) concludes that weekend time in transit is more highly valued than transit to work, and has offered 50 percent of the average wage as an approximation for the value of time in a journey to work. Using the Bureau of Labor Statistics (2003) of \$17.75 average hourly wage and taking the mid-point of Small's and Henscher's estimates of the value of travel time yields an opportunity cost of time for travel to purchase contact lenses of \$6.75 per hour.

[56] I implicitly assume that the time taken actually to complete the online and offline purchases is identical.

expensive than lenses online. In instances when a consumer purchases so many items in addition to contact lenses that the allocation of travel costs to the contact lenses approaches zero (perhaps most relevant for warehouse clubs and mass merchandisers), higher search costs still cause offline lenses to be 7 percent more expensive.

5. Conclusion

Like other studies, this paper exploits the Internet's reduced information costs to test two implications of search theory: because it is more costly to compare the prices of offline merchants than those of online merchants, all else equal, price dispersion and margins should be lower online than offline. I find that for disposable contact lenses online prices are significantly less dispersed than offline prices and average online prices are 25 percent lower than average offline prices. The online-offline price level difference, however, is sensitive to controls for offline business model features that are likely to be associated with the provision of services that consumers value. When I control for unique characteristics of independent ECPs and optical chains, the difference between online and offline price levels is more than halved, and when all business models save warehouse clubs are taken into account, there is no statistical difference between online and offline prices. Thus, it is unclear how much of the measured price difference is due to consumers' lack of price information versus merely the premium consumers are willing to pay for more valuable retail packages. These results indicate that without information on costs, caution must be used in interpreting comparisons of online and offline prices because the outcomes are likely to be sensitive to the composition of offline retailers.

With these caveats in mind, however, taken as a whole the empirical results seem to indicate that online contact lens markets are more efficient than their offline counterparts so that at least some portion of measured lower online prices is likely attributable to lower online search costs. For example, the price dispersion results are robust to the exclusion of warehouse clubs and to controls for interstore differentiation. Further, the data indicate that the online-offline price differential for Acuvue lenses is only half of what it is for non-Acuvue lenses; because it is unlikely that offline vendors have lower costs of selling Acuvue lenses than non-Acuvue lenses, this difference-in-difference suggests that the Internet has lowered consumer search costs non-Acuvue lenses. Finally, because selling replacement contact lenses consists only of transferring a pre-packaged product to the consumers – almost always without the involvement of an ECP – one has to wonder whether fully-informed consumers are wiling to pay an additional $60 a year to purchase lenses from a mass merchandiser, optical chain, or independent ECP.

The empirical results seem to beg the following questions: if consumers can buy the same good more cheaply online or at a warehouse club, why don't they, and why haven't all offline merchants lowered their prices to compete with their online counterparts? One obvious answer is that the Internet has not lowered all consumers' search costs; not every contact lens wearer has access to the Internet. According to the Department of Commerce (2004) as of October 2003, approximately 28 percent of

Americans from 14 - 49 (the demographic representing 75 percent of contact lens wearers (*see* 1-800 Contacts 2005b, at p.9)) are not "Internet users."[57]

Another factor to consider is the relative youth of the market for replacement lenses and its regulatory history. Many consumers still are likely to be unaware that someone other than their prescribing ECP can fill their contact lens prescription or, even if they are aware that they can shop their prescription around, they may not know that replacement lenses are sold by outlets other than independent ECPs and optical chains. Consumers will get an additional price quote only if the expected benefit is greater than or equal to the cost of obtaining the quote. General lack of market information – both the lower bound of the price distribution and specific prices in the distribution – coupled with the fact that a consumers' first draw from the price distribution will be from an offline seller would tend to create inertia toward purchasing from the prescribing ECP. This is likely to help explain why independent ECPs and optical chains charge the highest prices and together account for over 70 percent of contact lens sales.

As discussed earlier, FCLCA was intended to intensify competition among contact lens sellers by allowing consumers to shop their prescriptions around. The data suggest that many consumers still are unaware of their full range of options. As relatively nascent market for replacement lenses develops, however, consumers are likely to become more mindful of, and comfortable with, their options. More intense competition among contact lens sellers should accompany this increased consumer knowledge, allowing the goal of FCLCA to be realized more fully. Increased consumer

[57] Internet usage is likely positively correlated with income, however, so to the extent that contact lens usage also is positively correlated with income, the true proportion of contact lens wearers that do not use the Internet is probably to be lower.

knowledge in this market could have important welfare implications. Further, contact lens wearers in states that have and enforce regulations in a manner that impede online sellers' ability to operate would gain if these laws were eliminated. For example, that North Carolina, Tennessee, Mississippi and Washington have laws or regulations that seem to require anyone selling contact lenses to hold a valid ECP license issued by the state, and that Alaska and Georgia have considered similar laws.[58] Additionally, current Georgia law requires that contact lens sales take place in a "face-to-face" transaction,[59] and Arizona and New Hampshire require that nonresident sellers of contact lenses register with the state optometry board and hold a valid optometry or pharmacy license from their home state.[60] Although the extent to which states enforce these restrictions against online sellers of contact lenses is unknown, these laws have the potential to raise online sellers' costs of serving consumers in these states, causing them to raise their prices.

Future research would examine a sample of online and offline contact lens prices over time to see if prices converge or if offline sellers lose marketshare. In a full-information equilibrium, offline firms can charge higher prices than their online counterparts for the same lenses only if they are providing consumers something additional of value. Thus, unless independent ECPs, optical chains, and mass merchandisers enjoy persistent quality or locational advantages over online sellers, we should expect to see online and offline prices converge as more consumers become informed about their marketplace options. If observed price differences are solely a

[58] *See* 1-800 Contacts (2004b, p. 31)

[59] GA. CODE ANN. § 31-12-12(h).

[60] *See*, *e.g.*, ARIZ. REV. STAT. ANN. § 32-1773; N.H. RSA § 327:31.

function of higher offline costs, however, increased consumer information will cause shares of higher-priced offline outlets to fall as their business models become unprofitable.

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Appendix

The average standard deviation of online price lenses prices (S^{on}) is calculated as $\frac{1}{10}\sum_{i=1}^{10} s_i^{On}$, where s_i^{On} is the standard deviation of lens *i*, as measured by deviation from the mean online price of lens *i* over all online stores.

Specifically, $s_i^{On} = \sqrt{\frac{1}{k-1}\sum_j \left(p_{ij} - \overline{p}_i^{On}\right)^2}$, p_{ij} is the price of lens *i* at store *j*, *k* is the number of online stores sampled that carried lens *i*, and $\overline{p}_i^{On}$ is the average price of lens *i* over all *k* online stores. The average online coefficient of variation ($S^{On}/\overline{P}^{On}$) is calculated as $\frac{1}{10}\sum_{i=1}^{10}\frac{s_i^{On}}{\overline{p}_i^{On}}$. The same methodology is used to calculate S^{Off} and $S^{Off}/\overline{P}^{Off}$.

The average range of online prices (R^{On}), is calculated as $\frac{1}{10}\sum_{i=1}^{10} R_i^{On}$, where $R_i^{On} = (\overset{Max}{p_i^{On}} - \overset{Min}{p_i^{On}})$. The average online normalized range ($R^{On}/\overline{P}^{On}$) is calculated as $\frac{1}{10}\sum_{i=1}^{10}\frac{R_i^{On}}{\overline{P}_i^{On}}$. The same methodology is used to calculate R^{Off} and $R^{Off}/\overline{P}^{Off}$.

TABLE 1

AVAILABILITY

Online Outlet	Percent of Lenses Carried	Offline Outlet	Percent of Lenses Carried
1-800 Contacts	100	BJ's Wholesale Club	100
1-Save-on-Lens	100	Clear Vision Express	100
Aalens.com	30	Hoang & Bradley	90
Aclens	100	Hour Eyes	100
America's Best Online	80	Lenscrafters	100
BJ's Online	90	MacDonald Eye Care	90
CLE Contact Lenses	90	May & Hettler	100
Coastal Contacts	100	Northern Virginia Doctors of Optometry	90
Contact Lens King	100	Pearle Vision	90
Contact Lenses Discount	90	Rosslyn Eye Associates	100
Contactsland.com	100	Sam's Club	90
Discount Contact Lenses	100	Sears	100
First Choice Contacts	90	Target	100
Lens Discounters	100	Wal-Mart	90
Lenses for Less	100		
Lensmart.com	50		
Sears Online	70		
The Contact Lens Store	100		
Vision Direct	100		
Wal-Mart Online	80		
Average	88.5%		95.7%

Notes: Availability computed as percentage of lenses sampled available at outlet j.

TABLE 2
SUMMARY STATISTICS

	All Lenses				Spherical				Specialty			
Channel	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max
All Online	87.92	38.90	29.90	259.96	65.51	16.37	29.90	103.96	119.85	39.45	69.98	259.96
	(91.70)	(38.31)	(33.85)	(259.96)	(69.57)	(15.95)	(33.85)	(103.96)	(123.23)	(38.84)	(74.98)	(259.96)
Pure	84.40	35.72	29.90	191.96	63.57	15.51	29.90	95.80	113.93	35.51	69.98	191.96
	(88.47)	(35.25)	(33.85)	(201.96)	(68.00)	(15.51)	(33.85)	(101.75)	(117.45)	(35.09)	(74.98)	(201.96)
Hybrid	103.85	48.42	39.98	259.96	74.19	17.73	39.98	103.96	147.20	46.44	106.91	259.96
	(106.38)	(47.85)	(39.98)	(259.96)	(76.62)	(16.43)	(39.98)	(103.96)	(149.86)	(45.39)	(106.91)	(259.96)
All Offline	107.95	45.82	31.86	280	81.89	16.56	31.86	112	146.36	48.41	73.52	280
Warehouse	83.18	36.51	31.86	180	60.11	13.83	31.86	80	114.91	34.16	73.52	180
Mass Merchandiser	108.38	43.01	69.92	216	79.39	10.49	69.92	99.80	148.23	38.28	90.00	216
Optical Chain	109.02	40.84	40.00	239.80	86.61	15.77	40.00	112	143.37	43.91	88.00	239.80
Independent ECP	115.63	50.86	44.00	280	86.56	13.89	44.00	112	158.61	55.29	76.00	280
All Channels Combined	96.55	43.11	29.90	280	72.69	18.32	29.90	112	131.13	45.26	69.98	280

Notes: Unit of observation is price of lens i at outlet j. Observations are not weighted for intrachannel shares. Statistics including shipping and handling costs are in parentheses. Statistics for *All Channels Combined* computed without including shipping and handling costs.

TABLE 3
ONLINE AND OFFLINE PRICE DISPERSION

	All			Acuvue			Non Acuvue		
	Online	Offline	Offline (Warehouse Excluded)	Online	Offline	Offline (Warehouse Excluded)	Online	Offline	Offline (Warehouse Excluded)
Std. Dev.	8.53	19.77^{***} (0.01)	16.80^{**} (0.02)	6.27	11.65^{**} (0.05)	7.02 (0.14)	9.49	23.26^{***} (0.01)	20.99^{**} (0.03)
Std. Dev./ Ave. Price	0.10	0.19^{***} (0.01)	0.15^{*} (0.10)	0.08	0.14 (0.14)	0.08 (0.42)	0.10	0.20^{**} (0.02)	0.18^{**} (0.05)
Range	33.33	67.62^{***} (0.01)	53.30^{**} (0.05)	23.56	37.75^{**} (0.05)	23.99 (0.99)	37.52	79.99^{**} (0.02)	65.87^{*} (0.06)
Range /Ave. Price	0.37	0.62^{**} (0.02)	0.47 (0.24)	0.31	0.45^{**} (0.05)	0.27 (0.30)	0.39	0.69^{**} (0.04)	0.56 (0.15)

Notes: Standard deviation, coefficient of variation, range, and standardized range are measured for a specific lens across all store in either the online or offline channel, and then averaged over all lenses sampled. *See* Appendix for details of how dispersion measures were calculated. *P*-values from a Wilcoxon rank-sign test for difference between relevant offline and online dispersion measure are in parentheses. ***significant at 1% level, one-tailed test; **significant at 5% level, one-tailed test; *significant at 10% level, one-tailed test.

TABLE 4
WEIGHTED ONLINE AND OFFLINE PRICE DISPERSION

	All			Acuvue			Non Acuvue		
	Online	Offline	Offline (Warehouse Excluded)	Online	Offline	Offline (Warehouse Excluded)	Online	Offline	Offline (Warehouse Excluded)
Std. Dev.	8.40	20.08*** (0.01)	18.18*** (0.01)	6.60	9.55** (0.05)	6.32 (0.99)	9.17	24.59*** (0.01)	23.27*** (0.01)
Std. Dev./ Ave. Price	0.09	0.18*** (0.01)	0.16* (0.09)	0.06	0.11* (0.09)	0.07 (0.30)	0.09	0.21*** (0.01)	0.19*** (0.01)
Range /Ave. Price	0.35	0.60** (0.02)	0.47 (0.11)	0.23	0.44** (0.05)	0.27 (0.30)	0.37	0.66** (0.04)	0.55* (0.09)

Notes: Standard deviation, coefficient of variation, range, and standardized range are measured for a specific lens across all store in either the online or offline channel, and then averaged over all lenses sampled. *See* Appendix for details of how dispersion measures were calculated. Range is omitted because it does not vary with weighting. *P*-values from a Wilcoxon rank-sign test for difference between relevant offline and online dispersion measure are in parentheses. ***significant at 1% level, one-tailed test; **significant at 5% level, one-tailed test; *significant at 10% level, one-tailed test.

TABLE 5
PRICING DISTRIBUTIONS FOR ONLINE AND OFFLINE SELLERS

Online				Offline			
Outlet	Low Price	Middle	High Price	Outlet	Low Price	Middle	High Price
1-800 Contacts	1	2	7	BJ's Wholesale Club	7	3	0
1-Save-on-Lens	0	3	7	Clear Vision Express	4	6	0
Aalens.com	1	0	2	Hoang & Bradley	0	0	8
Aclens	0	7	3	Hour Eyes	0	7	3
CLE Contact Lenses	3	3	3	Lenscrafters	4	1	5
Coastal Contacts	8	2	0	MacDonald Eye Care	3	5	2
Contact Lens King	5	4	1	May & Hettler	0	4	6
Contact Lenses Discount	9	0	0	Northern Virginia Doctors of Optometry	0	3	6
Contactsland.com	2	8	0	Pearle Vision	0	6	3
Discount Contact Lenses	0	10	0	Rosslyn Eye Associates	4	6	0
First Choice Contacts	0	7	2	Sam's Club	9	0	0
Lens Discounters	5	4	1	Sears	2	4	4
Lenses for Less	0	4	6	Target	4	5	1
Lensmart.com	0	1	4	Wal-Mart	4	3	2
The Contact Lens Store	4	5	1				
Vision Direct	0	9	1				

Notes: "Low Price" is one of the four lowest prices offered for lens *i*; "High-Price" is one of the four highest prices offered for lens *i*.

TABLE 6
ONLINE AND OFFLINE PRICE DISPERSION
MEASURED BY RESIDUALS FROM FIXED-EFFECTS REGRESSION

	All		Acuvue		Non-Acuvue	
	Online	Offline	Online	Offline	Online	Offline
Std. Dev.	7.10	13.90*** (0.01)	5.24	10.03** (0.05)	7.88	15.56** (0.03)
Std. Dev./ Ave. Price	0.08	0.13** (0.03)	0.07	0.12** (0.05)	0.09	0.14* (0.06)
Range	30.44	46.39** (0.03)	21.46	32.48** (0.05)	34.29	52.36* (0.06)
Range /Ave. Price	0.37	0.45 (0.11)	0.35	0.38 (0.14)	0.37	0.48 (0.20)

Notes: Notes: Standard deviation, coefficient of variation, range, and standardized range are measured for a specific lens across all store in either the online or offline channel, and then averaged over all lenses sampled. *See* Appendix for details of how dispersion measures were calculated. *P*-values from a Wilcoxon rank-sign test for difference between relevant offline and online dispersion measure are in parentheses. ***significant at 1% level, one-tailed test; **significant at 5% level, one-tailed test; *significant at 10% level, one-tailed test.

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TABLE 7
REGRESSION RESULTS FOR LOG LENS PRICE

	Unweighted			Weighted		
	(1)	(2)	(3)	(4)	(5)	(6)
OFFLINE	0.251***	0.114***	-0.027	0.227***	0.058	-0.083
	(0.021)	(0.037)	(0.039)	(0.033)	(0.044)	(0.046)
EYESONLY		0.179***	0.320***		0.179***	0.320***
		(0.043)	(0.044)		(0.043)	(0.045)
INDEP		0.020	0.020		0.022	0.022
		(0.036)	(0.036)		(0.036)	(0.053)
MASS MERCHANDISER			0.282***			0.282***
			(0.054)			(0.053)
CONSTANT	4.15***	4.16***	4.16***	4.20***	4.21***	4.21***
	(0.30)	(0.026)	(0.024)	(0.058)	(0.056)	(0.056)
R^2	0.83	0.85	0.87	0.81	0.82	0.83
F	162.72***	174.24***	183.31***	84.63***	78.32***	76.93***

Notes: N = 279. Unit of observation is the log of price of lens *i* at outlet *j*. Robust standard errors in parentheses. ***significant at 1% level; **significant at 5% level. Acuvue lenses is the omitted category for lens fixed-effects.

TABLE 8

ACUVUE AND NON-ACUVUE LENSES:
DIFFERENCE-IN-DIFFERENCE FOR MEASURES OF PRICE DISPERSION

	Δ			
	Std. Dev.	Range	Std. Dev./Ave. Price	Range/Ave. Price
Unweighted Price	8.43 (0.15)	30.28 (0.11)	0.07 (0.11)	0.16 (0.21)
Unweighted Price (without warehouse)	10.74** (0.04)	27.92** (0.04)	0.10* (0.07)	0.21 (0.12)
Weighted Price	15.17*** (0.01)	-	0.09* (0.09)	0.15 (0.24)
Weighted Price (without warehouse)	14.37*** (0.01)	-	0.12** (0.02)	0.21** (0.04)
Residuals	2.90 (0.21)	7.91 (0.21)	0.01 (0.34)	0.09 (0.21)

Notes: Notes: Standard deviation, coefficient of variation, range, and standardized range are measured for a specific lens across all store in either the online or offline channel, and then averaged over all lenses sampled. *See* Appendix for details. Range is omitted for weighted statistics because it does not vary with weighting. *P*-values from a Wilcoxon ranksum test are in parentheses. ***significant at 1% level, one-tailed test;**significant at 5% level, one-tailed test; *significant at 10% level, one-tailed test.

TABLE 9
REGRESSION RESULTS FOR LOG LENS PRICE WITH ACUVUE INTERACTION

	Unweighted		Weighted	
	(1)	(2)	(3)	(4)
OFFLINE	0.290***	0.154***	0.269***	0.101**
	(0.027)	(0.340)	(0.043)	(0.50)
OFFLINE*ACUVUE	-0.137***	-0.132***	-0.144***	-0.139***
	(0.038)	(0.033)	(0.057)	(0.056)
EYESONLY		0.178***		0.178***
		(0.043)		(0.043)
INDEP		0.018		0.020
		(0.036)		(0.037)
CONSTANT	4.19***	4.20***	4.25***	4.25***
	(0.027)	(0.024)	(0.053)	(0.052)
R^2	0.84	0.86	0.81	0.83
F	149.03***	158.83***	90.03***	85.45***

Notes: N = 279. Unit of observation is the log of price of lens *i* at outlet *j*. Robust standard errors in parentheses. ***significant at 1% level; **significant at 5% level. Acuvue lenses is the omitted category for lens fixed-effects.

TABLE 10
REGRESSION RESULTS FOR TOTAL LENS PRICE

	(1)	(2)
OFFLINE	6.20**	10.89***
	(3.24)	(3.61)
OFFLINE*ACUVUE		-15.66***
		(3.14)
EYESONLY	16.30***	16.23***
	(3.88)	(3.87)
INDEP	4.00	3.77
	(4.00)	(3.96)
CONSTANT	65.99***	71.11***
	(2.15)	(1.64)
R^2	0.85	0.86
F	77.89***	79.17***

Notes: N = 279. Unit of observation is total price of lens *i* at outlet *j*. Robust standard errors in parentheses. ***significant at 1% level; **significant at 5% level. Acuvue lenses is the omitted category for lens fixed-effects.

TABLE 11
ESTIMATED OFFLINE PREMIUM WITH TRANSPORTATION COSTS

	Premium (%)	
Trip Cost Allocation (%)	All Lenses	Non-Acuvue
0	7.0	11.7
50	13.0	17.3
100	18.9	23.0

Notes: The relevant offline premium is calculated by dividing coefficient on OFFLINE from Table 10 plus relevant trip costs by the average online price for all lenses ($88.47) and non-Acuvue lenses ($93.26).