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PRICING IN RETAIL MARKETS WITH LOW SEARCH COSTS: EVIDENCE FROM A PRICE COMPARISON WEBSITE

Charlie Lindgren[*], Sven-Olov Daunfeldt[†] and Niklas Rudholm[‡]

Abstract: Price comparison websites, where consumers can compare prices at a search cost that is close to zero, have become increasingly common around the world. Using daily information on prices, click-throughs, and the number of retailers for a sample of consumer electronics and durable goods over a period of 62 months, we investigate the effects of the increased use of the Swedish price comparison website *PriceSpy* on prices and price dispersion. We find that increased use by consumers created potential savings of 290 million SEK in 2016, while increased use by retailers created potential savings of approximately 2.9 billion SEK. Reduced prices due to increased use of the price comparison website thus resulted in total potential consumer savings of nearly 3.2 billion SEK (289 million EUR) for the year 2016 alone. Price comparison websites thus place downward pressure on prices, thereby increasing economic efficiency. We also find that the increased use of the price comparison website by retailers resulted in increased price dispersion, while the effect of more consumers using the website was mixed.

Keywords: Consumer search, price dispersion, information, e-tailing, e-commerce.

JEL classifications: D21, D22, D83, L11, L81.

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1. INTRODUCTION

The current trend toward digitalization means that traditional retailers need to adapt to the increased use of price comparison websites, where consumers can compare prices at a search cost that is close to zero. Stigler (1961) emphasized the importance of search costs, showing that they create market power and lead to prices being set above the competitive level. The clearinghouse model by Varian (1980) showed that if retailers use intertemporal price discrimination to attract both uninformed and informed consumers, then an increase in the share of informed consumers will lead to lower prices. Price dispersion will remain in equilibrium, and it will be at its largest when the two groups, informed and uninformed consumers, are of equal size (see, e.g., Stahl, 1989). However, as also shown by Stahl (1989), in these models, entry by more retailers will increase rather than decrease price levels, and the market will reach the monopoly price if the number of retailers becomes large.

Considering this potential weakness in clearinghouse models, we instead build our study on a model developed by Frank and Salkever (1993), which predicts that reduced search costs for consumers and entry by additional retailers will both lead to lower prices. If there are two types of retailers, market leaders and followers, price dispersion is also likely to increase as the number of retailers increases, while the theoretical implications of reduced search costs on price dispersion are less clear. In addition to the theoretical advantages, this model also gives us direct guidance regarding what variables should be included in the empirical analysis.

We compare the theoretical implications of the Stahl (1989) and Frank and Salkever (1993) models to the data using information from the Swedish price comparison website *PriceSpy*. Previous empirical studies on how the increased use of price comparison websites affects prices and price dispersion are mainly based on data from the beginning of the century (e.g., Brynjolfsson and Smith, 2000; Clay et al., 2001; Brown and Goolsbee, 2002; Pan et al., 2002; Baye et al., 2004a; 2004b; Haynes and Thompson, 2008; Baye et al., 2009; Baye and Morgan, 2009; Ellison and Ellison, 2009; Tang et al., 2010; De Los Santos et al., 2012), which means that they are limited to a period when price comparison websites were still in their

infancy, with few listed retailers and considerably lower search intensity by consumers than at present. This is a drawback considering that there has been a remarkable increase in the use of price comparison websites by both consumers and retailers in recent years.

PriceSpy is the largest price comparison website in Sweden, and our dataset includes information on daily prices for products within the ten most popular consumer electronics product categories and the five most popular durable goods product categories from January 2012 to February 2017, i.e., we can follow how prices developed for a period of 62 months. We thus have access to more recent data, a longer period of analysis[1], and more products and product categories to analyze[2] than previous studies.

We find that the increased use of the price comparison website reduces prices. Specifically, an increase in click-through from the price comparison website to the retailer websites of 1000 clicks reduces average prices by 0.6 percent, resulting in potential consumer savings of 290 million SEK (26.1 million EUR) if evaluated in 2016.[3] However, the increase in the number of retailers competing on the price comparison website had an even larger negative effect on prices, with an increase of 10 retailers offering their products through the price comparison website causing a reduction in price of 1.8%. If evaluated in 2016, the increase in use of the price comparison website by retailers then created potential consumer savings of approximately 2.9 billion SEK (268 million EUR). Total potential consumer savings due to increased use of the price comparison website by both consumers and retailers

[1] Brown and Goolsbee (2002) and Jolivet and Turon (2019) have access to data for time periods equal to ours; however, of these, only Brown and Goolsbee (2002) use the full dataset in their analysis.
[2] Mizuno et al. (2010) and Mizuno and Watanabe (2013) have access to datasets including more products than we do, but they are only able to follow these products for a period of less than 2 years.
[3] We use the term potential savings since there are still retailers that do not market their products through any price comparison website and that might not have been found by the webscraping tools used by the price comparison website. Also, we cannot be certain that our sample of product categories and retailers are representative. Additionally, we use the last year under study for the evaluation of the size of the effects in the main text since this provides the most current and up-to-date measures of how increased use of price comparison websites affects prices and price dispersion. The results of instead using averages for the whole period under study in the evaluations are presented in footnotes in Sections 6 and 7.

thus amounted to nearly 3.2 billion SEK (289 million EUR) in 2016. That prices should decrease when the share of informed consumers increases is predicted by the clearinghouse models by Varian (1980) and Stahl (1989) and by the model developed by Frank and Salkever (1993). However, as shown by Stahl (1989), clearinghouse models also predict that prices will increase as more firms enter the market, while the model by Frank and Salkever (1993) predicts that increased competition will lower prices. As such, the empirical results seem to support the Frank and Salkever (1993) model over the clearinghouse models by Varian (1980) and Stahl (1989) regarding the impact of increased competition on price levels.

Considering our results from the perspective of the price stability target of the Swedish central bank, which stipulates that inflation should equal 2% per year, it is clear that the increased use of price comparison websites by consumers and retailers makes it more difficult for the central bank to reach its price stability target. Additionally, as shown by Goolsbee and Klenow (2018), online inflation is well below that found for brick-and-mortar retailers, and if the measurement methods used by central banks do not take this into account, inflation measures will be upward biased.

Turning to the impact of increases in the number of informed consumers on price dispersion, we find mixed results. They increase price dispersion for two out of ten consumer electronics product categories and one out of five durable product categories while decreasing prices for two other durable product categories. Increases in the number of retailers are, on the other hand, associated with an increase in price dispersion for all categories of products. As such, the empirical results are consistent with both types of theoretical models regarding how an increased share of informed consumers affects price dispersion. However, regarding the impact of an increased number of retailers, the empirical results are consistent with the predictions of the Frank and Salkever (1993) model if one or more firms act as Stackelberg leaders but not with the clearinghouse model by Stahl (1989), which predicts reduced price dispersion as the price moves toward the monopoly price when more retailers enter.

The remainder of the paper is structured as follows. Section 2 reviews the theoretical and empirical literature on how search costs affect prices and price dispersion, while we set up our theoretical model in Section 3. In Section 4, we present descriptive statistics on how prices and price dispersion, as well as the use of *Pricespy*, Sweden, by consumers and retailers, changed during the period under study. Our empirical specification is presented in Section 5, while the results from our estimations regarding prices and price dispersion are presented in Sections 6 and 7, respectively. Finally, we summarize and discuss our results and offer some suggestions for future research in Section 8.

2. LITERATURE REVIEW

2.1 Theoretical studies

Most of the early theoretical literature concerning how search costs affect prices and price dispersion focused on equilibrium price differences between stores (e.g., Stigler, 1961; Diamond, 1971; Salop and Stiglitz, 1977; Burdett and Judd, 1983). Salop and Stiglitz (1977), for example, set up a model where some consumers search for information about prices and buy not only for immediate consumption but also for storage and future consumption if they find sufficiently low prices. They show that some retailers will under such circumstances focus on informed consumers and sell at somewhat lower prices but compensate for these reduced prices with increases in quantities sold. Other retailers will focus on uninformed consumers and sell at higher prices for immediate consumption. In equilibrium, both types of retailers earn similar profits although charging different prices for identical products, and no one wants to change their price strategies. If the share of informed consumers increases, more retailers will focus on that group, and average prices in the market will fall.

The theoretical models most commonly used to analyze how reductions in consumer search costs affect prices and price dispersion are so-called clearinghouse models (Varian, 1980; Sobel, 1984; Stahl, 1989). Stahl (1989), for example, assumes that there are two groups of consumers, one with positive search costs and one with zero

search costs. Consumers with full information about prices always patronize the lowest price retailer, while uninformed consumers search until they find a price that is equal to or below their reservation price. The fact that there are two groups with different search costs and the use of mixed strategies by the retailers to attract both groups ensures that there will be remaining price dispersion in the market and that as the group of informed consumers increases in size, the price will move toward the competitive price. In this model, price dispersion will be greatest when the two groups are of equal size (Stahl, 1989). However, the model by Stahl (1989) also shows that entry by more retailers will increase rather than decrease price levels and that the market will reach the monopoly price when the number of retailers becomes sufficiently large.

Since the mid-1990s, there have also been attempts to theoretically model how increased online retailing affects prices and price dispersion more directly (see, e.g., Bakos, 1997; Baye and Morgan, 2001; Harrington and Leahey, 2007). Most of these studies are based on assumptions similar to those of Varian (1980) and Stahl (1989), using intertemporal price discrimination with mixed strategies to explain why prices fall as the share of informed consumers increases and why there will be remaining price dispersion in equilibrium even in markets with exceptionally low search costs such as price comparison websites.

2.2 Empirical studies

Several empirical studies have investigated how reduced search costs affect prices and price dispersion for a wide range of services and products in both online and brick-and-mortar markets. Examples can be found for insurance (Brown and Goolsbee, 2002; McDonald and Wren, 2017), pharmaceuticals (Sorensen, 2000; Granlund and Rudholm, 2011; Ohler and Smith, 2013; Shen, 2015), gasoline (Chandra and Tappata, 2011; Nishida and Remer, 2018), books and CDs (Brynjolfsson and Smith, 2000; Clay et al., 2001; Pan et al., 2002; Tang et al., 2010; De Los Santos et al., 2012; Jolivet and Turon, 2019), and groceries (Lach, 2002; Richards et al., 2016; Sherman and Weiss, 2017). However, the most common type of products under study have been consumer electronics products, including

printers, computer memories, digital cameras, etc. (Bayliss and Perloff, 2002; Pan et al., 2002; Baye et al., 2004a; 2004b; 2009; Haynes and Thompson, 2008; 2013; 2014; Baye and Morgan, 2009; Ellison and Ellison, 2009; Mizuno et al., 2010; Mizuno and Watanabe, 2013; Thompson and Haynes, 2015; Lindgren, 2020; Lindgren et al, 2020). These studies tend to find that decreased search costs reduce average prices while also reporting substantial remaining, and sometimes increasing, price dispersion.

Most studies seem to confirm that reductions in search costs due to the increased use of online markets or price comparison websites lead to lower prices. However, the reasons for the persistence of price dispersion remain a matter of debate, and several attempts have been made to explain price dispersion in online markets and on price comparison websites. One attempt takes the traditional clearinghouse model by Varian (1980) as its starting point, suggesting that for price dispersion to remain, there must be two groups of consumers, informed and uninformed, and prices must be chosen using mixed strategies, with retailers changing their prices randomly over time. Otherwise, consumers would learn which retailer had the lowest price over time, and eventually, all consumers would either patronize the low-price retailer or, alternatively, all retailers would charge the same price. In any case, there would be no price dispersion in the market. The use of mixed strategies has empirically testable implications, as there can be no grouping of firms with similar, and thus predictable, price strategies that remain over time. As such, the position of an individual retailer within a cross-sectional price distribution will change randomly over time. Thus, there will be no distinguishable patterns in a transition matrix of prices, and the probability of a specific retailer remaining in the same position in the transition matrix over time would be low.

These predictions have been tested by Bayliss and Perloff (2002) and Lindgren et al. (2020) for online markets, while Lach (2002) tests them in a store setting. Bayliss and Perloff (2002) and Lindgren (2020) report that firms do not change places in the transition matrix as often as would be expected from Varian (1980), while Lach (2002) concludes that there seems to be support for intertemporal price

discrimination taking place. It should, however, be noted that this is only the case when the analysis in Lach (2002) is done for a 6-month transition period. When using a one-month transition period, the results in Lach (2002) concur with those presented in Bayliss and Perloff (2002) and Lindgren (2020), showing that retailers remain in their original position more often than predicted by clearinghouse models. As such, the type of intertemporal price discrimination suggested by Varian (1980) does not seem to be the main cause of remaining price dispersion in the studied markets.

A more recent attempt to explain price dispersion is made in Tang et al. (2010), who base their empirical analysis on the model by Stahl (1989). The Stahl (1989) model assumes that there are two groups of consumers, informed and uninformed, and that what group a consumer belongs to is determined by the size of his or her search costs. Stahl (1989) shows that if search costs are high, no consumer bothers to search, and the equilibrium price will then be the reservation price of the consumer, while if search costs are reduced to zero, all consumers will be shoppers and buy the product from the lowest priced retailer at the marginal cost. Using a continuity argument, the Stahl (1989) model suggests that price dispersion will have an inverse U-shape, with price dispersion first increasing as the share of shoppers increases from zero and then decreasing as the share of shoppers moves toward one. Tang et al. (2010) assume that the share of shoppers can be proxied by the share of consumers using price comparison websites and set up a regression model where price dispersion is a function of the use of price comparison websites. Using books as their product category, they collect a sample consisting of all searches of book prices made on the price comparison website Dealtime.com during an 11-month period from August 25, 1999, to July 25, 2000, finding that a 1% increase in the use of price comparison websites is associated with a 1% decrease in price dispersion.

A third attempt to explain price dispersion focuses on differences between retailers in terms of services or consumer ratings (Brynjolfsson and Smith, 2000; Smith and Brynjolfsson, 2001; Pan et al., 2002; Thompson and Haynes, 2017; Lindgren, 2020). The results from these studies are mixed. Brynjolfsson and Smith (2000) and Pan et

al. (2002) find no correlation between the quality of services and prices or price dispersion, while Lindgren (2020), for the majority of the investigated products, finds no impact of consumer ratings on demand. However, Smith and Brynjolfsson (2001) and Thompson and Haynes (2017) both report some positive effects of good service and good ratings. Smith and Brynjolfsson (2001) find that well-known online bookstores with a reputation for good service can have a price premium of approximately 4%, while Thompson and Haynes (2015) report that one additional star in ratings for consumer service results in a price premium of 1% for digital cameras. As such, differences in service might be the cause of some of the remaining price differences for homogeneous products on price comparison websites, but most of the observed differences are still not accounted for.

A fourth possible explanation is related to the low cost of entry and exit into price comparison website markets. Haynes and Thompson (2013, 2014) focus on e-tailing markets in general, and price comparison websites in particular are markets with low costs of entry and exit. As such, these markets can be described as contestable markets (Baumol et al., 1982) where low-cost retailers can make quick entry at a low price and obtain a substantial market share until the established retailers react, at which point the low-cost retailer exits the market. These predictions are then tested using a sample of digital cameras sold through the price comparison website NexTag.com, and the results seem to support the predictions of the contestable market model with low-cost retailers making hit-and-run appearances in the market, causing some of the price dispersion in the NexTag.com market (Haynes and Thompson, 2014). However, using data from the Swedish *PriceSpy* market, Rudholm and Lindgren (2019) report that although there were some examples of what might be characterized as hit-and-run entries, these events were not common enough to explain most of the price dispersion on the website.

3. THEORY

In this section, we provide a theoretical framework for how increased use of price comparison websites affects prices using a model originally suggested by Frank and Salkever (1993). We choose this model over other available alternatives since it not

only makes it possible to analyze how increases in the number of informed consumers affect prices under different assumptions regarding the market but also provides direct guidance regarding what variables are important when setting up the empirical model.

In a specific product category, assume that there are $n + 1$ retailers that market at least one product each and have identical cost functions. As there are consumers on *PriceSpy* who are willing to pay a somewhat higher price when buying the product through their preferred retail outlet, we assume that consumers regard the products, including retailer services, as close rather than perfect substitutes.[4] A retailer cannot therefore obtain all customers by setting its price slightly below those of others. Consumers only differ in their preferences for the products and the information they have about prices. As we are mainly interested in the effects of how increases in the share of informed consumers affect prices, we also make the simplifying assumption that retailers take the prices of other retailers as given.[5] The demand function for product i sold through retailer r can then be written as:

$$Q_{ir} = \alpha D_{ir}^{I}(P_{ir}, P_n, n) + (1 - \alpha) D_{ir}^{UI}(P_{ir}, n)\,, \tag{1}$$

where α represents the share of informed consumers, being aware not only of the price of the product if bought through retailer r, P_{ir}, but also of the price of the other n retailers; P_n. $(1 - \alpha)$ is the share of uninformed consumers, and $\alpha D_i^I + (1 - \alpha) D_i^{UI}$ then represents the total demand for product i facing retailer r. The profit function of retailer r for selling product i can then be written as follows:

$$\pi_{ir} = P_{ir} \times [\alpha D_{ir}^{I}(P_{ir}, P_n, n) + (1 - \alpha) D_{ir}^{UI}(P_{ir}, n)]$$

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[4] Baye et al. (2009) find that only 13% of customers on the price comparison website *Kelkoo.com* were pure price shoppers when searching for personal digital assistants (PDAs). For *PriceSpy*, Lindgren (2020) reports that the share of price shoppers ranges between 4% and 12% in the seven search goods categories under study and between 9% and 33% in seven experience goods categories.

[5] This assumption only has a minor impact on the results regarding how increased consumer information affects pricing, something that is elaborated on in Granlund and Rudholm (2011). Additionally, when analyzing how increased use of price comparison websites affects price dispersion rather than prices in Section 7 below, we include a discussion of how the results might be affected if some retailers instead act as Stackelberg leaders based on results presented in Frank and Salkever (1993).

$$-C_{ir}\left(\alpha D_{ir}^{I}(P_{ir},P_n,n)+\ (1-\alpha)D_{ir}^{UI}(P_{ir},n)\right) \tag{2}$$

where $C_{ir}(Q_{ir})$ is the cost function of retailer r when selling product i. The wholesale cost of the product is assumed to be equal to zero for all retailers in the theoretical model, but in the empirical section, potential heterogeneity in this cost will be controlled for by including product-retailer-specific fixed effects in the regression model. The retailer then sets the price, P_{ir}, to maximize its profits, and this yields the following first-order condition:

$$\frac{\mathrm{d}\pi_{ir}}{\mathrm{d}P_{ir}}=\left(P_{ir}-\frac{dC_{ir}}{dQ_{ir}}\right)\times\left[\alpha\frac{\partial D_{ir}^{I}}{\partial P_{ir}}+(1-\alpha)\frac{dD_{ir}^{UI}}{dP_{ir}}\right]+\ \alpha D_{ir}^{I}(P_{ir},P_n,n)$$

$$+(1-\alpha)D_{ir}^{UI}(P_{ir},n)=0 \tag{3}$$

From this first-order condition, we know that the price of retailer r when selling product i will be a function of α, n, P_{ir}, and P_n, i.e., the share of informed consumers, the number of competing retailers, the price of retailer r, and the prices of the other retailers in the market. The impact of an increase in informed consumers is then given by:

$$\frac{\mathrm{d}P_{ir}}{\mathrm{d}\alpha}=\frac{\left\{\left(P_{ir}-\frac{\mathrm{d}C_{ir}}{dQ_{ir}}\right)\times\left[\frac{\partial D_{ir}^{I}}{\partial P_{ir}}+\frac{dD_{ir}^{UI}}{dP_{ir}}\right]+\left(D_{ir}^{I}-D_{ir}^{UI}\right)+\frac{\partial P_{ir}\partial P_n}{\partial P_n\ \partial\alpha}\right\}}{(-\delta_{ir})} \tag{4}$$

where $-\delta_{ir}$ is the second-order sufficient condition for a maximum, assumed to be negative.[6]

The markup, $(P_{ir}-\frac{dC_{ir}}{dQ_{it}})$, will be positive since some consumers do not always choose to patronize the lowest price retailers. The second term, $[\frac{\partial D_i^I}{\partial P_{ir}}+\frac{dD_i^{UI}}{dP_{ir}}]$, and therefore the first product, will be negative if informed consumers are on average more price sensitive than uninformed consumers, which seems reasonable.

[6] See Appendix B in Granlund and Rudholm (2011) for details.

The third term, $(D_{ir}^{I} - D_{ir}^{UI})$, shows how the total demand for product i sold by retailer r changes when there is an increase in informed consumers. This term will be negative if consumers using *PriceSpy* find a lower price for product i at some retailer other than r but positive if retailer r posts the lowest price. The probability of having the lowest price is not particularly high, especially on a site such as *PriceSpy*, with many retailers posting their prices, and the likely sign for this term is then also negative.

The last term in the numerator of equation 4, $\frac{\partial P_{ir}}{\partial P_n}\frac{\partial P_n}{\partial \alpha}$, measures the indirect effect of an increase in the number of informed consumers working through its effect on the prices of other retailers. The fact that some consumers have preferences for low-price retailers will lead to some retailers finding it profitable to lower their prices if there is an increase in informed consumers, and it is thus likely that this term will also have a negative impact on the price. Summing all these effects, we find that the likely effect of an increase in informed consumers is a reduction in price, and in Section 5, an empirical model based on equation (4) is established.

4. DATA AND DESCRIPTIVE STATISTICS

We investigate the effects of reduced search costs on prices and price dispersion using data from the Swedish price comparison website *PriceSpy*, which provides consumers with price and other information for a wide array of product categories. Prices are quoted from lowest to highest, granting consumers access to a price list for a given product at close to zero search cost. Consumers are also provided with information on product characteristics, shipping and payment alternatives, etc. When consumers find an offer that is to their liking, they can click on a link that will bring them directly to the retailer website where they can complete their purchase or continue browsing.

There is no fee for retailers to post prices on *PriceSpy*, but retailers can choose to pay a click-through fee. Retailers paying the click-through fee have the opportunity to present their logo in the price list, name three competitive advantages, analyze

click statistics, have access to market analysis, integrate reviews and ratings into their website, and show a symbol for being cheapest on *PriceSpy* when this occurs.

We have access to daily prices from *PriceSpy* for products within the ten most popular consumer electronics product categories and the five most popular durable consumer electronics product categories from January 2012 to February 2017 (62 months). Descriptive statistics regarding price (in SEK and measured at the retailer-product level) and price dispersion (measured at the product level as the price range between the highest and the lowest priced retailer offer for a specific product) are presented in Table 1 for consumer electronics and Table 2 for durables, both as an average over the whole period under study and by year.

The sample of consumer electronics product categories contains low-priced products such as games, mid-priced products such as cell phones and consoles, and high-priced products such as TV sets and laptops. The average price (for the period as a whole) is lowest for PC games at 270 SEK (24 EUR) and highest for laptops at 15,662 SEK (1,410 EUR), while for durables, the average prices range from 7,044 SEK (634 EUR) for washing machines to 20,178 SEK (1,816 EUR) for stoves. There are no clear patterns in price movements over time; for some products, prices trend downward, while for others, prices increase over time. The data show that this is due to how the composition of products marketed on *PriceSpy* changes over time as more retailers enter, and (in addition to the theoretical reasons) this motivates us to use retailer-product-specific fixed effects in the empirical analysis when analyzing prices.

The lowest price dispersion in SEK is found for the lowest priced product category, PC games, with an average price range of 108 SEK (10 EUR). However, since the average price for PC games is 270 SEK (24 EUR), this amounts to a price dispersion that equals 40% of the average price. For the most expensive categories, TV sets and laptops, the price dispersion is as high as 900 and 1,219 SEK (81 and 110 EUR), respectively. However, since the average prices in these categories are 14,009 and 15,662 SEK (1,261 and 1,410 EUR), the dispersion only reaches 6 and 8% of the price. Other consumer electronics products lie between these extremes, with an average price dispersion equal to 18% of the average price.

Table 1: Means and standard deviation, price and price range in SEK, consumer electronics.

	(1) Headphones	(2) Mobile Speakers	(3) Cell phones	(4) Tablets	(5) PlayStation 4	(6) PC games	(7) TV	(8) Laptops	(9) Xbox One	(10) Consoles
Price, all years.	1143.53	1989.21	4282.51	8704.03	486.48	270.46	14009.50	15662.22	485.72	3383.99
	(1707.48)	(2979.35)	(3037.96)	(7435.42)	(211.24)	(1434.40)	(31076.42)	(8962.74)	(225.85)	(1674.61)
Price, 2012	1256.18	2524.00	1398.27	8883.31	-	198.08	28093.14	7958.09	-	966.58
	(1832.19)	(3225.64)	(922.41)	(8010.87)	-	(126.27)	(13654.32)	(5806.81)	-	(523.70)
Price, 2013	1255.93	2273.43	1883.48	8719.29	639.36	191.81	21259.86	9736.08	632.08	1161.70
	(1763.81)	(3028.22)	(1824.80)	(8404.03)	(19.82)	(126.76)	(15427.81)	(5783.96)	(42.94)	(477.31)
Price, 2014	1221.86	2141.63	3038.28	6440.48	559.54	200.13	15439.15	13134.30	584.00	2498.20
	(1724.44)	(3486.10)	(2439.75)	(6125.06)	(119.80)	(135.05)	(14406.45)	(7518.04)	(185.32)	(1210.21)
Price, 2015	1180.00	2241.93	4206.40	7248.80	502.90	278.21	9274.987	17092.90	532.21	3398.64
	(1763.88)	(3553.35)	(3218.81)	(6701.07)	(182.27)	(2954.79)	(10236.82)	(8302.54)	(290.45)	(1727.56)
Price, 2016	1124.74	1952.17	4422.47	8998.39	479.71	290.32	14314.46	15704.65	471.28	3550.39
	(1702.95)	(2839.86)	(3045.01)	(7356.95)	(217.26)	(609.03)	(29974.62)	(8786.89)	(204.19)	(1795.08)
Price, 2017	1056.78	1724.19	4123.80	8844.29	465.14	274.63	13889.49	15508.16	458.26	3265.45
	(1576.93)	(2431.59)	(2966.14)	(7959.21)	(226.60)	(1918.02)	(36673.92)	(9341.82)	(225.19)	(1317.96)
Price range, all years	191.31	268.48	444.26	1243.29	119.42	108.67	900.04	1219.40	145.87	508.25
	(399.11)	(950.13)	(930.95)	(2523.43)	(151.13)	(1112.45)	(3714.54)	(1961.03)	(258.15)	(952.43)
Price range, 2012	81.54	71.13	0.00	0.00	-	8.42	0.00	0.00	-	0.00
	(238.71)	(258.43)	(0.00)	(0.00)	-	(31.84)	(0.00)	(0.00)	-	(0.00)
Price range, 2013	97.35	40.17	34.18	26.09	4.08	14.75	0.00	0.00	4.64	0.00
	(273.78)	(168.00)	(168.05)	(127.92)	(14.22)	(47.92)	(0.00)	(0.00)	(17.34)	(0.00)
Price range, 2014	116.23	109.67	117.88	363.75	33.16	21.10	3.17	16.50	44.21	48.88
	(307.31)	(600.38)	(362.29)	(1302.12)	(60.40)	(56.28)	(25.91)	(107.95)	(210.59)	(152.20)
Price range, 2015	150.02	211.09	214.51	730.71	80.25	55.69	213.24	752.84	146.10	272.68
	(325.64)	(937.99)	(579.93)	(1712.31)	(113.85)	(1139.04)	(1365.30)	(1524.13)	(404.36)	(524.87)
Price range, 2016	258.59	337.21	492.43	1486.98	141.05	162.94	912.48	1163.75	160.53	623.17
	(465.22)	(1037.07)	(953.63)	(2769.06)	(157.52)	(514.56)	(3772.10)	(1881.91)	(157.43)	(1057.38)
Price range, 2017	317.44	427.20	598.92	1811.13	197.86	211.66	1553.64	1658.81	232.85	824.03
	(516.81)	(1105.32)	(1146.49)	(2938.46)	(185.05)	(3092.47)	(4791.88)	(2265.29)	(194.26)	(1171.70)

Note: Standard deviation in parentheses.

Table 2: Means and standard deviation, price and price range in SEK, durable goods.

	(1)	(2)	(3)	(4)	(5)
	Washing machines	Stoves	Coolers/Freezers	Dishwashers	Dryers
Price, all years.	7043.94	20178.06	10618.34	7211.05	7227.78
	(4746.49)	(16914.66)	(6343.12)	(3868.15)	(3192.13)
Price, 2012	5094.26	14411.07	15981.18	6567.09	5307.37
	(461.19)	(6459.95)	(9094.06)	(3211.26)	(1034.21)
Price, 2013	6853.84	18757.34	11282.39	6487.44	5599.98
	(1753.50)	(13224.67)	(6407.53)	(2452.25)	(1231.79)
Price, 2014	6839.82	17765.39	10738.47	8315.23	6412.51
	(10889.44)	(13809.11)	(5507.57)	(10998.39)	(2914.33)
Price, 2015	7559.82	20483.55	10231.60	7513.35	7645.93
	(6482.76)	(16610.15)	(5702.14)	(3153.68)	(3651.23)
Price, 2016	7070.23	21246.23	10794.16	7112.45	7311.10
	(3913.39)	(17803.18)	(6563.68)	(2923.91)	(3155.34)
Price, 2017	6688.92	18010.76	10285.75	6949.92	7035.17
	(3486.35)	(16591.05)	(6532.29)	(2821.07)	(3001.16)
Price range, all years	421.44	629.86	809.29	548.33	467.63
	(920.22)	(1401.74)	(1559.50)	(1000.94)	(956.49)
Price range, 2012	194.04	14.15	76.97	22.22	0.00
	(506.20)	(88.85)	(504.09)	(175.23)	(0.00)
Price range, 2013	347.53	99.39	335.90	148.18	176.99
	(667.17)	(439.20)	(1160.40)	(365.50)	(408.86)
Price range, 2014	123.26	425.97	508.28	219.87	138.70
	(409.50)	(1155.98)	(1348.21)	(598.90)	(350.73)
Price range, 2015	229.42	453.81	627.88	333.86	221.65
	(539.64)	(1039.11)	(1496.98)	(727.64)	(504.58)
Price range, 2016	464.22	797.53	953.57	678.74	580.77
	(974.55)	(1603.77)	(1601.02)	(1097.66)	(1100.70)
Price range, 2017	657.94	1155.63	1212.48	849.59	768.77
	(1179.85)	(1876.09)	(1752.81)	(1237.07)	(1139.18)

Note: Standard deviation in parentheses.

For durables, the differences between categories are smaller, with average price dispersion ranging from 421 SEK (38 EUR) for washing machines to 809 SEK (73 EUR) for coolers/freezers. However, since durables are on average more expensive products than consumer electronics, the price dispersion ranges from 3% for stoves to 8% for coolers/freezers and dishwashers.

The year-by-year average price ranges presented in Table 1 reveal two interesting facts. First, for five consumer electronics product categories (cell phones, tablets, TV sets, laptops, and consoles) and one durables category (dryers), the retailer-product level price dispersion is zero during 2012, and for three of the consumer electronics categories (TV-sets, laptops, and consoles), this is also the case for 2013, despite there being a few retailers (more than one but fewer than 10; see Table 3) marketing products in these categories on *PriceSpy*. A closer inspection shows that retailers offering products in these categories during these years choose to market products with different product identification numbers, i.e., products with somewhat different product specifications, likely to avoid direct competition at the product level. Second, the average price range for all studied product categories increases over the period under study, and the size of the increases is also large. For the product categories where price dispersion was zero during 2012 and 2013, dispersion increased to between 598 SEK (54 EUR) for cell phones and 1,811 SEK (163 EUR) for tablets, while the other product categories also exhibit clear, but somewhat less sizable, increases in price dispersion.

Tables 3 and 4 present descriptive statistics on informed consumers (measured as the average daily number of clicks from *PriceSpy* to retailers' webpages) and competition (measured as the average daily number of retailers marketing a specific product on the *PriceSpy* website), both as an average over the full period under study and year-by-year.

For consumer electronics products, the average daily number of clicks over the whole period ranges from 178 for the Xbox One category to 1,017 for headphones. There is less traffic from *PriceSpy* to retailers for durables, ranging from 21 clicks for dryers to 75 for washing machines. The data also reveal clear positive trends for both

consumer electronics and durables. Note, however, that at the beginning of the period (2012 – 2014), the click-through frequency was much lower (fewer than 10 click-throughs and sometimes even less than one click-through per day) for the more expensive consumer electronics product categories tablets, TV sets, and laptops, as well as for the durables washing machines, dishwashers, and dryers. During this period, most of the traffic was instead for less expensive products such as headphones or PC games. The data thus seem to suggest a shift in consumer behavior where click-throughs for the more expensive products increase sharply at the end of the period under study, and those for TV sets and laptops reach similar levels as for the cheaper consumer electronics product categories. For durables, the development is not as strong as for consumer electronics. However, click-throughs still increase from often less than one per day on average in the beginning of the period to between 158 and 517 in 2017.

The average number of retailers marketing specific products ranges between 14 and nearly 200 for consumer electronics products during the study period, while there are much fewer retailers marketing durables (ranging between 9 and 15 retailers). Again, we observe clear trends in the data. The number of retailers ranges between 1 for consoles and 69 for headphones in 2012, increasing to 54 retailers marketing PlayStation 4 to 474 retailers marketing headphones in 2017. For durables, the number of retailers ranges from 1 for dryers to 3 for dishwashers in 2012, which increases to 35 retailers marketing dryers and 52 retailers marketing coolers/freezers in 2017. Note also that there is a sharp increase in the number of retailers marketing their products through the *PriceSpy* website during the years 2014 to 2015, where the number of retailers in many cases doubles or more during these years.

Table 3: Means and standard deviation, clicks and number of retailers, consumer electronics.

	(1) Headphones	(2) Mobile Speakers	(3) Cell phones	(4) Tablets	(5) PlayStation 4	(6) PC games	(7) TV	(8) Laptops	(9) Xbox One	(10) Consoles
Clicks, all years.	1017.19	232.06	808.54	219.92	464.26	244.27	442.84	230.44	177.76	252.83
	(178.88)	(536.70)	(1832.40)	(484.97)	(940.16)	(362.70)	(1654.11)	(683.77)	(345.66)	(933.12)
Clicks, 2012	109.18	1.40	0.37	1.28	-	74.56	0.28	0.27	-	2.50
	(57.87)	(1.49)	(0.78)	(4.42)	-	(98.93)	(0.56)	(0.55)	-	(4.88)
Clicks, 2013	161.48	11.55	9.95	0.97	6.52	61.88	0.21	0.36	1.00	10.13
	(57.72)	(18.12)	(24.70)	(2.71)	(11.11)	(46.10)	(0.51)	(0.66)	(1.53)	(14.66)
Clicks, 2014	426.73	55.21	53.47	5.17	76.24	98.29	1.62	0.66	19.61	26.68
	(225.00)	(64.20)	(36.16)	(7.40)	(93.05)	(54.26)	(2.73)	(0.95)	(28.79)	(57.24)
Clicks, 2015	1009.07	206.64	144.41	129.64	339.50	281.87	63.54	52.89	149.76	107.27
	(724.04)	(193.23)	(172.98)	(243.82)	(540.94)	(270.48)	(96.57)	(53.43)	(271.50)	(113.36)
Clicks, 2016	2762.45	750.70	2763.21	754.63	1141.64	633.63	1622.33	731.78	409.99	743.65
	(2903.78)	(950.58)	(2539.60)	(652.92)	(1445.06)	(561.61)	(3155.72)	(1041.69)	(491.80)	(1724.04)
Clicks, 2017	5023.91	1105.45	5620.27	1569.32	1888.20	703.79	3859.52	2612.79	690.84	2685.93
	(643.04)	(357.98)	(516.16)	(268.21)	(435.35)	(196.17)	(1216.23)	(251.78)	(139.23)	(1020.83)
n, all years	192.94	109.61	37.14	38.80	19.45	30.69	28.87	28.70	21.92	14.04
	(117.09)	(95.10)	(41.12)	(43.88)	(15.49)	(16.58)	(36.11)	(36.48)	(17.98)	(18.45)
n, 2012	69.13	10.96	1.66	1.25	-	11.58	2.23	2.29	-	1.26
	(8.22)	(3.02)	(0.72)	(0.52)	-	(1.50)	(0.42)	(0.46)	-	(0.44)
n, 2013	102.41	29.73	4.90	4.35	3.32	17.98	3.83	3.80	3.46	2.00
	(10.44)	(9.35)	(1.71)	(2.99)	(0.94)	(3.32)	(0.38)	(0.40)	(1.06)	(0.00)
n, 2014	154.34	79.19	13.49	19.58	7.55	26.62	8.66	6.76	7.50	4.14
	(19.36)	(17.70)	(4.00)	(6.41)	(3.40)	(1.70)	(3.27)	(1.98)	(3.06)	(1.21)
n, 2015	234.29	147.03	39.82	46.55	20.93	37.03	30.95	30.95	21.15	15.22
	(30.05)	(26.89)	(13.68)	(10.68)	(4.86)	(6.00)	(12.41)	(15.19)	(6.18)	(7.13)
n, 2016	361.37	248.90	95.06	104.60	38.05	54.95	83.75	84.47	44.36	38.30
	(43.66)	(28.86)	(19.67)	(19.41)	(5.22)	(3.28)	(18.61)	(14.44)	(5.22)	(12.18)
n, 2017	473.61	319.07	142.88	153.27	54.25	64.91	125.70	127.27	59.57	74.13
	(14.00)	(10.73)	(4.70)	(7.04)	(1.90)	(1.62)	(3.85)	(4.12)	(2.44)	(3.71)

Note: Standard deviation in parentheses.

Table 4: Means and standard deviation, clicks and number of retailers, durable goods.

	(1)	(2)	(3)	(4)	(5)
	Washing machines	Stoves	Coolers/Freezers	Dishwashers	Dryers
Clicks, all years.	74.97	38.39	49.88	58.73	21.00
	(137.07)	(52.67)	(71.56)	(96.86)	(47.65)
Clicks, 2012	0.10	1.51	0.49	1.62	0.23
	(0.35)	(1.80)	(0.87)	(2.92)	(0.60)
Clicks, 2013	0.91	5.43	3.03	3.22	0.40
	(1.33)	(4.41)	(2.88)	(2.69)	(0.76)
Clicks, 2014	6.41	17.22	17.39	9.77	3.14
	(11.19)	(10.40)	(9.96)	(12.47)	(3.67)
Clicks, 2015	53.08	44.99	53.45	60.09	14.04
	(32.28)	(26.11)	(30.12)	(45.37)	(15.70)
Clicks, 2016	246.33	99.05	143.44	169.31	66.14
	(134.34)	(52.50)	(59.11)	(88.76)	(70.35)
Clicks, 2017	516.63	192.73	255.14	381.27	157.93
	(115.41)	(54.68)	(79.19)	(93.01)	(48.48)
n, all years	11.00	14.37	15.38	13.61	9.27
	(10.33)	(13.15)	(13.90)	(11.45)	(9.77)
n, 2012	1.13	2.00	2.18	3.13	1.00
	(0.34)	(0.60)	(0.39)	(0.34)	(0.00)
n, 2013	3.26	4.72	5.17	5.53	2.70
	(0.84)	(1.56)	(1.77)	(1.14)	(1.27)
n, 2014	7.35	9.58	10.00	9.31	4.76
	(2.48)	(1.54)	(1.66)	(1.94)	(0.59)
n, 2015	13.30	16.55	18.38	15.32	9.83
	(1.67)	(3.74)	(3.82)	(2.25)	(2.89)
N,2016	25.83	33.98	35.59	30.05	24.01
	(5.69)	(6.88)	(6.82)	(7.18)	(4.91)
n, 2017	37.79	47.09	51.55	44.38	35.46
	(3.40)	(2.72)	(4.11)	(2.81)	(3.74)

Note: Standard deviation in parentheses.

5. EMPIRICAL SPECIFICATION

From equation (4), we know that an increase in the share of informed consumers, α, will have the following effect on the price of product i sold by retailer r:

$$\mathrm{d}P_{ir} = \left\{\left(P_{ir} - \frac{dC_{ir}}{dQ_{it}}\right) \times \left[\frac{\partial D_i^I}{\partial P_{ir}} + \frac{dD_i^{UI}}{dP_{ir}}\right]\right\}/(-\delta_{ir})\mathrm{d}\alpha +$$
$$\left(D_{ir}^I - D_{ir}^{UI}\right)/(-\delta_{ir})\mathrm{d}\alpha + \frac{\partial P_{ir}}{\partial P_n}\frac{\partial P_n}{\partial \alpha}/(-\delta_{ir})\mathrm{d}\alpha \quad (5)$$

The first product on the right-hand side of equation 5 includes the markup over marginal cost for product i sold by retailer r, the own price sensitivity of demand for informed and uninformed consumers, the second-order condition for profit maximization, and the change in the number of informed consumers due to increased use of the price comparison website. In accordance with Granlund and Rudholm (2011), our data only allow us to study heterogeneity in the first and fourth of these terms, i.e., the markup and the change in the share of informed consumers.

The markup is assumed to be a linear function of our proxy variable *ln markup* and can be written as follows:

$$\left(P_{ir} - \frac{dC_{ir}}{dQ_{it}}\right) = \gamma_0 + \gamma_1 \ln markup_{irt} \quad (6)$$

where $ln\ markup_{irt}$ is the logarithm of the difference between the price of product i sold by retailer r in period t and the lowest price of product i for any of the $n+1$ retailers selling that specific product, meaning that we proxy for the marginal cost by the lowest price in the market.

The change in informed consumers is given by:

$$\mathrm{d}\alpha = \gamma_3 Info_{it} \quad (7)$$

where $Info_{it}$ will be proxied by the number of click-throughs to retailers' websites. To make the size of the effect easy to interpret, we divide the number of click-throughs by 1000, as this is a good approximation of the one-year increase in clicks during the last years under study. Multiplication yields the following expression for the first product in equation 5.

$$\left(P_{ir} - \frac{dC_{ir}}{dQ_{it}}\right) \times \mathrm{d}\alpha = \gamma_0 \gamma_3 Info_{it} + \gamma_3 \gamma_1 (\ln markup_{irt} \times Info_{it}) \quad (8)$$

Turning to the second product in equation 5, it contains

$$\left(D_{ir}^{I} - D_{ir}^{UI}\right)/(-\delta_{ir})\mathrm{d}\alpha. \quad (9)$$

and the inclusion of retailer-product fixed effects, θ_{rp}, controls for time-invariant retailer-product-specific heterogeneity in the term $(D_{ir}^{I} - D_{ir}^{UI})$, and we do not model any additional heterogeneity in this term or in the second-order condition for profit maximization. What remains in equation (9) is dα, which is measured as described above.

The last product in equation 5 contains:

$$\frac{\partial P_{ir}}{\partial P_n}\frac{\partial P_n}{\partial \alpha}/(-\delta_{ir})\mathrm{d}\alpha \quad (10)$$

This product measures the indirect effect of an increase in the number of informed consumers working through its effect on the prices of other retailers. How other retailers react to price changes by one retailer will be directly affected by the number of retailers in the market, and as shown by Stiglitz (1979), the effect on prices of the number of sellers will also be affected by the share of informed consumers in the market. To capture heterogeneity in the numerator of equation (10), $\frac{\partial P_{ir}}{\partial P_n}\frac{\partial P_n}{\partial \alpha}$, we therefore include the number of retailers marketing a product in each period, both in itself, n_t, and interacted with our measure of consumer information, $n_t \times \mathrm{Info}_{it}$.

Combining the different parts, our price regression equation can be written as follows:

$$\ln Price_{irt} = \beta_1 Info_{it} + \beta_3 (\ln markup_{irt} \times Info_{it}) + \beta_5 n + \beta_6 (n \times Info_{it}) + \theta_{rp} + \varepsilon_{irt} \quad (11)$$

where $\ln Price_{irt}$ is the natural logarithm of the price posted on the price comparison website for one unit of product i sold by retailer r at time t.

Finally, as the theoretical model does not guide us regarding the impact of trends and possible nonlinear effects of the number of retailers or the share of informed consumers on price, we choose to also include quadratic terms for n_t and $Info_{it}$ as well as 62 monthly time-specific fixed effects, α_m, from January 2012 to February 2017. The empirical model that we estimate can thus be written as follows:

$$\ln Price_{irt} = \beta_1 Info_{it} + \beta_2(Info_{it} \times Info_{it}) + \beta_3(\ln markup_{irt} \times Info_{it}) + \beta_4 n + \beta_5(n \times n) + \beta_6(n \times Info_{it}) + \theta_{rp} + \alpha_m + \varepsilon_{irt} \quad (12)$$

6. EFFECTS ON PRICE LEVELS

Table 5 presents the results for the estimation of equation (12) for the ten consumer electronics categories, while Table 6 presents the results for the five categories of consumer durables. We are primarily interested in how increases in the number of informed consumers and retailers affect prices in the market for these products. Since both of these variables have been interacted with other variables, while we are interested in the effect of the variables themselves, the marginal effects of changes in these variables have been calculated and are presented at the bottom of Tables 5 and 6. To provide some indication of the economic significance of our results, we also present the change in price (in both SEK and EUR) due to an increase in informed consumers or the number of retailers marketing the product on *PriceSpy* in Tables 5 and 6.

The marginal effects show that decreasing search costs for consumers lowers average prices for all ten categories of consumer electronics. It is not surprising that increased use of a price comparison website reduces average prices, as has previously been reported by, among others, Brynjolfsson and Smith (2000), Brown and Goolsbee (2002), Haynes and Thompson (2008) and Tang et al. (2010). An increase of 1,000 daily click-throughs reduces average prices by between 0.1 and 3.5% depending on the product category, and the click-weighted average effect for all consumer electronics products equals 0.5%. An increase in click-throughs of 1,000

clicks is roughly equal to the increase during the last year under study[7], and this estimate will be used to calculate potential savings due to the increased use of price comparison websites below. Turning to consumer durables, the results show that an increase of 1,000 click-throughs reduces the price by between 1.5 and 5.8%, and all results are statistically significant at the 1% level. The average effect for consumer durables equals a reduction in price of 2.1% for an increase of 1,000 clicks.

Calculating the savings for the consumer on an individual purchase, we find that the savings are not particularly impressive, especially in the consumer electronics category where they range between 1 SEK (0.09 EUR) and 56 SEK (5 EUR). For durables, the savings are somewhat higher, ranging from 120 SEK (11 EUR) to 419 SEK (38 EUR). However, total turnover for the Swedish consumer electronics retail sector (including sales of the durables included in our study) is 48.6 billion SEK (4.4 billion EUR) according to HUI Research (2019). The average effect for both consumer electronics and durables equals a reduction in price of 0.6% for every 1,000 additional clicks, and if we assume that these price reductions are representative of the market as a whole, total potential consumer savings due to the increased use of price comparison websites by consumers during the last year under study would then equal approximately 290 million SEK (=0.006 × 48 600 000 000; 26.1 million EUR).[8]

Turning to the impact of an increase in the number of retailers, Frank and Salkever's (1993) model shows that an increase in the number of retailers will lead to a reduction in price.[9] This differs from the predictions of the Stahl (1989) model, where an increase in the number of retailers instead leads to an increase in price.

[7] An exact calculation of the increase in clicks during the last year under study gives an average increase for all product categories of 948 clicks.
[8] Making the calculation using the yearly average increase in clicks over the whole 2012-2017 period instead of the increase in clicks during the last year under study yields yearly savings equal to approximately 105 million SEK (9.5 million EUR).
[9] If one (or more) retailer acts as a Stackelberg leader, taking the impact of its price decisions on the prices of others into consideration, this can lead to a situation where an increase in the number of retailers makes a price increase the profit maximizing response for the leader (Frank and Salkever, 1993). Even if this were to occur, the size of this effect is unlikely to be of such magnitude that it would have any major impact on how increased competition affects average prices. It could, however, affect price dispersion in the market, and this will be discussed in more detail in Section 7.

The intuition behind this unexpected result is that as the number of firms increases, the probability of being the lowest priced retailer decreases at a faster rate, thus removing the incentive to cut prices in the Stahl (1989) model. We find that for all categories, regarding both consumer electronics and durables, an increase in the number of retailers reduces prices, and all marginal effects are significant at the 1% level. Increased competition on the price comparison website thus lowers prices, supporting the theoretical predictions of Frank and Salkever (1993) and empirical results previously reported by, among others, Haynes and Thompson (2008), Baye and Morgan (2009), Tang et al. (2010) and Thompson and Haynes (2015).

The results imply that having ten additional retailers offering a consumer electronics product on *PriceSpy* reduces the price by between 0.1 and 7%, with most estimates being in the lower part of the range, while the price decrease for durables ranges between 0.5 and 1%. On average, prices are reduced by 1.8% when the number of retailers is increased by ten. This can be related to the average increase in retailers on *PriceSpy* during 2016, which was 34. Total potential consumer savings due to increased competition was thus approximately 2.9 billion SEK (= 0.018 × 3.4 × 48 600 000 000; 268 million EUR) during the last year of our study.[10]

Hence, total potential consumer savings (due to both the increased number of informed consumers and the increase in the number of retailers) sums to a total of 3.2 billion SEK (284 million EUR) in 2016, while average yearly savings for the whole period under study equals approximately 2.1 billion SEK (see notes 9 and 11; 190 million EUR).

[10] When making the calculations for the average increase in the number of firms during the whole period under study, we find that the potential savings equals approximately 2.0 billion SEK (181 million EUR) per year.

Table 5: Regression results for consumer electronics categories, price.

	(1) Headphones	(2) Mobile Speakers	(3) Cell phones	(4) Tablets	(5) PlayStation 4	(6) PC games	(7) TV	(8) Laptops	(9) Xbox One	(10) Consoles
info	-0.008	-0.014	-0.002	-0.028	-0.031	-0.028	-0.012	-0.024	-0.059	-0.022
	$(3.27e^{-4})^{***}$	$(0.002)^{***}$	$(7.62e^{-4})^{**}$	$(0.003)^{***}$	$(0.002)^{***}$	$(0.005)^{***}$	$(0.001)^{***}$	$(0.002)^{***}$	$(0.007)^{***}$	$(0.004)^{***}$
info × info	$-7.70e^{-6}$	$-7.73e^{-6}$	$-2.11e^{-5}$	$1.97e^{-4}$	$2.51e^{-4}$	$3.67e^{-4}$	$5.39e^{-5}$	$9.06e^{-5}$	0.003	$6.94e^{-5}$
	$(1.13e^{-6})^{***}$	$(2.51e^{-5})$	$(6.83e^{-6})^{***}$	$(5.62e^{-5})^{***}$	$(1.49e^{-5})^{***}$	$(1.05e^{-4})^{***}$	$(3.01e^{-6})^{***}$	$(2.11e^{-5})^{***}$	$(1.82e^{-4})^{***}$	$(2.10e^{-5})^{***}$
n	$-9.99e^{-5}$	$-6.42e^{-4}$	-0.001	-0.001	-0.004	-0.002	$4.39e^{-4}$	$4.61e^{-4}$	-0.013	-0.001
	$(4.16e^{-5})^{**}$	$(1.47e^{-4})$	$(3.60e^{-4})^{***}$	$(2.18e^{-4})^{***}$	$(0.001)^{***}$	(0.001)	$(3.16e^{-4})$	$(2.42e^{-4})^{*}$	$(0.001)^{***}$	(0.001)
n × n	$3.08e^{-10}$	$4.71e^{-7}$	$3.19e^{-7}$	$1.33e^{-6}$	$-3.28e^{-6}$	$4.43e^{-5}$	$-7.35e^{-6}$	$-5.83e^{-6}$	$8.78e^{-5}$	$-1.30e^{-5}$
	$(5.20e^{-8})$	$(2.77e^{-7})^{*}$	$(1.47e^{-6})$	$(8.38e^{-7})$	$(1.10e^{-5})$	$(8.48e^{-6})^{***}$	$(1.49e^{-6})^{***}$	$(1.12e^{-6})^{***}$	$(1.18e^{-5})^{***}$	$(8.59e^{-6})$
info × n	$1.10e^{-5}$	$-4.29e^{-5}$	$-3.06e^{-5}$	$-9.63e^{-5}$	$-1.30e^{-4}$	-0.001	$5.94e^{-5}$	$7.19e^{-5}$	-0.002	$1.78e^{-4}$
	$(7.78e^{-7})^{***}$	$(9.98e^{-6})^{***}$	$(6.80e^{-6})^{***}$	$(1.92e^{-5})^{***}$	$(4.72e^{-5})^{***}$	$(8.31e^{-5})^{***}$	$(9.95e^{-6})^{***}$	$(1.36e^{-5})^{***}$	$(1.41e^{-4})^{***}$	$(4.41e^{-5})^{***}$
info × ln markup	0.003	0.007	$9.79e^{-4}$	0.007	0.008	0.034	$5.86e^{-4}$	0.003	0.031	0.002
	$(6.78e^{-5})^{***}$	$(3.26e^{-4})^{***}$	$(1.16e^{-4})^{***}$	$(4.67e^{-4})^{***}$	$(3.71e^{-4})^{***}$	$(0.001)^{***}$	$(3.85e^{-5})^{***}$	$(1.09e^{-4})^{***}$	$(0.001)^{***}$	$(4.60e^{-4})^{***}$
constant	6.483	7.004	8.157	8.691	6.210	5.628	9.201	9.459	6.796	7.927
	$(0.010)^{***}$	$(0.048)^{***}$	$(0.013)^{***}$	$(0.007)^{***}$	$(0.024)^{***}$	$(0.028)^{***}$	$(0.026)^{***}$	$(0.009)^{***}$	$(0.172)^{***}$	$(0.016)^{***}$
Marginal Effects										
∂ln price/∂info	-0.001	-0.005	$-9.07e^{-4}$	-0.004	-0.012	-0.012	-0.004	-0.002	-0.035	-0.006
	$(9.09e^{-5})^{***}$	$(6.49e^{-4})^{***}$	$(1.57e^{-4})^{***}$	$(6.11e^{-4})^{***}$	$(5.91e^{-4})^{***}$	$(0.001)^{***}$	$(2.11e^{-4})^{***}$	$(2.51e^{-4})^{***}$	$(0.002)^{***}$	$(0.001)^{***}$
∂ln price/∂n	$-1.28e^{-4}$	$-4.54e^{-4}$	-0.001	$-8.65e^{-4}$	-0.005	-0.002	$-8.47e^{-4}$	$-6.14e^{-4}$	-0.007	-0.002
	$(1.10e^{-5})^{***}$	$(3.70e^{-5})^{***}$	$(7.73e^{-5})^{**}$	$(5.69e^{-5})^{***}$	$(2.82e^{-4})^{***}$	$(2.96e^{-4})^{***}$	$(6.53e^{-5})^{***}$	$(4.39e^{-5})^{***}$	$(3.13e^{-4})^{***}$	$(3.80e^{-4})^{***}$
Average price (SEK/EUR)	1144/101	1989/176	4283/379	8704/783	486/44	270/24	14000/1260	15662/1410	486/44	3384/305
Change in price info (SEK/EUR)	1/0.09	10/1	4/0.36	35/3	6/0.54	3/0.27	56/5	31/3	17/2	21/2
Change in price n (SEK/EUR)	0/0	1/0.09	6/0.54	8/0.72	2/0.18	1/0.09	12/1	10/1	3/0.27	7/0.63
Observations	11919975	2105213	775861	896794	1066454	4379955	832265	1741850	986384	79971
Adjusted R^2	0.03	0.01	0.01	0.04	0.04	0.01	0.00	0.07	0.07	0.01

Notes: 1 SEK = 0.09 EUR, exchange rate 2020-10-09. Effects treated as zero if the marginal effect is not statistically significant at conventional levels. The regressions include product-retailer fixed effects and monthly fixed effects. Robust standard errors are reported in parentheses. ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively. The derivatives are evaluated at the mean for each variable.

Table 6: Regression results for durable goods categories, price.

	(1)	(2)	(3)	(4)	(5)
	Washing machines	Stoves	Coolers/Freezers	Dishwashers	Dryers
info	-0.053	-0.018	-0.034	-0.045	-0.063
	$(0.019)^{***}$	$(0.009)^{**}$	$(0.009)^{***}$	$(0.009)^{***}$	$(0.027)^{**}$
info × info	0.005	0.014	0.031	0.013	0.079
	$(0.002)^{***}$	$(0.006)^{**}$	$(0.004)^{***}$	$(0.003)^{***}$	$(0.011)^{***}$
n	0.002	0.001	$-2.18e^{-4}$	0.002	$-7.83e^{-4}$
	$(9.54e^{-4})^{**}$	$(2.57e^{-4})^{***}$	$(3.04e^{-4})$	$(5.54e^{-4})^{***}$	(0.001)
n × n	$-5.84e^{-5}$	$-2.03e^{-5}$	$8.99e^{-6}$	$4.65e^{-5}$	$-8.16e^{-6}$
	$(1.45e^{-5})^{***}$	$(3.59e^{-6})^{***}$	$(3.37e^{-6})^{***}$	$(7.67e^{-6})^{***}$	$(1.82e^{-5})$
info × n	$-5.21e^{-4}$	-0.002	-0.003	-0.002	-0.004
	$(5.05e^{-4})$	$(2.35e^{-4})^{***}$	$(1.91e^{-4})^{***}$	$(2.44e^{-4})^{***}$	$(8.85e^{-4})^{***}$
info × ln markup	0.017	0.026	0.033	0.024	0.027
	$(0.002)^{***}$	$(0.003)^{***}$	$(0.002)^{***}$	$(0.002)^{***}$	$(0.005)^{***}$
constant	8.965	9.661	9.287	8.918	8.909
	$(0.007)^{***}$	$(0.084)^{***}$	$(0.056)^{***}$	$(0.085)^{***}$	$(0.021)^{***}$
Marginal Effects					
∂ln price/∂info	-0.017	-0.015	-0.018	-0.019	-0.058
	$(0.005)^{***}$	$(0.003)^{***}$	$(0.003)^{***}$	$(0.003)^{***}$	$(0.010)^{***}$
∂ln price/∂n	-0.001	$-8.18e^{-4}$	-0.001	$-6.74e^{-4}$	-0.001
	$(2.88e^{-4})^{***}$	$(8.64e^{-4})$	$(1.03e^{-4})^{***}$	$(1.58e^{-4})^{***}$	$(4.56e^{-4})^{***}$
Average price (SEK/EUR)	7044/634	20178/1816	10618/956	7211/649	7228/651
Change in price info (SEK/EUR)	120/11	303/27	191/17	137/12	419/38
Change in price n (SEK/EUR)	7/0.63	0/0	11/1	5/0.45	7/0.63
Observations	425359	1165914	1228575	639997	210883
Adjusted R^2	0.01	0.01	0.01	0.01	0.00

Notes: 1 SEK = 0.09 EUR, exchange rate 2020-10-09. Effects treated as zero if the marginal effect is not statistically significant at conventional levels. The regressions include product-retailer fixed effects and monthly fixed effects. Robust standard errors are reported in parentheses. ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively. The derivatives are evaluated at the mean for each variable.

7. EFFECTS ON PRICE DISPERSION

From the previous section, we know that increased use of the price comparison website by consumers reduces average prices, a result supported by the theoretical models of both Stahl (1989) and Frank and Salkever (1993). Regarding the impact of increased use by retailers on average prices, we found that average prices fell as more retailers marketed their products on the website, a result consistent with Frank and Salkever (1993) but at odds with the predictions of Stahl (1989).

Next, we investigate how increased use of the price comparison website by consumers and retailers affects price dispersion. Clearinghouse models predict that there will be remaining price dispersion in the market and that price dispersion will be largest when the two groups of consumers, informed and uninformed, are of equal size (Stahl, 1989). As the number of informed consumers increases, price dispersion is thus likely to first increase, reach a maximum when the groups are approximately of equal size, and then decrease as the number of informed consumers continues to rise. As such, the sign of how increased use of the price comparison website by consumers affects price dispersion will depend on the size of the groups, and for low levels of informed consumers, the clearinghouse model of Stahl (1989) predicts that increases in the share of informed consumers will lead to increased price dispersion. However, the Stahl (1989) model also predicts that as the number of retailers increases, prices will move toward the monopoly price, thus reducing price dispersion in the market.

Turning to the predictions of the Frank and Salkever (1993) model, we focus on what happens if one retailer acts as a Stackelberg market leader and incorporates the pricing responses of its competitors into its own pricing decisions. Under these circumstances, Frank and Salkever (1993) show that if entry makes the residual demand curve for the market leader steeper (i.e., its demand becomes less price sensitive), market leaders can have an incentive to increase prices in response to entry, which will then lead to higher price dispersion in the market for a given minimum price. In our setting, one can imagine that some retailers actively focus on the less price-sensitive part of the market as competition increases, and if these firms

also take the pricing behavior of their competitors into account when setting their prices, we should observe that price dispersion increases when more retailers compete on the website, contrary to the prediction of clearinghouse models.

Turning to how increases in the share of informed consumers affect pricing when one retailer acts as a Stackelberg leader, Granlund and Rudholm (2011) show that an increase in the share of informed consumers is likely to lower the price of the Stackelberg leader retailer, while their results regarding the impact on other retailers are unclear. However, increases in the share of informed consumers could also cause reductions in price for other retailers, making the overall effect on price dispersion difficult to predict because it will depend on which part of the market (Stackelberg leader or other retailers) is more strongly affected by an increase in the share of informed consumers. Note, however, that if the market leader retailer sets the highest price, theory predicts that we should observe a negative correlation between the share of informed consumers and the highest price in the market.

The results when estimating equation (11), using the range between the highest- and lowest-priced retail offers for a specific product as the dependent variable, are presented in Tables 7 and 8. Following Brynjolfsson and Smith (2000), we measure price dispersion as the price range because it facilitates the interpretation of the economic impact of the increased use of *PriceSpy*. Marginal effects of changes in both the number of informed consumers and the number of retailers are presented, and to make it possible to assess the economic significance of our results, we also present the average price of the products, the average price range, and the estimated change in price range at the bottom of the tables.

The marginal effects show that more informed consumers increase price dispersion for 2 out of 10 consumer electronics product categories and for one additional durable product category. In the latter case, we also find 2 products for which decreases in price dispersion are observed. As such, the results are mixed regarding how the increased use of the price comparison website by consumers affects price dispersion, which is in line with the predictions of both clearinghouse models and the Frank and Salkever (1993) model, as well as with empirical results from previous

studies. On the one hand, McDonald and Wren (2017), for example, report that car insurance price dispersion is lower for consumer groups that use the internet to search for prices. On the other hand, Haynes and Thompson (2008) and Tang et al. (2010) report that increased use of price comparison websites by consumers increases price dispersion for digital cameras and books, respectively.

An increase of 1,000 clicks increases price dispersion for headphones by 0.4% and for consoles by 3.4%. However, the initial price ranges are quite small, implying that having 1,000 more clicks only increases the price range between 1 and 17 SEK (0.09 and 2 EUR) for the two statistically significant consumer electronics categories. For durables, the initial price dispersion is larger, with an average price range of between 421 and 802 SEK (38 and 72 EUR), and since the estimated impacts are also larger, with both positive and negative effects, an increase of 1,000 clicks results in a changed price range of between -244 and +522 SEK (-22 to +47 EUR).[11]

Turning to how price dispersion is affected by the number of retailers, the marginal effects show that an increase in the number of retailers is associated with an increase in price dispersion for all categories of products, both consumer electronics and durables, consistent with the Frank and Salkever (1993) model if one or more retailers acts as a Stackelberg leader but contrary to the predictions of the Stahl (1989) model. For consumer electronics, one additional retailer marketing a specific consumer electronics product on *PriceSpy* increases price dispersion by between 2.9% and 25%, while the increase is between 7.4% and 22% for durables. The number of retailers offering products on the price comparison website is thus positively correlated with price dispersion, as suggested by the theoretical model of Frank and Salkever (1993), and supports the empirical results presented by Baye and Morgan (2009), Haynes and Thompson (2008) and Tang et al. (2010).

[11] When using the average yearly increase in clicks during the whole period, the result is between –88 and +188 SEK (– 8 and +17 EUR).

Table 7: Regression results for consumer electronics categories, range.

	(1) Headphones	(2) Mobile Speakers	(3) Cell phones	(4) Tablets	(5) PlayStation 4	(6) PC games	(7) TV	(8) Laptops	(9) Xbox One	(10) Consoles
info	-0.132	-0.372	-0.165	-0.511	-0.283	-0.806	-0.095	-0.345	-0.807	0.073
	(0.006)***	(0.040)***	(0.017)***	(0.056)***	(0.026)***	(0.039)***	(0.012)***	(0.035)***	(0.082)***	(0.099)
info × info	-2.24e^{-4}	-0.003	-1.65e^{-4}	-0.003	-0.002	-0.005	-1.34e^{-4}	-0.001	-0.011	-9.71e^{-4}
	(2.63e^{-5})***	(5.96e^{-4})***	(2.26e^{-4})	(0.001)***	(2.17e^{-4})***	(8.95e^{-4})	(1.01e^{-4})	(5.80e^{-4})*	(0.002)***	(5.61e^{-4})*
n	0.087	0.141	0.061	0.086	0.180	0.387	0.165	0.128	0.175	0-276
	(0.014)***	(0.019)***	(0.013)***	(0.014)***	(0.026)***	(0.026)***	(0.021)***	(0.011)***	(0.027)***	(0.075)***
n × n	-0.001	-0.002	-3.97e^{-4}	-9.43e^{-4}	-0.003	-0.013	-0.003	-0.002	-0.003	-0.005
	(4.21e^{-4})***	(4.95e^{-4})***	(1.59e^{-4})***	(2.76e^{-4})***	(0.001)***	(0.001)***	(5.30e^{-4})***	(4.24e^{-4})***	(8.86e^{-4})***	(0.002)***
info × n	-0.005	-0.013	-0.007	-0.020	-0.019	-0.082	-0.003	-0.022	-0.059	0.001
	(4.00e^{-4})***	(0.002)***	(8.30e^{-4})***	(0.003)***	(0.002)***	(0.006)***	(6.83e^{-4})***	(0.002)***	(0.007)***	(0.006)
info × ln markup	0.056	0.146	0.056	0.147	0.137	0.412	0.027	0.103	0.392	-0.011
	(0.002)***	(0.015)***	(0.005)***	(0.013)***	(0.011)***	(0.019)***	(0.003)***	(0.008)***	(0.032)***	(0.031)
constant	3.921	4.728	6.028	6.581	4.084	3.299	6.246	6.475	4.154	5.358
	(0.099)***	(0.111)***	(0.123)***	(0.131)***	(0.169)***	(0.165)***	(0.144)***	(0.077)***	(0.197)***	(0.411)***
Marginal Effects										
∂ln price/∂info	0.004	0.001	0.003	0.010	-0.003	0.002	-0.005	0.001	0.013	0.034
	(0.001)***	(0.009)	(0.005)	(0.012)	(0.006)	(0.007)	(0.004)	(0.006)	(0.019)	(0.014)**
∂ln price/∂n	0.062	0.107	0.029	0.055	0.127	0.250	0.122	0.067	0.120	0.223
	(0.009)***	(0.014)***	(0.010)***	(0.011)***	(0.018)***	(0.016)***	(0.016)***	(0.006)***	(0.019)***	(0.061)***
Average price (SEK/EUR)	1144/101	1989/176	4283/379	8704/783	486/44	270/24	14000/1260	15662/1410	486/44	3384/305
Average price range (SEK/EUR)	191/17	268/24	444/40	1243/112	119/11	109/10	900/81	1219/110	146/13	508/46
Change in price range info (SEK/EUR)	1/0.09	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0	17/2
Change in price range n (SEK/EUR)	12/1	29/3	13/1	68/6	15/1	27/2	110/10	82/7	18/2	113/10
Observations	1632204	281621	84675	105694	176171	803829	95014	199835	155591	12672
Adjusted R^2	0.24	0.17	0.43	0.28	0.24	0.41	0.17	0.34	0.25	0.09

Notes: 1 SEK = 0.09 EUR, exchange rate 2020-10-09. Effects treated ad zero if the marginal effect is not statistically significant at conventional levels. The regressions include product fixed effects and monthly fixed effects. Robust standard errors are reported in parentheses. ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively. The derivatives are evaluated at the mean for each variable.

Table 8: Regression results for durable goods categories, range

	(1)	(2)	(3)	(4)	(5)
	Washing machines	Stoves	Coolers/Freezers	Dishwashers	Dryers
info	-3.508	-6.964	-8.092	-4.550	-8.639
	(0.328)***	(0.520)***	(0.428)***	(0.356)***	(1.138)***
info × info	-0.004	-2.532	1.973	-0.126	0.304
	(0.070)	(0.513)***	(0.302)***	(0.126)	(0.531)
n	0.200	0.212	0.238	0.271	0.361
	(0.047)***	(0.045)***	(0.041)***	(0.042)***	(0.063)***
n × n	$-3.25e^{-4}$	0.002	-0.002	-0.001	-0.008
	(0.002)	(0.002)	(0.002)	(0.002)	(0.003)***
info × n	-0.452	-1.598	-1.040	-0.778	-1.103
	(0.055)***	(0.135)***	(0.074)***	(0.075)***	(0.162)***
info × ln markup	1.313	3.615	2.734	1.889	3.277
	(0.110)***	(0.199)***	(0.135)***	(0.115)***	(0.380)***
constant	5.759	5.846	6.086	5.475	4.816
	(0.239)***	(0.203)***	(0.199)***	(0.190)***	(0.354)***
Marginal Effects					
∂ln price/∂info	-0.177	0.828	-0.302	-0.029	-0.424
	(0.080)**	(0.195)***	(0.110)***	(0.102)	(0.365)
∂ln price/∂n	0.074	0.087	0.088	0.121	0.220
	(0.034)**	(0.031)***	(0.029)***	(0.029)***	(0.045)***
Average price (SEK/EUR)	7044/634	20178/1816	10618/956	7211/649	7228/651
Average price range (SEK/EUR)	421/38	630/57	809/73	548/49	468/42
Change in price range info (SEK/EUR)	-75/-7	522/47	-244/-22	0/0	0/0
Change in price range n (SEK/EUR)	31/3	55/5	71/6	66/6	103/9
Observations	76342	213775	250964	129921	39384
Adjusted R^2	0.43	0.37	0.45	0.38	0.37

Notes: 1 SEK = 0.09 EUR, exchange rate 2020-10-09. Effects treated as zero if the marginal effect is not statistically significant at conventional levels and with monthly fixed effects. The regressions include product fixed effects. Robust standard errors are reported in parentheses. ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively. The derivatives are evaluated at the mean for each variable.

When calculating the size of the effects in SEK, the results imply that one additional retailer marketing its product on *PriceSpy* increases price dispersion by, on average, between 12 and 113 SEK (1 and 10 EUR) for consumer electronics products. Hence, the average increase in the number of retailers between 2016 and 2017 of 34 will result in an increase in price dispersion of between 408 and 3,842 SEK (37 and 346 EUR). For durables, having an additional retailer increases price dispersion by between 31 and 103 SEK (3 and 9 EUR), and an increase of 34 retailers will thus increase the price range with between 1,054 and 3,502 SEK (95 and 315 EUR).[12]

To learn more about what is driving our results, we performed several additional estimations. First, using the range between the lowest and highest price as our measure of price dispersion implies that our results could be due to a few extreme values for the minimum and maximum prices, and there is thus a need to investigate whether this is the case. As such, we re-estimated the model using two trimmed range measures (Brynjolfsson and Smith, 2000) as the dependent variable. The first of these excludes observations that are outside the 5th to 95th percentiles of the original price range variable, while the second excludes observations outside the 10th to 90th percentiles.[13]

The results of these estimations (Tables 9 and 10; original estimations of range and price included in the tables in bold for comparison) show that excluding the most extreme prices does not in any major way change how the observed price range is affected by increases in the number of informed consumers or the number of retailers competing on *PriceSpy*.

[12] When instead using the average yearly increase in the number of retailers during the full period under study, we find an average yearly increase in price dispersion for consumer electronics of between 276 and 2,599 SEK (25 and 234 EUR) and for durables of between 713 and 2,369 SEK (64 and 213 EUR).
[13] The original trimmed range measure of Brynjolfsson and Smith (2000) only excluded the highest and the lowest price. In our case, such estimations give the same results as presented in Tables 7 and 8, and we thus opt for somewhat more strict trimming of the price range variable using the percentiles mentioned above.

Table 9: Regression results for consumer electronics categories, additional outcome measures for price dispersion.

Outcome variable	*Marginal Effects*	(1) Headphones	(2) Mobile Speakers	(3) Cell phones	(4) Tablets	(5) PlayStation 4	(6) PC games	(7) TV	(8) Laptops	(9) Xbox One	(10) Consoles
Range	**∂ln Range/∂info**	**0.004**	**0.001**	**0.003**	**0.010**	**-0.003**	**0.002**	**-0.005**	**0.001**	**0.013**	**0.034**
		(0.001)* **	**(0.009)**	**(0.005)**	**(0.012)**	**(0.006)**	**(0.007)**	**(0.004)**	**(0.006)**	**(0.019)**	**(0.014)** **
	∂ln Range/∂n	**0.062**	**0.107**	**0.029**	**0.055**	**0.127**	**0.250**	**0.122**	**0.067**	**0.120**	**0.223**
		(0.009)* **	**(0.014)*** **	**(0.010)*** **	**(0.011)*** **	**(0.018)*** **	**(0.016)*** **	**(0.016)*** **	**(0.006)*** **	**(0.019)*** **	**(0.061)*** **
Range5-95	∂ln Range5-95/∂info	0.005	0.003	0.003	0.013	-0.003	0.002	-0.006	0.001	0.012	0.033
		(0.002)***	(0.009)	(0.005)	(0.013)	(0.006)	(0.008)	(0.004)	(0.006)	(0.019)	(0.014)**
	∂ln Range5-95/∂n	0.044	0.101	0.020	0.048	0.131	0.253	0.122	0.068	0.125	0.223
		(0.012)***	(0.016)***	(0.010)**	(0.011)***	(0.019)***	(0.016)***	(0.016)***	(0.006)***	(0.019)***	(0.061)***
Range10-90	∂ln Range10-90/∂info	0.005	0.005	0.002	0.014	-5.09e^{-4}	0.003	-0.004	0.002	0.017	0.035
		(0.001)***	(0.010)	(0.005)	(0.012)	(0.006)	(0.008)	(0.004)	(0.006)	(0.020)	(0.015)**
	∂ln Range10-90/∂n	0.068	0.040	-2.38e^{-4}	0.020	0.066	0.241	0.099	0.022	0.067	0.182
		(0.082)	(0.016)**	(0.010)	(0.011)**	(0.019)***	(0.017)***	(0.018)***	(0.007)***	(0.020)***	(0.058)***
Std. dev.	∂ln Std. dev./∂info	0.672	-0.126	-2.106	14.003	-0.022	1.636	2.913	5.205	0.316	6.932
		(0.187)***	(2.051)	(1.656)	(11.275)	(0.370)	(6.246)	(6.845)	(4.618)	(1.219)	(3.238)**
	∂ln Std. dev./∂n	1.119	0.418	-5.261	-27.313	1.123	2.317	21.455	-6.120	0.390	11.833
		(0.680)*	(3.250)	(2.805)**	(20.590)	(0.910)	(8.868)	(26.158)	(5.428)	(1.860)	(7.382)
Price	**∂ln price/∂info**	**-0.001**	**-0.005**	**-9.07e^{-4}**	**-0.004**	**-0.012**	**-0.012**	**-0.004**	**-0.002**	**-0.035**	**-0.006**
		(9.09e^{-5})* **	**(6.49e^{-4})*** **	**(1.57e^{-4})*** **	**(6.11e^{-4})*** **	**(5.91e^{-4})*** **	**(0.001)*** **	**(2.11e^{-4})*** **	**(2.51e^{-4})*** **	**(0.002)*** **	**(0.001)*** **
	∂ln price/∂n	**-1.28e^{-4}**	**-4.54e^{-4}**	**-0.001**	**-8.65e^{-4}**	**-0.005**	**-0.002**	**-8.47e^{-4}**	**-6.14e^{-4}**	**-0.007**	**-0.002**
		(1.10e^{-5})* **	**(3.70e^{-5})*** **	**(7.73e^{-5})** **	**(5.69e^{-5})*** **	**(2.82e^{-4})*** **	**(2.96e^{-4})*** **	**(6.53e^{-5})*** **	**(4.39e^{-5})*** **	**(3.13e^{-4})*** **	**(3.80e^{-4})*** **
Min price	∂ln Min price/∂info	-0.002	-0.004	-0.002	-0.007	-0.010	-0.004	-0.002	-0.004	-0.028	-0.004
		(2.63e^{-4})***	(0.001)***	(6.02e^{-4})***	(0.002)***	(0.002)***	(0.002)**	(3.27e^{-4})***	(5.32e^{-4})***	(0.006)***	(0.002)*
	∂ln Min price/∂n	-0.012	-0.008	-0.005	-0.006	-0.001	-0.116	-0.013	-0.002	9.20e^{-4}	-0.032
		(0.002)***	(0.003)***	(0.002)**	(0.001)***	(0.006)	(0.008)***	(0.002)***	(9.61e^{-4})**	(0.007)	(0.010)***
Max price	∂ln Max price/∂info	-0.002	-0.005	-0.002	-0.008	-0.005	-0.016	-0.002	-0.002	-0.012	0.002
		(2.22e^{-4})***	(0.001)***	(4.49e^{-4})***	(0.002)***	(8.60e^{-4})***	(0.002)***	(2.75e^{-4})***	(4.81e^{-4})***	(0.003)***	(0.002)
	∂ln price/∂n	0.028	0.042	0.006	0.010	0.032	0.155	0.011	0.007	0.036	-0.005
		(0.002)***	(0.004)***	(0.002)***	(0.002)***	(0.004)***	(0.011)***	(0.002)***	(0.001)***	(0.006)***	(0.011)

Notes: Range (in **bold**) is the maximum price (Max price) minus the minimum price (Min price) for product *i* on day *t* and is the same as in Table 8 and reported in this table for comparison. Range 5-95 represents data where observations outside the 5-95th percentiles of the original dataset have been excluded from the regressions, and Range 10-90 represents data where observations outside the 10-90th percentiles have been excluded. Std. dev. is the standard deviation of the price. Price (in **bold**) is the price of the product and is the same as reported in Table 6. The derivatives are evaluated at the mean for each variable.

Table 10: Regression results for durable goods categories, additional outcome measures for price dispersion.

Outcome variable	*Marginal Effects*	(1) Washing machines	(2) Stoves	(3) Coolers /Freezers	(4) Dishwashers	(5) Dryers
Range	**∂ln Range/∂info**	**-0.177**	**0.828**	**-0.302**	**-0.029**	**-0.424**
		(0.080)**	**(0.195)*****	**(0.110)*****	**(0.102)**	**(0.365)**
	∂ln Range/∂n	**0.074**	**0.087**	**0.088**	**0.121**	**0.220**
		(0.034)**	**(0.031)*****	**(0.029)*****	**(0.029)*****	**(0.045)*****
Range5-95	∂ln Range5-95/∂info	-0.176	0.828	-0.303	-0.030	-0.425
		(0.080)**	(0.195)***	(0.110)***	(0.102)	(0.364)
	∂ln Range5-95/∂n	0.075	0.088	0.089	0.122	0.221
		(0.034)**	(0.031)***	(0.030)***	(0.029)***	(0.045)***
Range10-90	∂ln Range10-90/∂info	-0.170	0.843	-0.295	-0.027	-0.414
		(0.079)**	(0.200)***	(0.109)***	(0.102)	(0.363)
	∂ln Range10-90/∂n	0.070	0.082	0.084	0.116	0.214
		(0.034)**	(0.031)***	(0.029)***	(0.030)***	(0.046)***
Std. dev.	∂ln Std. dev./∂info	39.944	525.987	-10.784	80.819	163.949
		(31.102)	(93.327)	(46.035)	(34.888)**	(106.124)
	∂ln Std. dev./∂n	-19.850	31.782	20.964	-20.656	53.721
		(21.220)	(22.503)	(14.837)	(13.888)	(22.891)**
Price	**∂ln price/∂info**	**-0.017**	**-0.015**	**-0.018**	**-0.019**	**-0.058**
		(0.005)***	**(0.003)*****	**(0.003)*****	**(0.003)*****	**(0.010)*****
	∂ln price/∂n	**-0.001**	**-8.18e^{-4}**	**-0.001**	**-6.74e^{-4}**	**-0.001**
		(2.88e^{-4})***	**(8.64e^{-4})**	**(1.03e^{-4})*****	**(1.58e^{-4})*****	**(4.56e^{-4})*****
Min price	∂ln Min price/∂info	-0.025	-0.032	-0.008	-0.036	-0.098
		(0.007)***	(0.004)	(0.006)	(0.007)***	(0.019)***
	∂ln Min price/∂n	-0.021	-0.003	-0.018	-0.018	-0.031
		(0.004)***	(0.003)	(0.002)***	(0.004)***	(0.006)***
Max price	∂ln Max price/∂info	-0.019	0.002	-0.029	-0.027	-0.068
		(0.006)***	(0.007)***	(0.005)***	(0.006)***	(0.014)***
	∂ln Max price/∂n	0.006	-0.021	0.009	0.016	0.021
		(0.004)	(0.004)***	(0.002)***	(0.003)***	(0.006)***

Notes: Range (in **bold**) is the maximum price (Max price) minus the minimum price (Min price) for product *i* on day *t* and is the same as in Table 8 and reported in this table for comparison. Range 5-95 represents data where observations outside the 5-95th percentiles of the original dataset have been excluded from the regressions, and Range 10-90 represents data where observations outside the 10-90th percentiles have been excluded. Std. dev. is the standard deviation of the price. Price (in **bold**) is the price of the product and is the same as that reported in Table 7. The derivatives are evaluated at the mean for each variable.

Regarding the estimations of how the lowest and highest prices in the market are affected by changes in the number of informed consumers or the number of retailers, we find that there is a negative impact of both of these variables on the lowest price in the market. However, for the highest price, we find that increasing the number of informed consumers reduces the maximum price, in line with the theoretical predictions from Granlund and Rudholm (2011). They use a variant of the Frank and Salkever (1993) model to show that an increase in the share of informed consumers is likely to lower the price of the Stackelberg leader. Thus, if the market leader retailer sets the highest price, our empirical findings again support the Frank and Salkever (1993) model, as we observe a negative correlation between the share of informed consumers and the highest price in the market.

Finally, and again following Brynjolfsson and Smith (2000), we also use the standard deviation of the price as the dependent variable. For increases in the number of informed consumers, the results are similar to those found for the three price range measures, with the same sign and significance level for the different product categories. However, for increases in the number of retailers, the results differ, as most estimates become insignificant. This is likely because an increase in the number of retailers also increases the number of observations, and since an increase in observations will lower the standard deviation (all else being equal), this counteracts the direct impact of the increase in the number of retailers on price dispersion.

8. DISCUSSION

The purpose of this paper has been to study how increased use of price comparison websites affects price levels and price dispersion. Based on a theoretical model by Frank and Salkever (1993), we expect that increases in the number of informed consumers will, on average, reduce price levels, while the impact on price dispersion is less clear. When more retailers are competing, the Frank and Salkever (1993) model suggests that increased competition will reduce average prices, but it should also increase price dispersion.

Our results confirm the theoretical predictions above, showing that if click-through from the price comparison website to the retailer webpages increase by 1000 clicks, this lowers prices by, on average, 0.6 percent for the product categories under study. The savings are not particularly impressive for a consumer buying a single product, ranging from 1 SEK (0.09 EUR) to 56 SEK (5 EUR) for consumer electronics and from 120 SEK (11 EUR) to 419 SEK (38 EUR) for durables. However, aggregating savings for the market as a whole results in potential consumer savings of approximately 290 million SEK (26.1 million EUR) in 2016 alone.

The reduction in prices due to the increased competition on the price comparison website is even larger. On average, 10 additional retailers marketing their products through the price comparison website will lower prices by 1.8 percent. When aggregating potential consumer savings for the market as a whole, increased competition due to retailer entry into *PriceSpy* during 2016 indicates potential savings of 2.9 billion SEK (268 million EUR). Total potential consumer savings thus sum to approximately 3.2 billion SEK (284 million EUR).

One can also consider our results from the perspective of the price stability target of the Swedish central bank, which stipulates that inflation should equal 2% per year. Online marketplaces that deliver yearly price reductions in the ranges found in this paper means that there is an underlying downward pressure on inflation, which makes it more difficult for central banks to reach their price stability targets. In fact, according to Statistics Sweden, inflation measured as the change in consumer prices was below the price stability target of the Swedish central bank for every month (62 months) during our study period. The increased use of price comparison websites is likely not the sole, or even main, explanation for the problems in reaching the target, but it may have played a contributing role, something that has also been acknowledged by the Swedish Riksbank (2015). In addition, recent research by Goolsbee and Klenow (2018) reports that online inflation rates are 1.3 percentage points lower for the same product categories than those calculated using traditional data collection methods, indicating that if the measurement methods used by central banks do not take increased use of online retailing and price comparison websites

into account, their inflation measures will be upward biased. This is also recognized by Statistics Sweden (2020), which found that changes in consumer behavior due to ongoing digitalization that are not accounted for by traditional measurement methods might bias the measurement of the consumer price index, the perhaps most widely used measure of inflation.

Turning to how the increased use of the price comparison website by consumers affected price dispersion, our results are mixed. For consumer electronics, we found an increase in price dispersion in 2 out of 10 categories when more consumers used *PriceSpy*, while we found a decrease in price dispersion for one category and increases for two others for durables. We also found, in accordance with the Frank and Salkever (1993) theoretical model and the empirical studies by Baye and Morgan (2009), Haynes and Thompson (2008) and Tang et al. (2010), that price dispersion increased for all 15 product categories when more retailers became listed on the price comparison website.

The main reason for the remaining price dispersion on the price comparison website is likely that there are different types of retailers listed on such websites. Market leaders that focus on consumers who are less price minded and take the pricing of their rivals into account when setting their own prices, and followers that do not focus on any special consumer segment or take the pricing behavior of their competitors into account when setting their prices.

There are of course other possible explanations why price dispersion increases when more retailers are listed on a price comparison website. However, we find that these other possible explanations are unlikely to have had any major impact in the *PriceSpy* setting. Lindgren et al. (2020), Lindgren (2020), and the results presented above all showed that the predictions from clearinghouse models (Varian, 1980; Stahl, 1989), which are the most commonly used models to explain remaining price dispersion in markets with low search costs, do not hold in the *PriceSpy* setting.

Another attempt at explaining remaining price dispersion focuses on differences between retailers in terms of services or consumer ratings for retailers or products

(Brynjolfsson and Smith, 2000; Smith and Brynjolfsson, 2001; Pan et al., 2002; Thompson and Haynes, 2017; Lindgren, 2020). However, the results from Lindgren (2020) show little or no advantage in terms of increased demand for products having high consumer ratings in the Swedish setting, and even if some studies show statistically significant effects on demand due to good service or high consumer ratings (Smith and Brynjolfsson, 2001; Thompson and Haynes, 2017), these effects are too small to explain most of the remaining price dispersion.

Haynes and Thompson (2013, 2014) instead explain the remaining price dispersion by noting that price comparison websites are markets with exceptionally low entry and exit costs, resembling what Baumol et al. (1982) defined as contestable markets. In such markets, low-cost retailers can make quick entry at a low price and obtain substantial market share until established retailers react, at which point the low-cost retailer exits the market. Haynes and Thompson (2013, 2014) find some evidence for such behavior on price comparison websites, but again, the effects are not large enough to explain the level of price dispersion observed in most markets. Additionally, Rudholm and Lindgren (2019) find that while there are some examples on *PriceSpy* that might be characterized as hit-and-run entries, these events are too few to explain most of the price dispersion on the website.

One of our main results is that the increased use of price comparison websites lowers prices, implying that these websites increase economic efficiency because retailers' prices are closer to marginal costs. This is obviously good for consumers but also raises the question of why retailers then seem content and, on some occasions, even eager to participate in such markets. Answering this question would require access to data regarding how entry into price comparison websites affects the profits of the firms that enter. This is clearly beyond of the scope of the present paper but would be an interesting avenue for future research.

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