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Different Prices for Identical Products? Market Efficiency and the Virtual Location in B2C E-Commerce

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Non-technical Summary

In the beginning of the Internet era, economists believed that e-commerce would lead to strongly increased competition. The most important theoretical argument fostering this view was the expectation of highly increased market transparency due to the increased possibilities to search for and compare prices. Instead of the time-consuming walking through different shops on a shopping trip in the 'real world', different sellers are only a few mouse clicks apart in the 'virtual world'. At the same time, the cost of changing a price should be very low for online retailers, since a price can be increased or decreased by changing a single entry in a database.

If perfect competition prevailed in digital markets, one should be able to observe that identical products are sold for the same price by all online retailers. Today, conventional wisdom is however that comparing prices online can get very tedious, and the variety of online shop designs and general terms and conditions across online retailers can be quite confusing.

In this study, competitive effects of digital markets are investigated in an empirical analysis using a data set from the online market for contact lenses. The data were collected between March and September 2002 and comprise 23,046 price quotes for single packages of contact lenses from all relevant online shops as well as rich information on retailer and product characteristics and on the virtual location of the retailers. Since a substantial extent of price dispersion is observed, potential sources thereof are analysed. One source of differences in prices could be the virtual location of the online shops, a concept which is developed based on the observation that some online shops are easier to find than others, analogous to the role of geographical location. Another source could be the strategy of retailers to differentiate with respect to their services and with respect to the features of their online shops in order to mitigate price competition.

The results presented in this paper suggest enhanced market efficiency through digital markets. Particularly for the segment of planned replacement contact lenses, evidence is found for lower prices, less price dispersion and more frequent price changes among e-retailers in comparison to hybrid retailers. The price differential observed between e-retailers and hybrid retailers is decomposed into a part which is due to different retailer and product characteristics and a part which represents the effect of competition. Furthermore, the results are consistent with the notion of a virtual location of the retailers. However, price dispersion can only partially be explained by retailer characteristics.

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Abstract

This paper analyses market efficiency and the role of the virtual location in digital markets using a data set containing more than 23,000 price observations from the online market for contact lenses as well as detailed information about online retailer and product characteristics. The data allow to implement and test the concept of virtual location. The empirical results reveal evidence for lower prices and less price dispersion among e-retailers in comparison to hybrid retailers, which supports the hypothesis of enhanced market efficiency in electronic markets. Furthermore, the results show that an online shop's virtual location influences its prices and that differences in prices are partially driven by differentiation in retailer service. A decomposition of the price differential reveals that there may indeed be a competition effect.

JEL–Classification: L11, D43, L81, C23
Keywords: electronic markets, efficiency, virtual location, pricing

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1 Introduction

In the beginning of the Internet era, economists believed that e-commerce would lead to nearly perfect competition. The euphoric view on the emerging possibilities of conducting e-commerce comprised expectations for increased market transparency due to near-to-zero search costs, as well as decreased menu costs for producers and retailers. Barriers to entry should also be substantially lower than in conventional markets. Thus, the overall transaction costs were expected to decrease, which should lead to increased market efficiency. The extreme view is a perfectly competitive market (Bertrand competition), in which the law of one price prevails. The prerequisites for Bertrand competition are however homogeneous products, free market entry, perfect information of the buyers (implying negligible search costs) and a sufficiently great number of buyers and sellers.

Several arguments apply for online markets in this context. There are more possibilities to search for and to compare prices. Not only can consumers get informed about prices more easily, retailers can also quickly screen the offers of their competitors. Instead of the time-consuming walking through different shops on a shopping trip in the 'real world', different sellers are only a few mouse clicks apart in the 'virtual world'. Additionally, virtual malls and shopping centers offer links to various online shops, and search engines, price comparison web sites and shopbots[1] promise to supply information which is valuable to the consumer in terms of quickly finding the cheapest supplier, thus lowering search costs in terms of money or time. Therefore digital markets should be characterised by lower prices and less price dispersion.

At the same time, it is easy to imagine that price setting costs for suppliers of products are substantially lower online than offline. Brynjolfsson and Smith (2000, p. 572) point out that "On the internet, (...) menu costs should be much lower — comprised primarily of the cost to change a single entry (per title) in a database." Since a retailer will only change a price if the expected benefit exceeds the marginal cost of the price change, price changes should occur more often and the amounts of change should be smaller when menu costs are lower.

If perfect competition prevailed in digital markets, one should be able to observe the law of one price which would make price comparisons across retailers useless. Today, conventional wisdom is that comparing prices online can get very tedious, and the variety of online shop designs and general terms and conditions across online retailers can be quite confusing. However these assessments often rely heavily on personal experience, and empirical evidence often relies on heavily selective data sets.

The contribution of this paper is threefold: This is – to the best of my knowledge – the first attempt to use and test empirically the concept of the 'virtual location'. The concept of virtual location is based on the notion of "neural real estate" from Smith, Bailey and Brynjolfsson (2000, p. 110). Second, the analysis is based on

[1]The notion 'shopbots' refers to automated programmes searching retailer web sites for prices, whereas 'price comparison web sites' means databases where retailers can enter their prices into a database by themselves.

a unique data set on nearly the whole digital market of contact lenses relevant for consumers living in Germany, which was collected in 2002 and contains more than 23,000 price observations. And third, the price differential observed between e-retailers (retailers that operate solely online) and hybrid retailers (retailers operating a conventional outlet as well as an Internet shop) is decomposed into a part which is due to different retailer and product characteristics and a part which represents the effect of competition.

The price data are merged with information on product and retailer characteristics as well as information on the virtual location of online retailers. The analysis of the market for contact lenses complements the existing literature on the efficiency of digital markets, where mainly books, CDs or electronics have been considered, and avoids the problem of legal price-fixing in the German market for books. Comparisons are made between e-retailers and hybrid retailers. Neither is the observed product range restricted to a predetermined subset of products, nor are the retailers selected. The price observations are collected directly at the retailers' web sites instead of using shopbot data or price quotes from price comparison web sites. Thus the data set is not a selected sample but it represents the whole population of online shops, which are relevant for consumers living in Germany. The data set contains 23,046 price observations collected between March and September 2002 on a monthly basis.

The results presented in this paper suggest enhanced market efficiency through digital markets. Particularly for the segment of planned replacement contact lenses, evidence is found for lower prices, less price dispersion and more frequent price changes among e-retailers in comparison to hybrid retailers. Furthermore, the results are consistent with the notion of a virtual location of the retailers. However, price dispersion can only partially be explained by retailer characteristics.

The paper is organised as follows: Section 2 describes the existing literature and derives hypotheses for the empirical analysis. Section 3 desecribes the data set, which is analysed in Section 4. Section 5 concludes.

2 Hypotheses and Empirical Evidence

2.1 Empirical Evidence With Respect to Market Efficiency

A growing body of literature analyses the relative degree of market efficiency of online markets. In his pioneering work, Bailey (1998b) developed four criteria for the analysis of the relative degree of market efficiency of online markets in comparison to conventional markets: A more efficient market leads to *lower prices* and *less price dispersion*, because lower search costs lead to more price transparency. Consequently, the law of one price should prevail in a perfectly competitive market and no price dispersion should be observed. Furthermore, lower menu costs lead to *more frequent and smaller price changes*. And finally, the *price elasticity of demand* should be higher in a more efficient market with better informed consumers (this point is not evaluated further, since the data used in the analysis do not include information about the quantities sold).

Price Level — The evidence on the relative price level of online retailers compared to conventional retailers is mixed. Bailey (1998b) finds higher prices online for books, CDs and software, whereas Brynjolfsson and Smith (2000) find between 9 and 16 percent lower prices on the Internet for books and CDs, depending on the inclusion of taxes, shipping and shopping costs into the price. In a study by Clay, Krishnan, Wolff and Fernandes (2002) there is no significant difference found for book prices online versus offline. When taxes and shipping costs are included in the analysis, book prices at conventional retailers are lower, as sales tax (only incurred at conventional retailers) is lower on average than shipping costs (only incurred at online retailers). In contrast to this, Scott Morton, Zettelmeyer and Silva-Risso's (2001) results suggest that cars are sold for 2 percent less when bought via an Internet referral service (which refers potential buyers to car dealers). Controlling for retailer characteristics, Pan, Ratchford and Shankar (2002a) find that prices of e-retailers are lower than those of hybrid retailers for CDs, DVDs, desktops and laptops, higher for books and software and not significantly different for personal digital assistants and consumer electronics.

Price Dispersion — The result of substantial price dispersion online is replicated in many studies, but only some of them compare the degree of price dispersion online to the amount of price dispersion prevailing offline. Brynjolfsson and Smith (2000) find relative price ranges[2] of as much as 33 percent for books and 25 percent for CDs on average. Depending on the measure which is used, price dispersion on the Internet is higher or lower than on the physical channel. Bailey (1998b) finds no empirical evidence for less price dispersion online, as well.

Price Changes — With regard to price changes, the empirical results found in the literature are more clear cut. Bailey (1998b) finds significantly more price changes made by online than by conventional book, CD and software retailers, which hints to a more efficient market on the Internet. The analysis of Brynjolfsson and Smith (2000) for the markets for books and CDs reports price changes to be significantly smaller at online retailers — furthermore the smallest observed price change among Internet retailers is 0.01$, compared to 0.35$ being the smallest price change observed in a conventional outlet.

Therefore considering market efficiency, the first hypothesis will be:

Market efficiency hypothesis: *Digital markets enhance market efficiency. This hypothesis is investigated by testing the partial hypotheses of a lower price level, less price dispersion and both more as well as smaller price changes among e-retailers compared to their hybrid competitors.*

2.2 A more Realistic View on Digital Markets

Caused by everyday observation and by empirical research results, a more realistic view on market efficiency in online markets is nowadays established. Obviously, the law of one price is not prevailing in online markets. The theoretical considerations

[2]The relative price range is defined as the difference of the highest and the lowest price for a given product, divided by its average price.

explaining this observation are illustrated in the next paragraphs and complemented by e-commerce specific arguments. Possible violations of the Bertrand model, which are relevant in the context of this paper refer to the assumptions of homogeneous products, perfectly informed consumers, and zero search costs.

Virtual location — Smith et al. (2000, p. 110) mention: "It is a truism that the three critical success factors for conventional retailers are location, location, and location." The same argument should hold for online retailers in the sense that there certainly exists some kind of 'virtual location', as the probability of passing a certain retailer's web site is not equally distributed across retailers. Factors such as the publicity of the company and its Internet address, the listing and position in Internet search engines or banner ads on web sites with high traffic should considerably increase the probability of being found by potential customers. Smith et al. (2000, p. 110) point out the high investments in product placement on Internet portals and "content sites". In a theoretical model, Smith (2002) shows that a small group of retailers with a high mental awareness on the consumer side can cooperate and set high prices. In contrast to this, the less-known retailers randomize over prices. This result is supported by empirical evidence in Smith's paper.

High investments in a superior location can also signal trust. Tang and Lu (2001) note that location merges in the virtual space with brand, which also drives price dispersion among retailers. Therefore the second hypothesis states:

Virtual location hypothesis: *In e-commerce, a better virtual location allows retailers to charge higher prices.*

Product and retailer differentiation — If price dispersion is still present after controlling for observable product characteristics, there may be unobserved factors influencing product prices. In their study of the online book market, Clay et al. (2002, p. 353) suggest that "(...) the products that firms offer may not be identical, even if the books are." Buying a product from a retailer represents the purchase of a composite good, which consists of the product itself plus complementary services of the retailer, regardless of whether the product is bought online or offline. Therefore differences in retailer characteristics must be accounted for when price dispersion is analysed. In addition to this however, differentiation in retailer services and in the design of online shops make price comparisons more costly and thus leads to incomplete information among potential buyers. This leads to the third hypothesis being investigated:

Differentiation hypothesis: *Potential price dispersion is partially driven by differentiation among online retailers.*

Other factors driving price dispersion — Price dispersion may result if consumers are imperfectly informed about prices or about the full range of retailers offering a certain product. In theoretical models explaining price dispersion by incomplete information, there are informed consumers, who always buy at the cheapest

retailer and uninformed consumers, who randomly choose a retailer to buy from (see for example Varian, 1980; Salop and Stiglitz, 1982). In some approaches, this behaviour is strategically exploited by retailers in order to mitigate competition. Some of the aspects described in this paragraph are implicitly tested by including variables describing retailer attributes in the analysis in Section 4.2.

Trust and reputation — The temporal divergence of ordering, paying and receiving the product in the case of online ordering creates additional uncertainty for consumers, who are ex ante not sure if they finally receive the product they have paid for. Therefore there is an increased need for signalling trustworthiness or reliability in online markets (see Smith et al., 2000). Also consumers who are informed about prices may not buy from the cheapest retailer in the market if retailer branding or reputation plays a decisive role. Brynjolfsson and Smith (2000) argue that providing detailed product information may signal trust and thus leads to price premiums, although information could be consumed separately from ordering a certain product. Thus information need not be part of the composite good consisting of the product itself and additional services that are inseparably connected to the product. The authors show in their empirical analysis that well-known retailers can charge price premiums in the markets for books and CDs. A similar hypothesis cannot be tested in this paper, because there simply does not exist any well-known branded online seller of contact lenses in the market considered.

Search costs — A further source of price dispersion arises when consumers are not perfectly informed and face positive search costs. During the process of getting informed about prices, an imperfectly informed consumer has an incentive to continue searching for a lower price as long as the expected benefit from getting better informed exceeds marginal costs. In models with consumer search costs, price dispersion is a result of different incentives to search for the lowest price (see for example Burdett and Judd, 1983; Stahl, 1996).

On the one hand, search costs should be considerably lower for consumers shopping online. Different online shops are only a few mouse clicks apart, and the services of price comparison web sites or shopbots are available without any cost. On the other hand, evaluating the offers of different online shops can be a very tedious task, as the "lack of standardization renders comparisons expensive" (see Schmitz and Latzer, 2002, p. 168). Online retailers might use a complex design for online shops in order to distinguish time-sensitive consumers with high search costs from time-insensitive consumers with lower search costs. Such an approach can serve as a screening device in order to enable price discrimination. Thus, retailers with more convenient and easy-to-navigate online shops can maybe charge a premium for this convenience, as it is reported by Smith et al. (2000).

Lock-in effects and switching costs — Consumers can refrain from buying at the lowest price retailer if they repeatedly purchase the same item or products from the same product category and if there are switching costs which lead to lock-in effects (for a review of the switching costs literature see Klemperer, 1995). Different kinds of switching costs can arise naturally (for example, simply by getting familiar with a retailer's web site) or can strategically be enforced by retailers (for example by the option of one-click-ordering or personal recommendations for repeat buyers (see

Smith et al., 2000)).

2.3 E-Retailers versus Hybrid Retailers

As already mentioned, a business-to-consumer e-commerce market is observed and analysed in order to test these hypotheses: the online market for contact lenses. Contact lenses are homogeneous products and thus well-suited for an empirical analysis of market efficiency and pricing. In order to obtain a judgement on the relative degree of market efficiency online, comparisons are made between retailers which operate solely online (which are called 'e-retailers') and so-called 'hybrid' retailers. The notion of 'hybrid retailers' refers to those retailers which operate a conventional outlet as well as an Internet shop.[3] This approach is also pursued by Tang and Lu (2001) in their analysis of the online market for CDs, Tang and Xing (2001) for DVDs and by Pan et al. (2002a) in their analysis of the prices for eight different product categories.

Tang and Lu (2001) argue that pricing in the online shops of conventional retailers forms a part of their overall pricing strategy. Thus, their pricing strategy is influenced by considerations concerning both sales channels. For example, the prices for products sold online by a hybrid retailer may be higher than those of an e-retailer because the hybrid retailer does not want to undercut the prices in its conventional outlet – this is a decision a pure e-retailer is not faced with. Bailey (1998a, p. 8) expresses this view even more strongly: "While physical retailers may have an Internet presence, their purpose is[4] doing so is to promote sales via its other channels and their corporate cultures, cost structures, and dominant strategies stem from their origin in the physical marketplace." Thus, it can be assumed that the online pricing of hybrid retailers is not a stand-alone issue but influenced by considerations with respect to the conventional distribution channel. Consequently, prices from pure online shops should exhibit more evidence for market efficiency than hybrid retailers' prices. If hybrid retailers behave less competitively than their purely online counterparts, this could also be due to market power from the conventional market which can be transferred to the online market (see Tang and Lu, 2001). Such market power could result from typical sources, such as being a well-known brand or having a reputation for being reliable.

The question of competition between hybrid retailers and e-retailers is of particular importance because many conventional retailers decide to run an online shop in addition to their conventional shop. These online shops then possibly underlie different competitive aspects than e-retailers. Hybrid retailers must coordinate their sales channels in order to avoid channel conflicts (see for example Zettelmeyer, 2000). The fundamental assumption in all the following analyses is therefore that hybrid retailers are *ceteris paribus* more strongly linked to the conventional market.

Pan, Shankar and Ratchford (2002b) compare e-retailers (which they call "pure

[3]The notion 'online retailer' refers in this text to all online shops, i.e. to e-retailers as well as hybrid retailers. 'Conventional retailer', 'physical retailer' or 'offline retailer' refers to a brick-and-mortar retailer with a conventional shop.

[4]This typing error is part of the original paper.

play e-tailers") with the online prices of hybrid retailers (which they call "bricks-and-clicks e-tailers"). The data are automatically collected at a price comparison web site. A model is analysed in which e-retailers compete with conventional retailers. The latter decide upon launching an online shop, which would make them to hybrid retailers. The model concludes that conventional retailers only launch an Internet branch if consumers perceive such branches as superior to e-retailers. Reasons for such a perceived superiority are higher trust by customers which have not been to the conventional store yet and higher loyalty by existing customers from the conventional store. The model concludes that the price level should be higher among hybrid retailers than among e-retailers, which is confirmed in the associated empirical analysis.

3 Data

3.1 The Online Market for Contact Lenses

According to Liebowitz (2002), four attributes of products make them suitable for being sold on the Internet or not: Goods to be sold on the Internet should have a relatively small ratio of weight to price, they should usually not be impulse purchases[5], they must not be perishable, and they must not be experience goods.[6]

It is straightforward to see that contact lenses fulfill all these requirements: the packages are very lightweight and small relative to product value, so that shipping costs do not get too high, and usually consumers do not buy them spontaneously driven by the shopping atmosphere. Furthermore, once a suitable contact lens has been fitted by a contact lens specialist, the consumer knows which product suits his/her medical needs and there is little need to evaluate the product each time before buying it. In the case of planned replacement lenses, there are predetermined exchange intervals, so that there is a continuous replacement requirement. Furthermore, contact lenses are clearly not perishable within a short period of time.

There are additional reasons, why contact lenses are well-suited for an empirical analysis. First, the product is highly standardised – most consumers choose a product which is not made to order, but is chosen among a range of standard parameters. Second, the characteristics can be described in a limited number of objective specifications, and there are no concerns of fashion or individual taste which influence a consumer's valuation of the products. As the choice of a certain product depends decisively on medical needs and on the individual condition of the eyes, there are relatively little possibilities for substitution between the products driven by brand preferences or quality attributes. Third, particularly in the case of planned replacement lenses, there is a continuous replacement requirement, and so there should be

[5]There is one exception to this rule: Digital products can also be bought on the Internet in an impulse buying, as they are delivered immediately.

[6]The author also mentions the role of two additional factors which influence if goods are traded online: thin markets (which means markets with a small number of potential buyers like markets for specialty products), and sales tax reductions.

a strong incentive for consumers to search for the lowest price.[7] This is a major difference to previous empirical studies evaluating markets for products like books, CDs, software or consumer electronics, where the same product is usually bought only once.

3.2 Data Set

Identification of the Online Shops — The online shops for contact lenses were identified by searching for the German word for contact lenses in its two spellings (*Kontaktlinsen* and *Contactlinsen*) in the 10 most-widely used search engines at the beginning of March 2002.[8] From each of these search queries, the first 250 hits were examined in order to identify sellers of contact lenses.[9] Furthermore, in each of the search engines a search was run for the nouns *contact lenses* and *Euro* in order to identify online shops with web sites in English whose prices are announced in Euros. This seemed to be an appropriate way to account for the perspective of a German consumer who is willing to order contact lenses from abroad and prefers to have price information without any need to convert currencies and without any risk from exchange rate volatility.

Only online shops which at least provided an electronic order form were included in the sample. Other web sites where the consumer has to write an e-mail using separate e-mail software were excluded from the analysis.[10] The result of the monthly data collection is an unbalanced panel consisting of the price observations from 146 online retailers since some shops stopped their operations and others opened during the period of data collection.

Retailer Attributes — The service attributes of the retailers were collected once during the data collection period, as none of the shops underwent major changes. All online shops were extensively browsed and their attributes categorised in an attempt to capture the immediate judgement a consumer makes when browsing through an online shop. Therefore, a bulk of variables was created, describing the characteristics of online shops. These characteristics are described in Table 1. All attributes are measured either as dummy variables (available versus not available) or on an ordinal scale ranging from 0 to 2 according to the service level the retailers

[7] Sorensen (2000) points out that search incentives are only affected by repeat purchases if prices are expected to remain stable over some time. This is clearly the case for the online market for contact lenses (for the frequency of price changes see Section 4.1).

[8] The complete list of these search engines can be found in the Appendix.

[9] During the planning of the data collection, a search for price comparison sites or shopbots for contact lenses in German was conducted. At that point of time, there was only one shopbot listing contact lenses from only one online retailer, and the prices listed were identical to the prices at the retailer's web site itself. Therefore, the sample contains no observations from shopbots or price comparison web sites.

[10] Interestingly, none of the shops is operated by a contact lens manufacturer, nor can consumers order contact lenses directly on any of the manufacturers' web sites. This suggests that there are no attempts from manufacturers to bypass the retailer network in order to increase the manufacturers' margins.

provide. For online shops with the lowest service level (or which do not provide the feature at all), the variable takes on the value 0, for the best service level the value 2 is assigned.[11] Aspects of the physical location are proxied by the relative purchasing power index of the region where the retailer is physically located, as it is measured by the *Gesellschaft für Konsumforschung*.

Table 1: Online shop attributes

Range of products	contact lens care
	packages of lenses and care products
	accessories for contact lenses
Product presentation	product photos
	information on material and water contents
	hint to suitable contact lens solution
Ease of navigation	possibility for individual search
	sorting capabilities (lens type, brand)
Trustworthiness	return policy: return period
	return policy: who incurs cost of returns
	payment modes
	certified online shop
Technical configuration	shopping basket
	data encryption
	order tracking or personal login
Help and information	information about the order process
	general terms and conditions
	information about contact lenses
	telephone or fax number
Extra service	links to web sites with information on contact lenses
	recommendation premium
	delivery within 24 hours possible
	free trial lenses
	printed version of the catalogue
	discussion forum for customers

In addition to these attributes the fees for handling, shipping and delivery, henceforth referred to simply as shipping cost, were collected. For the inclusion of shipping cost, the cheapest option of the most popular modes of payment (which are described in table 11 in the Appendix) was calculated. The fees for cash on delivery were only taken into account if there was no other option available.

[11] An indicator for retailers' services could not be constructed from evaluations by consumers as in Pan et al. (2002a) because there are not enough evaluations posted on the German web site www.ciao.com.

Virtual location — As already mentioned, a novel approach in this study is the attempt of measuring the 'virtual location' of the online-shops. The concept of location (in conventional markets) is derived from the notion that potential customers are in some places more likely to notice and pass a shop and thus to enter it than in other places. Therefore it is advantageous to be settled in a pedestrian zone or in a shopping centre, for example. In analogy to this, customers are more likely to click through to an online shop, which is ranked very high in an Internet search engine or which has ads appearing on the result sites of a search engine whenever a search for a relevant word has been conducted.

The virtual location is measured at each data collection date by the rank in the Google search results list among the first 100 hits for both relevant search terms, and by dummies for banner ads or sponsored links[12] in any of the 10 most used search engines when a search for the both relevant search terms is executed.

Contact Lens Attributes — Information about the product attributes were – as much as possible – gathered from the manufacturers' web sites. Since many manufacturers supply little detailed information about product characteristics, there was a need for additional information, which was found on the web sites of the British and French associations of contact lens manufacturers[13], as well as on the web site of a British retailer which included very detailed information[14].

The relevant attributes of contact lenses are the general type of product (frequent replacement, soft or rigid), the type of ametropia which is to be corrected (myopia/hyperopia, astigmatism, presbyopia) the range of dioptres, base curves, diameters, axes, cylinders and additions (if applicable). Besides there are additional features like handling tint and UV filter, and additional information like centre thickness and dk value (which measures the oxygen permeability of the material). It was possible to collect these characteristics for 237 distinct products.

Prices — From March until September 2002 the whole range of contact lenses offered by each online shop was gathered, with the exception of coloured and fun lenses.[15] For each offered product and packaging unit, the associated unit price including sales tax and possible quantity discounts were collected by every fourth week (between Monday and Wednesday) at each online shop in the sample. The results were 23,046 price quotes for single packages, because quantity discount schemes offered by the retailers were excluded from the analysis. The price quotes are distributed among the three segments of planned replacement lenses according to Table 2 where also the segmentation in the overall market for contact lenses in Germany

[12]'Sponsored links' refers to the fact that all for commercial search engines, firms can pay in order to appear at the beginning of the results list when a search for a certain search term is executed. These links are less distinguishable from the 'normal' results list than banner ads.

[13]The Internet addresses are www.contaguide.fr and www.aclm.co.uk, respectively.

[14]www.jnj-contact-lenses.co.uk

[15]Coloured and fun lenses (i.e. contact lenses with pictures on them, which are not suitable for driving, for example) were excluded, because this market segment was considered to have low substitution relationships to ordinary contact lenses. Furthermore, the demand for coloured and fun lenses can be assumed to underly more strongly to fashion concerns to a certain extent.

can be found. An obvious drawback is that there is no information on sales volumes. The number of observations in the data set is however correlated with the market share of the three market segments, as can be seen in Table 2.

Table 2: Market segments

	Market for contact lenses in Germany 2002	Observations in the sample
Planned replacement lenses	62%	70%
Soft contact lenses	21%	22%
Rigid contact lenses	17%	8%

Source for market data: Der Spiegel (2003).

The data collection was done manually. Automated data collection was impossible because the relevant web sites do not follow a standard design. In contrast to this, some studies (see for example Baylis and Perloff (2002) or Pan et al. (2002a)) use data from shopbots, which are automatically recorded by so-called "spider" software. This bears the disadvantage that many suppliers prohibit automated price queries as reported by DeLong and Froomkin (2000), that many price comparison sites do not contain prices identical to those on the online shops' web sites (see Ellison and Fisher Ellison (2001)) or that only a biased selection of suppliers is listed on price comparison web sites. It is an additional advantage of the data set used in this study, that not only selected products, but the whole product range of the retailers was recorded. For example, Clay et al. (2002) argue that the differences between their results and those of Brynjolfsson and Smith (2000) could be driven by the different sets of products and shops considered for the price comparisons.

4 Empirical Analysis

4.1 Descriptive Analysis of Market Efficiency

In the first step, the three criteria for market efficiency which were described in Section 2.1 are compared between the subgroups of hybrid and e-retailers.

Comparison of the price level: In Table 3, the hypothesis of equal mean prices between hybrid and e-retailers against the alternative hypothesis of a lower price level among e-retailers is evaluated using the nonparametric Wilcoxon ranksum test which compares the price distributions of the two groups of retailers.[16] The tests include only products which are available at both retailer types. In order to avoid possible biases due to the choice of products offered by the retailers, the tests on equal prices which are reported in Table 3 are calculated separately for each product and packaging unit.

[16]The results of testing for equal means using t-tests can be found in Table 12 in the Appendix.

Table 3: Descriptive analysis of price level

	Separate ranksum tests on equality of price level		
	# of tests	# of significant tests	% significant
Planned replacement lenses			
Tests	78	42	53.8%
Observations	15,603	11,320	72.6%
Soft lenses			
Tests	47	18	38.3%
Observations	4,459	1,946	43.6%
Rigid lenses			
Tests	16	7	43.8%
Observations	1,688	735	43.5%

Notes: $H_0 : F_{e-ret.}(p) = F_{hybr.}(p)$ is tested against $H_a : F_{e-ret.}(p) > F_{hybr.}(p)$ (the alternative hypothesis implies a lower price level of e-retailers). A test's p-value must not exceed 0.05 in order to be counted as a significant test. Comparisons are made across retailers and across time.

For the product segment of planned replacement lenses, the null hypothesis of equal prices can be rejected for 53.8% of the products. However, these products which are significantly cheaper when bought from e-retailers represent 72.6% of all prices for planned replacement lenses. Note that more price observations for one product than for other products mean that this product is available from more retailers. This may imply that e-retailers compete more intensively on prices for products which are offered by a higher proportion of online retailers. Although the quantities sold are unknown, it can be assumed that these are the products with high sales volumes within the segment of planned replacement lenses.

For soft and rigid contact lenses, a lower fraction of the products is significantly cheaper among e-retailers. For soft lenses, 38.3% of the products are cheaper from e-retailers, and 43.8% for rigid lenses.

Comparison of price dispersion: With respect to price dispersion, the F-tests, which evaluate the null hypothesis of equal standard deviation of prices versus the alternative hypothesis of a lower standard deviation of prices among e-retailers are reported in Table 4. Separate tests for different products and packaging units have been calculated in order to investigate price dispersion. The results are similar to the results from the price level comparisons. In this test procedure, the null hypothesis of equal price dispersion can be rejected in the group of planned replacement lenses at a significance level of five percent for 60.9% of the products, which represent 81.8% of the observations. For soft and rigid contact lenses, the tests are significant for 37.9% and 25.0%, respectively.

Table 4: Descriptive analysis of price dispersion

	Separate F-tests on equality of standard deviation		
	# of tests	# of significant tests	% significant
Planned replacement lenses			
Tests	64	39	60.9%
Observations	15,189	12,428	81.8%
Soft lenses			
Tests	29	11	37.9%
Observations	3,521	1,770	50.3%
Rigid lenses			
Tests	12	3	25.0%
Observations	1,476	384	26.0%

Notes: $H_0 : \sigma_{e-ret.} = \sigma_{hybr.}$ is tested against $H_a : \sigma_{e-ret.} < \sigma_{hybr.}$. A test's p-value must not exceed 0.05 in order to be counted as a significant test. The standard deviations are calculated across retailers and across time.

Menu costs: In order to analyse menu costs (see Table 5), each price observation was compared to the observation of the previous month. In the subgroup of hybrid retailers, a price change in the segment of planned replacement lenses occurred in 7.5% of the observations, compared to 5.9% among e-retailers. This difference is statistically significant. In contrast to this, the hypothesis of equally frequent price changes across the two types of retailers cannot be rejected for the two other market segments. When the amount of price changes is analysed, relative price changes (in % of the original price) are compared. The null hypothesis (equal amounts of the average price change) can not be rejected in favour of the alternative hypothesis of smaller price changes by e-retailers in each market segment.
The descriptive results support the hypothesis of more market efficiency in digital markets only insofar as e-retailers are cheaper and have less dispersed prices. However, only weak differences between the two retailer types can be found with respect to the frequency and and no evidence with respect to the amount of price changes. These results are obtained from the comparison between hybrid and e-retailers. Therefore, they are not directly comparable to empirical studies in which differences between online and conventional retailers are evaluated (see for example Bailey, 1998b; Brynjolfsson and Smith, 2000; Clay et al., 2002; Lehmann, 2001; Ward, 2002). However, some retailers in the data set emphasise in their general terms and conditions that the prices in their online shops are not valid in their conventional outlets or explicitly mention that the prices in their online shops are lower than in their conventional shops. So it can be assumed that the resulting differences were even more pronounced if online prices were compared to offline prices.

Obviously, the results hold primarily for the product segment of planned replacement lenses. This could be due to the fact that ordering contact lenses online is

Table 5: Descriptive analysis of price changes

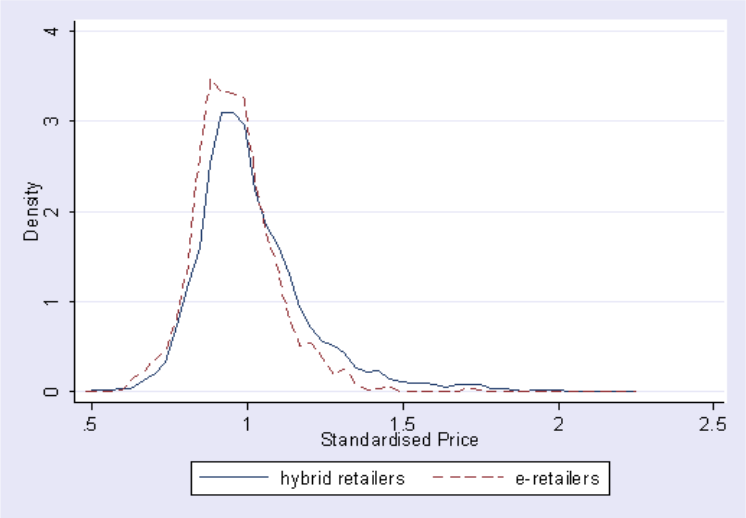
	Tests on equality of frequency and amount of price changes		
	e-retailers	hybrid retailers	p-value
Planned replacement lenses			
Fraction of price changes	7.5%	5.9%	0.000
# of observations			13,505
Relative price change	9.0%	9.1%	0.447
# of observations			848
Soft lenses			
Fraction of price changes	3.1%	4.8%	0.983
# of observations			4,357
Relative price change	9.6%	11.7%	0.227
# of observations			197
Rigid lenses			
Fraction of price changes	3.8%	3.9%	0.533
# of observations			1,483
Relative price change	7.8%	5.0%	0.741
# of observations			57

Notes: The first null hypothesis of equality of the number of fractions of prices changed is tested against the alternative hypothesis that e-retailers change prices more often. The second null hypothesis of equality of the average amount of change is tested against the alternative hypothesis of e-retailers realising smaller price changes. Equality of the fractions of price changes is tested by binomial tests; equality of the average amount of change is tested by t-tests.

particularly advantageous for planned replacement lenses, as these lenses are replaced in fixed intervals between one day and one month. As soft and rigid contact lenses need to be replaced every 12 or 18 months (or even less often), the eyes should be examined and the contact lenses be fitted by a specialist before replacement. Online ordering should be an alternative only if the lenses are lost or broken shortly after they have been fit. This fact is also represented by the high percentage of observations for planned replacement lenses in the data set. Moreover, it must be kept in mind that the pairwise test strategy for the descriptive tests in this section only controls for product attributes but not for differences in retailer service. These differences are controlled for in the hedonic price regressions in the next section, where *ceteris paribus* effects will be estimated.

The result of a lower price level among e-retailers is supported by a kernel density estimation for standardised prices. Each price is standardised in terms of a division by the mean of all prices for this product and package size. This standardised price describes the relative deviation of the average price across all online retailers and is a first attempt to control for product heterogeneity. Figure 1 depicts the kernel estimates for both sub-samples. Note that Figure 1 also reveals

Figure 1: Kernel Density Estimation of Standardised Prices



Notes: Epanechnikov kernel, optimal bandwidth

the high degree of price dispersion: The average price takes on a value of one being divided by itself. One can easily see that prices range from about 60% of the average price up to 1.6 times this average price.

4.2 Hedonic Price Regressions

In order to represent retailer service attributes by a reasonable amount of variables to be used in the price regressions, a factor analysis of variables representing retailers' service characteristics was performed. The variables describing retailer service (see Table 1) underwent a principal factor analysis. The factor loadings were obtained after a varimax rotation. The results are 5 principal factors, which represent 91% of the total variation. The variables whose factor loadings exceed 0.4 in absolute terms are reported in Table 6. These factors are scored for each retailer and used as proxy variables describing the retailer service in the hedonic price regressions. The names assigned to the factors correspond to the underlying variables with high factor loadings. Thus, the factors describe the extents of convenient navigation of the web pages, customer service, the return policy and the offer lens care (which is a highly complementary product), security aspects and service for customers who are new to wearing contact lenses.

In order to evaluate the influence of retailer service characteristics and the virtual location on product pricing, the following hedonic price function is estimated:

$$ln(p_{ijt}) = \alpha + \gamma r_j + \delta c_i + \lambda l_{jt} + \mu d_t + u_{ij} + e_{ijt} \quad (1)$$

where $log(p_{ijt})$ denotes the natural logarithm of the price of product i offered by retailer j at time t in Euros. r_j is a vector describing the characteristics of retailer

Table 6: Factor analysis of retailer service

Factor	Features of online shops	Sign
Convenient navigation	Possibility for individual search	+
	Shopping basket	+
	Sorting capabilities (lens type, brand)	+
Customer service	Delivery within 24 hours possible	+
	Recommendation premium	+
Return policy + lens care	Return policy: return period	+
	Contact lens solutions available	+
	Hint to suitable solution	+
Security + trustworthiness	Encrypted data transfer	-
	Certified online shop	-
New CL user service	Free trial lenses	-
	Links to informative web pages	-

Note: Only variables with factor loadings exceeding 0.4 in absolute value are depicted.

j, c_i represents the product characteristics of product i, l_{jt} is the virtual location of retailer j at time t, d_t is a full set of time dummies and e_{ijt} is an error term with the usual properties. u_{ij} represents a product i offered by retailer j specific unobserved effect, which is either assumed to be zero (pooled OLS), or which is assumed to be uncorrelated with the explanatory variables (random effects estimator) or which is assumed to be correlated with some of the explanatory variables (Hausman-Taylor estimator). A product i is defined as a combination of product and package size. Because planned replacement lenses are the segment of contact lenses which is most suited for e-commerce, the empirical analysis in the following sections is based only on the sub-sample of planned replacement lenses. Prices per lens are calculated from the prices for single packages, which means that quantity discount schemes are excluded from the analysis. Furthermore only retailers with a physical location in Germany are included because the regional purchasing power (which is used as an explanatory variable in r_j) is only available for Germany. This leads to the exclusion of 799 observations representing about 5% of the sample.

Estimation results for various estimation techniques are reported in Table 7. To get a baseline for comparison with other estimation techniques, Equation (1) is estimated by pooled OLS assuming that there is no unobserved product or retailer heterogeneity.[17] The standard errors are estimated by nonparametric bootstrapping in order to take into account the inclusion of generated regressors, which were obtained by the factor analysis.

[17]Contact lens attributes and time dummies are included in all specifications. Results are available from the author on request.

Table 7: Hedonic price regressions

	Dependent variable: ln(price per lens)		
	Pooled OLS	Random Effects	Hausman-Taylor
Package size	-0.010***	-0.010***	-0.010***
	($0.019*10^{-2}$)	($0.007*10^{-2}$)	($0.013*10^{-2}$)
Package size$^2 * 10^{-2}$	0.003***	0.003***	0.003
	($0.988*10^{-4}$)	($0.379*10^{-4}$)	($0.699*10^{-4}$)
Extra lenses	-0.073***	-0.082***	-0.072***
	(0.009)	(0.002)	(0.005)
Convenient navigation	-0.022***	-0.026***	-0.016***
	(0.002)	(0.001)	(0.003)
Superior customer service	-0.050***	-0.059***	-0.050***
	(0.002)	(0.001)	(0.003)
Return policy + lens care	-0.051***	-0.050***	-0.047***
	(0.005)	(0.005)	(0.005)
Security + trustworthiness	0 .016***	0.010**	0.016***
	(0.003)	(0.005)	(0.003)
New CL user service	0 .005**	0.004***	-0.007*
	(0.002)	(0.001)	(0.004)
Regional purchasing power$*10^{-2}$	-0.012	0.010**	0.003***
	(0.010)	(0.005)	(0.050)
E-retailer	-0.031***	-0.038***	-0.112***
	(0.004)	(0.002)	(0.026)
Banner ad	-0.049***	-0.006***	-0.005**
	(0.004)	(0.002)	(0.002)
Sponsored link	0.029***	-0.001	-0.001
	(0.005)	(0.002)	(0.002)
Google: Hit on 1^{st} page of results	0.055***	-0.004**	-0.005***
	(0.006)	(0.002)	(0.002)
Constant	1.521***	1.508***	1.249***
	(0.022)	(0.009)	(0.107)
Contact lens attributes	included	included	included
Time dummies	included	included	included
Number of observations	14,646	14,646	14,646
R^2 overall	0.969	0.968	
σ_u		0.183	0.212
σ_e		0.034	0.034

Notes: ***, **, * depicts significance at the 1%, 5% and 10% level. Standard errors in parentheses.

In the second column of Table 7, Equation (1) is estimated using a random effects model. However, a Hausman test statistic indicates correlation between the exogenous variables and the unobserved individual specific effect, implying that the estimation results of the random effects model cannot be assumed to be consistent.[18] Therefore, a Hausman-Taylor model is estimated, which allows for correlation between some of the exogenous variables with the random effects (see Wooldridge, 2002). It is assumed that the matter of being an e-retailer, the physical location proxy and the eventual appearance on the first page of results in Google when searching for the notion 'contact lenses' are possibly correlated with unobserved heterogeneity.

Taking into account unobserved heterogeneity and allowing for correlation between this unobserved heterogeneity and exogenous variables, the coefficients of the Hausman-Taylor model can be assumed to be consistently estimated and are therefore the basis for the interpretation of the results.

First of all, the estimation results indicate that the e-retailers offer significantly lower prices than their hybrid competitors. This further supports the descriptive results of the tests in Section 4.1 and thus the hypothesis of stronger competition and higher efficiency in digital markets.

The hypothesis that a better virtual location can be exploited in monetary terms is not supported. Both the placement of banner ads and being ranked prominently in the Google results list have a significantly negative effect on the product price.[19] A price premium would allow retailers to exploit their outstanding presence by charging higher prices. But the negative coefficients suggest a contrary interpretation, thus hinting to a different strategy pursued by online retailers: Retailers invest in banner ads and sponsored links in order to increase their web site traffic and thus their sales volumes in order to generate higher profits by a low price – high volumes strategy. Nevertheless, the negative influence of the dummy variable indicating an entry on the first page of results at Google is somewhat surprising, as a retailer's direct influence on its search engine rank is quite limited. While the virtual location clearly seems to exert influence on prices, the physical location has economically a much smaller influence. The higher the regional purchasing power the higher the price, but this result is far less meaningful in economic terms, since the estimated coefficient is very small (0.00003).

The estimation results for the influence of the different factors describing retailer service are all statistically significant. Four coefficients however have a negative sign which means that online shops which are more easily to navigate, offer better customer service or have a more favourable return policy, do not charge a price premium for these services but instead offer lower prices. Only more secure and trustworthy online shops seem to be able to generate payoff from these services.

[18] The test statistic takes on a value of 84.26 and is $\chi^2(9)$-distributed. The resulting p-value is 0.000.

[19] One could suspect that there might be a problem of multicollinearity with the three variables describing the virtual location. This was checked by including only one or two of the variables in separate regressions which led to equivalent results. The results also hold when a fixed effects model is estimated (the variables describing the virtual location are time-variant).

Maybe the four factors with negative coefficients represent more basic features which shops pursuing a low price – high sales volume strategy pay more attention to.

A second component of the product price for a good being ordered consists of shipping cost. Therefore, Equation (1) is re-estimated with prices including this additional cost. The shipping cost when ordering one single package of the product was added to the price per package, and this sum was then divided by the number of lenses in the package. 395 observations are lost since some online shops do not inform about shipping cost on their web sites, and because some online shops have a minimum order value which is higher than the price for a single package for some products. Estimation results can be found in Table 14 in the Appendix. The inclusion of shipping cost does not change the results qualitatively.

The estimated dummy variable coefficients of the results in Table 7 are transformed in order to express the percentage price differential between the two types of retailers and the influence of the virtual location factors on prices. Table 8 describes that prices are *ceteris paribus* 10.6% lower for e-retailers than for their hybrid competitors. This is rather strong evidence in favour of competitive effects from digital markets and in line with the results of Bailey (1998b) and other authors. A superior virtual location however does not pay off for the retailers in terms of price premiums. On the contrary, retailers with a better location offer slightly lower prices. Further research is clearly needed in order to investigate this result.

Table 8: Influence of characteristics in %

	POLS	Hausman-Taylor
E-retailer	-3.0%	-10.6%
Banner ad	-4.8%	-0.5%
Sponsored link	+3.0%	insign.
Google: Hit on 1^{st} page of results	+5.7%	-0.5%

Notes: The percentages are obtained by $(exp(\hat{\beta}) - 1) * 100$.

Further insight can be gained if the observed price differential between the two groups of online retailers is decomposed into several parts using a technique which was originally developed for the analysis of the sources of wage inequality in the field of labour economics. It was proposed independently by Blinder (1973) and Oaxaca (1973) and has been widely applied in labour economics. When the decomposition method is applied, two groups (e.g. wages for men and women) are compared by comparing differences in their endowments and differences in the estimated coefficients if regressions are run separately. The effects of differences in the estimated coefficients can be interpreted as discrimination, i.e. different returns to equivalent endowments.

In the case of product prices a price differential which is caused by differing retailer service and product attributes can thus be separated from a price differential due to unobserved factors. Since unobserved individual heterogeneity is taken

account of by the use of panel data techniques, a remaining price differential is interpreted here as an effect of competition. Absent any competitive effects, the different retailer service and the different product range offered by e-retailers would lead to on average 9.1% higher prices in this group (see Table 9). However, stronger competition in this group drives prices down by 6.2% compared to the hybrid group being in line with the estimation result in Table 8. The competitive effect comprises the effect of different slope coefficients which would drive prices for given attributes (endowments) down by 63.2% and the unexplained shift by different intercepts of +56.9% when comparing e-retailers to hybrid retailers.

Table 9: Decomposition of price differential

	POLS	Hausman-Taylor
Due to different endowments	+7.3%	+9.1%
Due to different coefficients	-14.2%	-63.2%
Unexplained	+9.7%	+56.9%
Due to competition	-4.5%	-6.2%

Notes: Decomposition ist based on the coefficients of the previous estimations.

One caution has however to be kept in mind when interpreting the results of hedonic regressions: The estimated coefficients reflect various factors which can influence prices. A hedonic function is always driven by marginal cost as well as a markup (see Pakes, 2003), and the characteristics of the competing products as well as the distribution of consumer preferences can influence this markup. In our case, one could imagine two distinct groups of consumers ordering contact lenses online: one group of consumers who are absolutely loyal to "their" local optician also in virtual space and thus buy only from hybrid retailers, and another group which does not care at which online shop the order is placed. The first group would clearly exhibit a less elastic demand than the second group, which would imply different pricing schemes by the two types of retailers.

This hypothetic situation gains additional weight in the light of the model of Lal and Sarvary (1999), who argue that e-commerce can reduce price competition if there are hybrid retailers selling products which have important "nondigital" attributes. Nondigital attributes are those attributes which need physical inspection, such as the size of clothes. In the model, Lal and Sarvary (1999) show that the Internet can increase customer loyalty because buying a familiar product online is cheaper than searching for an alternative and buying offline if nondigital attributes are significant. This result is obtained in a model with vertically integrated firms and thus seems to be in a different context than a situation with differentiated retailers selling homogeneous products. In the competition between e-retailers and hybrid sellers trust of the customers of a conventional optician could be seen as an attribute which increases customer loyalty to this single optician and the associated web site.

This consideration should be seen as additional to the general aspects of trust as a factor which could mitigate competition between online sellers (see Section 2.2).

5 Conclusions

The possibilities of trading goods on the Internet in electronic markets have given rise to various considerations about the economic effects thereof from a theoretical point of view. The main questions driving the analysis in this paper were the expectation that trading online would increase competition which was accomplished by the observation that there are numerous ways for retailer strategies in order to mitigate strong price competition. Since search costs are nonzero even in digital markets, retailers need a prominent positioning on the web, which leads to the concept of a virtual location. The fundamental assumption underlying the empirical analysis is that hybrid retailers are in contrast to e-retailers strongly linked to conventional markets.

The empirical evidence found is in favour of enhanced market efficiency through digital markets. In particular for the segment of planned replacement contact lenses, evidence is found for lower prices, less price dispersion and more frequent price changes among e-retailers in comparison to hybrid retailers. Hybrid retailers seem indeed to be constrained in their price setting behaviour by their physical presence.

Second, the results clearly reveal the influence of the virtual location on the pricing of online shops. It seems however to be the case that a good virtual location pays off through higher web site traffic and not through higher prices. The high spending for ads on the web is clearly a sign that generating web site traffic is the crucial goal in order to be profitable. In line with this consideration is the result that trust leads to higher web site traffic in the study of Pan et al. (2002b).

Insofar the results are conflicting with the result of Smith (2002), but the results could be driven by the fact that in Smith's study awareness is measured by being well-known and not by observed online advertising. Nevertheless, B2C e-commerce is certainly for most product categories still a growing field for economic transactions. Maybe we are still in the phase in which convincing consumers to buy online by retailer branding and building up a reputation is the first goal of online advertising. And certainly these activities being pursued in order to establish well-known brands, are paying off now by higher sales volumes or are expected to be exploitable by price premiums later.

The third result is that price dispersion can partially be explained by retailer characteristics, but not all features of online shops result in monetary returns. On the contrary, better service seems to be associated with lower prices for some features. The result that better retailer service can be related to lower prices is also reported by Baylis and Perloff (2002). As we have seen, the observed price differential between the two types of retailers can only partially be explained by different retailer characteristics (endowments), the other part can be attributed to competition.

This study is a first attempt to measure and analyse the effects of the virtual

location. Further research could consider for example the competition between e-retailers and hybrid retailers. As the Internet matures, more and more companies will regard it as an additional sales channel which can create channel conflicts within firms – a problem which e-retailers do not face. On the other side of the market, research on consumers' search activities on the Internet and the associated costs could be a useful complement to the literature on the efficiency of digital markets.

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Appendix

Table 10: 10 most-widely used search engines

www.google.de
www.yahoo.de
search.msn.de
www.lycos.de
www.t-online.de
www.altavista.de
www.web.de
www.metager.de (meta search engine)
www.fireball.de
suche.aol.com

Source: www.webhits.de, 04.03.2002.

Table 11: Modes of payment in B2C

	Acts of purchase
Bank transfer after delivery	36.4%
Bank transfer in advance	23.6%
Direct debit	19.2%
Credit card	13.6%
Cash on delivery	3.7%
Other	3.6%

Source: Gesellschaft für Konsumforschung (2003).

Table 12: Descriptive analysis of price level

	Separate t-tests on equality of mean prices		
	# of tests	# of significant tests	% significant
Planned replacement lenses			
Tests	73	43	58.9%
Observations	15,547	11,527	74.1%
Soft lenses			
Tests	44	18	40.9%
Observations	4,418	1,839	41.6%
Rigid lenses			
Tests	14	4	28.6%
Observations	1,632	411	25.2%

Notes: $H_0 : \mu_{e-ret.} = \mu_{hybr.}$ is tested against $H_a : \mu_{e-ret.} < \mu_{hybr.}$. A test's p-value must not exceed 0.05 in order to be counted as a significant test. Means are calculated across retailers and across time. Degrees of freedom are adjusted for the assumption of unequal variances between the two types of retailers.

Table 13: Descriptive Statistics

	Excl. shipping cost		Incl. shipping cost	
	Mean	Std. Dev.	Mean	Std. Dev.
ln(price per lens)	1.165	1.033	1.260	1.036
Package size	22.494	35.202	22.836	35.592
Package size^2	1,745.067	5,217.522	1,788.221	5,282.523
Extra lenses	0.005	0.144	0.005	0.146
Convenient navigation	0.141	0.741	0.159	0.720
Superior customer service	-0.059	0.475	-0.062	0.476
Return policy + lens care	0.274	0.695	0.293	0.683
Security + trustworthiness	-0.041	0.923	-0.053	0.932
New CL user service	-0.153	0.999	-0.162	1.011
Regional purchasing power	103.620	14.647	103.641	14.764
E-retailer	0.245		0.252	
Banner ad	0.180		0.185	
Sponsored link	0.133		0.137	
Google: Hit on 1^{st} page of results	0.075		0.077	
# of observations	14,646		14,251	
# of product-retailer combinations	2,365		2,306	
# of months	7		7	

Notes: The price per lens is measured in Euros. The shipping cost is calculated by adding the proportional part of the shipping cost per package to the price per lens.

Table 14: Hedonic price regressions including shipping cost

	Dependent variable: ln(price per lens)		
	Pooled OLS	Random Effects	Hausman-Taylor
Package size	-0.015***	-0.016***	-0.016***
	$(0.026*10^{-2})$	$(0.008*10^{-2})$	$(0.016*10^{-2})$
Package size$^2 * 10^{-2}$	0.006***	0.006***	0.006***
	$(1.301*10^{-4})$	$(0.430*10^{-4})$	$(0.863*10^{-4})$
Extra lenses	-0.084***	-0.096***	-0.094***
	(0.014)	(0.002)	(0.008)
Convenient navigation	-0.036***	-0.039***	-0.036***
	(0.002)	(0.001)	(0.003)
Superior customer service	-0.046***	-0.059***	-0.056***
	(0.008)	(0.009)	(0.006)
Return policy + lens care	-0.052***	-0.052***	-0.045***
	(0.006)	(0.007)	(0.006)
Security + trustworthiness	0.011***	0.002	0.007***
	(0.002)	(0.001)	(0.003)
New CL user service	-0.003	-0.007***	-0.010**
	(0.003)	(0.002)	(0.005)
Regional purchasing power$*10^{-2}$	0.046***	0.076***	0.004***
	(0.011)	(0.005)	(0.058)
E-retailer	-0.029***	-0.046***	-0.059*
	(0.005)	(0.002)	(0.031)
Banner ad	-0.068***	-0.005***	-0.005**
	(0.005)	(0.002)	(0.002)
Sponsored link	0.031***	-0.002	-0.002
	(0.006)	(0.002)	(0.002)
Google: Hit on 1^{st} page of results	0.080***	-0.003*	-0.004**
	(0.008)	(0.002)	(0.002)
Constant	1.588***	1.563***	1.202***
	(0.025)	(0.010)	(0.130)
Contact lens attributes	included	included	included
Time dummies	included	included	included
Number of observations	14,251	14,251	14,251
R^2 overall	0.959	0.959	
σ_u		0.209	0.247
σ_e		0.031	0.031

Notes: ***, **, * depicts significance at the 1%, 5% and 10% level. Standard errors in parentheses.