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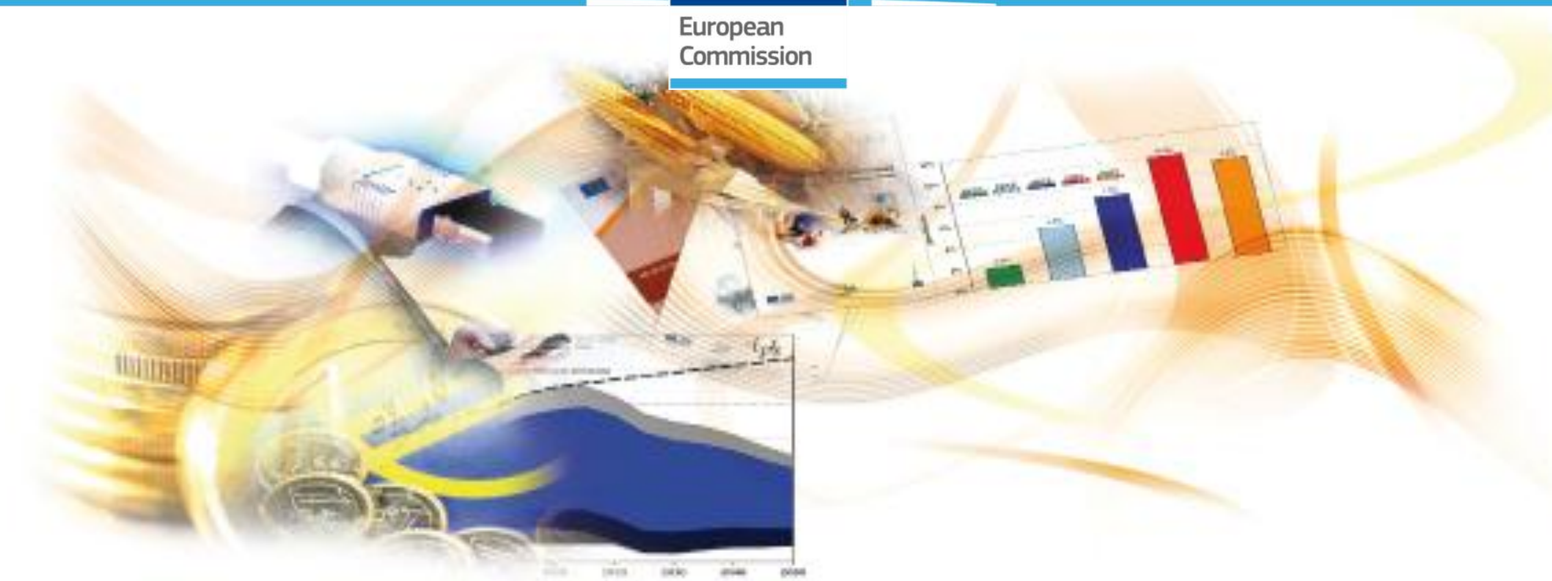

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Consumer Benefits from the EU Digital Single Market: Evidence from Household Appliances Markets

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Abstract:

This paper investigates price differences between online and offline retail channels in the EU Digital Single Market. Using price and sales data for ten household appliances product categories sold both offline and online in 21 EU countries in 2009, and correcting for product characteristics, we find evidence that online prices and price dispersion are lower than offline. Online demand is more price-elastic. We compute consumers' welfare effects for different scenarios. E-commerce increases consumer surplus by €34 billion or 0.3% of EU-27 GDP. Full online price convergence across the EU towards the lowest observed average price would further increase welfare by 0.02% of GDP.

Keywords: price dispersion; e-commerce; consumer welfare

JEL-codes: L11; L15; L68

1. Introduction[1]

Consumers are expected to benefit from online shopping on the internet in several ways. First, the internet can reduce search costs and bring much more information to the consumer at a lower cost. Search costs are an important part of a consumer's time and money budget. Second, the consumer may become better informed about available prices and product varieties in a larger geographical catchment area with a larger number of suppliers from which he can order products. This increases the probability that she finds a product that exactly meets his preferred characteristics. Third, a larger geographical catchment area for consumers enhances competition in the market as the number of suppliers bidding for a consumer's expenditure increases. At the same time, suppliers who successfully exploit this larger market can benefit from economies of scale to reduce production costs. Overall, this should reduce market prices and increase welfare, both for consumers and producers. In practice, many sources of market segmentation can still stand in the way of the realisation of these potential benefits from online shopping. Transport costs for the physical delivery of goods, regulatory barriers to cross-border trade, language barriers to cross-border online shopping, -among others- may still hamper full geographical integration of online markets.

The EU has a long-standing policy to integrate its national markets into a Single Market where goods, services, capital and labour can freely move around, in order to generate economies of scale, innovation, growth and jobs. The Digital Agenda for Europe (2010) policy packages seeks to extend the achievement of the Single Market to the domain of digital transactions, including online services such as e-commerce. Although this channel currently represents only around 5% of total commerce within the EU[2], it is a fast-growing channel that seems to lend itself more easily to cross-border shopping and opening up larger markets. The internet offers the promise of "the death of distance" (Cairncross, 1997) and the seamless integration of markets over a very wide geographical area. The next shop is only a click away, whatever its physical distance from the consumer.

The objectives of this paper are (a) to assess empirically to what extent online markets in the EU are integrated using price indicators and (b) to estimate the potential impact of different e-commerce scenarios on consumer welfare. Previous papers examined these questions from the point of view of the volume of cross-border trade flows (Gomez et al,

1 We are grateful to participants at the 5th Workshop on the Economics of ICTs held at the University of Porto for their constructive comments and suggestions. We also thank Pedro Pereira, Frank Verboven, Gregory Crawford and Dimitri Lorenzani for helpful comments and advice on previous versions. We remain responsible for any remaining errors and omissions.

2 According to Eurostat data, the turnover share from e-commerce for enterprises in the retail sector for the EU-27 went from 5.4% in 2009 to 6.8% in 2012.

2013; Cowgill et al, 2013, Lendle et al 2012). This paper examines price dispersion. Price differences for similar products across countries constitute a potential source of evidence for market segmentation. Price differences between online and offline markets may tell us something about differences in the degree of competition in these markets and price competition spill-over channels between them. Price differences also represent an important opportunity for welfare-enhancing arbitrage by consumers, provided real costs and regulatory obstacles do not stand in the way.

We use a comprehensive dataset including online and offline prices and sales for ten different household appliances product categories in 21 EU countries in 2009. Theory and recent empirical evidence lead us to expect to find that online prices are lower than offline prices and that demand is more price-elastic online than offline. We test whether the data support this hypothesis. In addition, we compute some welfare counterfactuals to assess the benefits to consumers deriving from different e-commerce scenarios. Our results show that indeed price dispersion is lower online than offline and that (own) price elasticities are higher online Our welfare analysis indicates that e-commerce boosts consumer surplus by €34 billion or 0.3% of EU-27 GDP.

This paper is organised as follows. After a brief literature review in section 2, section 3 describes the data used to assess price differences and presents evidence of "uncontrolled" price dispersion. In section 4 we econometrically estimate some hedonic pricing equations to analyse online-offline price differences and to estimate price dispersion, controlling for product characteristics. Section 5 investigates some of the drivers of online price dispersion. Section 6 estimates log-linear demand functions in order to compute own price elasticities for both offline and online sales. In section 7 we compute consumer welfare. Finally, the last section includes some discussion of the results as well as future research topics related to online-offline pricing.

2. Literature review

Several arguments suggest that price dispersion should be lower online than offline. For instance, since search costs are an important component of price dispersion and these are typically lower online than offline, it is to be expected that price dispersion among e-tailers should be lower than among traditional retailers (Bakos, 1997). In addition to search costs, other factors may also influence this difference. For example, entry is also easier in online markets because the infrastructure is simplified to a Website and online retailing represents lower menu cost than offline retailing (Brynjolfsson and Smith, 2000). This reasoning suggests that online markets should be more competitive and observe less price dispersion than conventional markets.

However, early empirical evidence on online price dispersion has frequently reported results that contradict these theoretical insights. For instance, Bailey (1998), Erevelles et al. (2001), Clay et al. (2002), and Lee and Gosain (2002), among others, have documented higher online price dispersion than its offline counterpart. These papers deal with different product categories, methodological approaches and time periods for the analysis, but all coincide in analysing an immature digital market at a time when there were only a few widely known e-tailers and online competition was somewhat limited. On the other hand, there is also early evidence for higher (or at least not lower) offline price dispersion. Examples of this strand of the literature are the contributions by Morton et al. (2001), Brown and Golsbee (2002), and Scholten and Smith (2002). These papers, like the previous ones, are highly heterogeneous in terms of their methodological approach and data used, but in general show that some of the hypothesised advantages of electronic markets in terms of greater information flow and easier consumer search could have been achieved early.[3]

Early research quantifying price dispersion in electronic markets has yielded mixed results. In contrast, recent research has documented lower levels of price dispersion online than offline attributing it to the use of transaction prices as opposed to posted prices and the increase in competition observed in electronic markets in the past years. For instance, Chen (2006) find that -after controlling for ticket availability and heterogeneities that affect ticket prices-, there is little systematic difference in the average fares of two distinct online travel websites. The similarity in average fares observed in 2002 data is in contrast to differences as large as 18% documented by Clemons et al. (2002), who used 1997 data.

Ghose and Yao (2010), argue that a key feature of previous work on the issue was affected by its use of posted prices to estimate price dispersion. According to these authors, this can lead to an overestimation of price dispersion because a sale may not have occurred at the posted price. In their research, they use a unique dataset of actual transaction prices collected from both electronic and offline markets of buyers in a business-to-business market to evaluate the extent of price dispersion. They find that price dispersion in the electronic market is as low as 0.22%, which is substantially less than that reported in the previous existing literature. This near-zero price dispersion suggests that in some electronic markets the “law of one price” can prevail when we consider transaction prices, instead of posted prices.

[3] Brynjolfsson and Smith (2000) and Ancarani and Shankar (2004) find mixed evidence for both greater and lower online price dispersion, depending on the measure used.

Using contemporaneous online and offline transaction data for airline tickets including ticket characteristics and medium of sale permitting comparison of online versus offline price dispersion, Sengupta and Wiggins (2012) find evidence of significantly lower price dispersion on the internet compared to offline market, though some positive dispersion still persists. Rosello and Riera (2012) investigate differences in price levels and price dispersion in both offline and online markets and across tour operators and new emerging Internet retailers, using microdata for individual tourist expenditure on travel and accommodation in the Balearic Islands. Results suggest that prices offered on the Internet are lower than those offered through other channels, independently of quality and quantity considerations. Leong (2013) show that price dispersion in the UK's online grocery markets is relevant. With price data gathered for thirteen weeks for twenty-one product categories, the author suggest that there is an indication of a price-quality relationship, but more significantly, retailers undertake randomized pricing strategies, culminating in sporadic price changes across the given time period.

Substantial price dispersion has been observed on electronic markets. In general, early empirical evidence showed that Internet markets did not exhibit smaller price dispersion than traditional markets. More recent empirical evidence, however, tends to point to lower price dispersion online than offline. It appears that greater information flow and easier consumer search facilitated by the Internet has only recently made online markets more competitive and "frictionless" as predicted by theory. However, substantial online price dispersion has been documented recently as well. Given that e-commerce still represents only a small fraction of total commerce, it is possible that the Internet market will exhibit higher competitiveness and efficiency as it grows in relevance in the coming years.

3. Data

In order to assess the presence of price differences among online and offline retail channels, we rely on data from *Gfk Retail and Technology* that contains sales information on ten different product categories (from household appliances to consumer electronics) in 21 EU countries for a representative number of offline and online retailers[4]. The dataset includes information on more than 90.000 different models from over 2.000 brands. The categories of products are: digital cameras; flat screen TVs; portable media players, mobile personal computers, microwave ovens, refrigerators, washing machines, coffee makers,

[4] According to the data source, the market coverage of the dataset in the period observed ranges from 30% to 80% depending on the product categories.

irons, and vacuum cleaners. Data refers to the period April 2008 to March 2009[5]. Since the dataset contained significant outliers[6], we trimmed the data by removing the top and bottom 5% of the price distribution. Prices include sales tax[7]. In the resulting trimmed dataset, mobile PCs is the product with the lowest number of brands (99) while portable media players is the one with the highest number of brands available, a surprising 737. With respect to models, digital cameras is the product type with the lower number of different models, around 2.500, while the data includes more than 17.000 different models of mobile PCs.

The data covers sales in 21 EU countries. However, the coverage is quite unbalanced, since we do not observe the same geographic coverage for all product types nor for different retail channels (online vs. offline). Online retail represents on average around 15% of total price observations whereas only 43% of all observed models were available through the online channel. Besides prices, quantities and retail channels (online and offline), we also observe product characteristics. The number of characteristics available varies by product, ranging from 6 in the case of digital cameras, to 27 for mobile PCs (table 1). Most characteristics have been transformed to binary variables that indicate the presence or absence of a given feature. Besides these summary attributes of the dataset, table 1 also shows some information about prices. Concretely, the three last columns of the table show the minimum and maximum observed prices (after trimming) and the average price. Direct comparison of average prices is not informative, given that products differ in many dimensions (from both supply and demand sides of the markets). However, table 1 show that the range of price dispersion varies considerably. For instance, the ratio of the highest price to the lowest price is between 4 and 5 for washing machines and mobile PCs, increases to 20 for irons and reaches a maximum of 60 in the case of coffee makers.

Price dispersion has been found in a number of markets, and the EU household appliances market is no exception. Table 2 shows some descriptive statistics of the retail pricing patterns of the products included in the database separating among the different distribution channels observed. The statistics included are the average price per unit sold, the standard deviation, the coefficient of variation, the ratio of the third quartile to the first quartile and, finally, the ratio of the 95% to the 5% quantiles. Here, we do not control for

[5] Except for major domestic appliances for which the period covered is March 2008 to February 2009. Note, however, that the data is aggregated so we are not able to identify when (week or month) the sale occurred.

[6] For instance, prices close to zero or several orders of magnitude higher than average prices.

[7] There is a considerable debate on the literature regarding the appropriate measure of prices for the assessment of price dispersion. Theoretically, a retailer can set low prices that can be altered by shipping costs or taxes. However, empirical studies have generally found very similar results using prices with and without shipping costs (e.g. Baye et al., 2004 and Brynjolfsson and Smith, 2000). The effects of taxes on price dispersion have been less studied.

product differentiation so price dispersion can be the result of differentiated product characteristics as well as brand and country specificities, among others. Comparing prices by channel, we see that in five product categories (digital cameras, portable media players, coffee makers, irons and vacuum cleaners) average prices are higher online than offline. This corresponds roughly to consumer electronics and small domestic appliances groupings. The picture in table 2, however, is one of huge price dispersion in all product categories, independently of the distribution channel used. For instance, looking at the interquartile difference, we see that prices in the middle of the distribution differ from some 60% in the case of offline sales of washing machines, up to 400% in the case of online sales of coffee makers. These differences in the case of the ratio of the 95% to the 5% quantile are even more striking. These figures result from the highly differentiated products we are considering.

Table 1: Data summary

	Obs.	Brands	Models	Charact.	Prices		
					Lowest	Avg.	Highest
Consumer electronics:							
Digital cameras	23,629	170	2,429	6	51.0	183.1	572.3
Flat screen TVs	35,673	363	7,100	21	199.0	747.6	2,338.0
Portable media player	21,272	737	6,564	18	15.0	59.4	202.6
Information technology:							
Mobile PCs	43,633	99	17,378	27	345.2	765.1	1,616.5
Major domestic appliances:							
Microwave ovens	5,599	174	2,747	17	49.9	251.5	884.3
Refrigerators	18,320	174	9,073	18	201.1	564.7	1,431.7
Washing machines	9,324	101	5,089	14	242.8	462.9	962.2
Small domestic appliances:							
Coffee makers	10,141	291	2,967	15	14.9	164.5	854.4
Irons	9,051	255	3,085	10	11.6	69.3	250.0
Vacuum cleaners	17,217	371	6,265	14	24.7	108.2	300.6

However, the products we are considering are strongly differentiated. We compute the interquartile price differences as before (Q75/Q25), but now instead of considering the full price distribution we do it by quintiles, as shown in table 3. Once we group products according to its position in the price distribution, these differences are now much lower than before. Now, the highest difference between any two prices occurs again for the online sales of coffee makers, but now this difference amounts to 70%. We even observe price differences for some quintiles low as only 9%, for instance, in the case of mobile PCs of washing machines. On average, price differences are of about 27%. Interestingly, a clear pattern emerges in which extreme quintiles show higher price differences than intermediate quintiles. According to these results, there seems to be more price dispersion at the two ends of the distribution than in the middle.

Table 2: Distribution of prices by product category and sales channel

Product category	Channel	Avg Price	StdDev	Coef of Var	Q75/Q25	Q95/Q5
Digital cameras	Off	179.4	101.7	0.567	2.213	5.916
	On	190.4	103.7	0.544	2.100	5.733
Flat screen TVs	Off	750.5	456.1	0.608	2.408	7.166
	On	741.8	443.7	0.598	2.401	6.991
Portable media player	Off	57.2	36.7	0.642	2.286	7.261
	On	63.2	40.1	0.634	2.337	7.563
Mobile PCs	Off	770.5	278.0	0.361	1.627	3.335
	On	757.0	286.4	0.378	1.698	3.445
Microwave ovens	Off	252.8	209.9	0.830	4.236	11.964
	On	249.0	205.9	0.827	4.104	11.953
Refrigerators	Off	569.8	264.5	0.464	1.908	4.419
	On	553.9	265.2	0.479	1.962	4.516
Washing machines	Off	464.4	157.9	0.340	1.584	2.912
	On	459.9	161.5	0.351	1.618	2.989
Coffee makers	Off	157.8	181.1	1.147	5.007	30.412
	On	178.1	191.1	1.073	5.103	28.259
Irons	Off	68.1	53.3	0.783	3.018	12.276
	On	72.4	56.5	0.780	3.126	13.008
Vacuum cleaners	Off	106.6	64.9	0.609	2.548	7.670
	On	112.0	63.4	0.566	2.365	7.033

An additional result that derives from this descriptive exercise is the fact that interquintile price differences are lower for higher average prices, both offline and online (figure 1). This result is consistent with the idea that search costs have a fixed cost component (Dubois and Perrone, 2012). In the case of more expensive products (in our case mobile pcs) search costs are low relative to the price of the good and consumers have more incentives to search more intensively for the lowest price. Since more searches are done, consumers are better informed about prices, forcing stores towards fiercer price competition, a competitive situation where price dispersion should be minimal, unless other issues are at stake, for instance a strong product differentiation strategy.

Table 3: Interquartile price differences by product category and sales channel

Product category	Channel	Quintiles				
		1	**2**	**3**	**4**	**5**
Digital cameras	Off	1.32	1.19	1.15	1.19	1.38
	On	1.29	1.18	1.15	1.18	1.40
Flat screen TVs	Off	1.32	1.24	1.18	1.20	1.42
	On	1.31	1.23	1.17	1.21	1.40
Portable media player	Off	1.34	1.19	1.16	1.22	1.50
	On	1.35	1.20	1.16	1.23	1.50
Mobile PCs	Off	1.23	1.10	1.09	1.13	1.26
	On	1.23	1.10	1.10	1.13	1.27
Microwave ovens	Off	1.26	1.22	1.31	1.45	1.38
	On	1.25	1.22	1.28	1.46	1.43
Refrigerators	Off	1.24	1.13	1.13	1.17	1.32
	On	1.25	1.12	1.13	1.17	1.32
Washing machines	Off	1.14	1.10	1.09	1.12	1.27
	On	1.14	1.09	1.09	1.12	1.26
Coffee makers	Off	1.51	1.34	1.36	1.47	1.69
	On	1.45	1.34	1.37	1.48	1.70
Irons	Off	1.42	1.27	1.23	1.28	1.48
	On	1.44	1.28	1.24	1.27	1.52
Vacuum cleaners	Off	1.42	1.21	1.18	1.22	1.35
	On	1.41	1.20	1.19	1.22	1.33

4. Quality-adjusted price differences

Since product differentiation could be an important source of differences in prices, we control for quality differences and compare quality-adjusted[8] hedonic prices in order to be able to identify price deviations. One of the key challenges in empirically testing price differences between online and offline retailers is modelling the relationship between product quality, or product characteristics, and price. Each product can have characteristics that affect consumer preferences. Fortunately, we have a sufficiently large number of characteristics by product type in order to appropriately control for quality differences

[8] We use the terms “quality” and “characteristics” interchangeably in this paper. Some characteristics could indeed be considered as quality indicators, for example the processor speed for a computer or the energy efficiency of a fridge. Others are just characteristics that reflect consumer choice (e.g. the size of the TV screen). There are econometric techniques to separate these two categories but we have not applied these so far.

using a hedonic approach. In the baseline hedonic model the estimated coefficients for characteristics dummy variables represent the premium price that the consumer is willing to pay for these characteristics. We also add country and brand dummies to the baseline model to represent the price premium for every country and brand name.

There is substantial debate in the literature of hedonic price models as to the appropriate functional form of the price-characteristics relationship. In our case, we have adopted the log-linear form, where characteristics lead to a percentage change in the base price (rather than an absolute increment). Moreover, the combination of country and brand effects and the log-linear specification virtually eliminates the heteroskedasticity derived from the fact that lower and higher prices have more variation than intermediate prices. The remaining heteroskedasticity is addressed by the computation of robust standard errors. The model we estimate is:

$$\ln\left(P_{ijc}\right) = \alpha + \beta * Online + \gamma_k * X_k + \delta_c * C_c + \omega_j * B_j + \varepsilon \quad (1)$$

where $\ln\left(P_{ijc}\right)$ is the price of model *i* of brand *j* in country *c*; *Online* is a dummy variable indicating if the product has been sold online, X_k is a vector of product characteristics, C_c is a vector of country dummies and B_j is a vector of brand dummies. In this specification we separate online from the rest of characteristics (not shown in the results) since we are mainly interested in the effect of online distribution on prices. We estimate this equation separately for each product type. As the table 4 shows, online retail always has lower prices, except in the case of coffee makers, where the coefficient is not statistically different from zero (although the sign is negative as well). After controlling for differences in product characteristics and country and brand fixed effects, this reduction ranges from 2.5% in the case of vacuum cleaners to 8% for flat screen TVs.

This base model allows us to analyse the extent of geographical price dispersion between countries. The coefficients of the country dummies introduced can be interpreted as differences in average prices compared to the reference country. For simplification, the chosen reference country is the country with the lowest price level. Hence, the coefficients indicate average price premium compared to the lowest price country. If the law of one price holds, we should expect that $\delta_1 = \delta_2 = \cdots \delta_c = 0$. In other words, there should be no price differentials. However, table 5 shows important price differences across countries for similar products. Hence, the data reject this hypothesis since the coefficients are globally different from zero and conversely show great variation. In the case of coffee makers, for instance, these differences are as high as 38% between the cheapest country (UK) and the most expensive Member State (Czech Republic). All products show relatively important price variations. The lowest is for washing machines, with a difference of 17% between the cheapest and the most expensive country, while the product showing the highest variation in prices is vacuum cleaners, up to 40% more expensive in the Czech Republic than in the UK. The UK turns out to be the country with the lowest price for 7 out of 10 product categories, and very close to the lowest base prices for the 3 remaining categories.

A similar exercise is carried out for brand quality-adjusted price differences. In this case, price dispersion is huge, ranging from some 50% in the case of washing machines to 350% for digital cameras. Here, several considerations are in place. These differences are much lower than those observed with the pre-quality adjusted data. For example, the price differences in the case of digital cameras was around 5800%, even after trimming the price distribution by the top and bottom 5% of the observations. The corresponding figure for washing machines was 380%. These results indicate that different brands appear to be targeting different price-quality combinations and hence there should be a strong segmentation among consumers. This result suggests that product differentiation could account for some of the observed price variation. Since products could be differentiated horizontally and vertically, a deeper analysis of the characteristics at hand that account for which type of differentiation would help determine if price dispersion comes from differences in product attributes, product quality, or consumers' characteristics and preferences (mainly summarised in their search intensity)[9].

5. What determines online price dispersion?

Now that we have observed that online price dispersion is significant, persistent and, in some way ubiquitous, a next step is to try to understand why it exists. Several theoretical explanations have been put forward, ranging from the balance between price and non-price information that consumers can access in online markets (Degeratu et al., 2000), consumer's awareness and sensitivity to retailers name (Chen and Hitt, 2003), to random pricing strategies (Smith, 2001). In addition, others have begun to investigate specific types of market imperfections that could lead to these results, such as customer learning (Johnson et al. 2004), brand loyalty (Chen and Hitt 2000), competition (Orlov, 2011) or systematic variations in the nature of products offered in online versus regular channels (Lee 1998). Understanding the presence or absence of exploitable imperfections in Internet markets and their implications for pricing strategy is critical not only for Internet retailers but also for firms that must compete in environments with increasingly informed consumers.

[9] Such a research would require a different methodological approach than the one taken here.

Table 4: Price differences by channel, among countries and brands

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Online	-0.00429	-0.0745***	-0.0792***	-0.0360***	-0.0792***	-0.0418***	-0.0257***	-0.0553***	-0.0255***	-0.0652***
	(0.00909)	(0.00510)	(0.00271)	(0.00772)	(0.00843)	(0.00222)	(0.00718)	(0.00381)	(0.00672)	(0.00395)
Constant	3.493***	3.968***	4.786***	0.943***	3.181***	6.296***	3.428***	4.971***	4.028***	5.058***
	(0.0725)	(0.0556)	(0.0234)	(0.0477)	(0.0889)	(0.0311)	(0.0595)	(0.0253)	(0.165)	(0.0723)
Price dispersion										
By country	0,373	0,267	0,219	0,284	0,226	0,177	0,309	0,212	0,396	0,174
By brand	2.978	2.655	2.554	2.883	2.088	1.491	2.336	1.941	3.067	1.432
Characteristics	15	6	20	10	17	27	18	18	14	14
Observations	8,231	23,559	35,342	8,447	5,568	43,624	12,068	14,693	12,433	9,012
R-squared	0.867	0.523	0.829	0.815	0.868	0.614	0.613	0.775	0.633	0.699

Note: column numbers refer to the following products: (1) Coffee makers; (2) Digital cameras; (3) Flat screen TVs; (4) Irons; (5) Microwave ovens; (6) Mobile PCs; (7) Portable media player; (8) Refrigerators; (9) Vacuum cleaners; (10) Washing machines. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 5: Online and offline price dispersion by country and product type

	(1)		(2)		(3)		(4)		(5)		(6)		(7)		(8)		(9)		(10)	
	On	**Off**	**On**	**Off**	**On**	**Off**	**On**	**Off**	**On**	**Off**	**On**	**Off**	**On**	**Off**	**On**	**Off**	**On**	**Off**	**On**	**Off**
Austria	19%	28%	18%	17%	11%	25%	6%	14%			9%	10%	19%	26%			32%	33%		
Belgium	32%	34%	16%	16%	10%	22%	18%	12%			10%	9%	25%	24%			**38%**	32%		
Bulgaria			6%	12%																
Czech R.	**32%**	**41%**	19%	29%	12%	24%	**25%**	**31%**	13%	21%	8%	11%	18%	30%	16%	9%	37%	**42%**	13%	16%
Denmark			25%	22%							**12%**	**20%**								
Finland			17%	14%																
France	23%	25%	14%	15%	8%	21%	11%	15%	**20%**	25%	7%	8%	20%	22%	**28%**	**18%**	38%	37%	**15%**	**20%**
Germany	21%	21%	18%	21%	11%	**30%**	base	0%	13%	**25%**	10%	11%	25%	**37%**	24%	15%	27%	21%	12%	12%
Great Britain	base	base	base	base	0%	9%	1%	base	base	base	base	base	base	base	16%	4%	base	base	1%	base
Greece			4%	30%																
Hungary	10%	21%	11%	8%	5%	11%	15%	12%					25%	31%			20%	18%		
Ireland			10%	17%																
Italy	21%	27%	21%	24%	5%	16%	5%	8%			6%	4%	17%	19%			34%	36%		
Netherlands	21%	26%	15%	14%	10%	22%	7%	8%	11%	16%	10%	8%	21%	20%	23%	15%	28%	28%	16%	17%
Poland			8%	15%	base	12%			1%	12%	7%	7%	9%	15%	base	base			base	6%
Portugal			17%	13%	6%	16%							16%	8%						
Romania			22%	4%	10%	base							12%	12%						
Slovakia			23%	**26%**	**16%**	22%							**26%**	31%						
Slovenia			**26%**	18%	11%	17%	22%	22%					25%	14%			37%	33%		
Spain	23%	21%	6%	11%	5%	16%	12%	10%			1%	6%	19%	23%			34%	29%		
Sweden			21%	18%							4%	7%								

Note: Price differences in percentage to base country. Column numbers refer to the following products: (1) Coffee makers; (2) Digital cameras; (3) Flat screen TVs; (4) Irons; (5) Microwave ovens; (6) Mobile PCs; (7) Portable media player; (8) Refrigerators; (9) Vacuum cleaners; (10) Washing machines. Column **On** refers to online price dispersion and column **Off** to the corresponding offline price dispersion. The base country is where the lowest average prices are listed. In bold, the country with the highest price difference with respect to the base country.

Unfortunately, our dataset does not include characteristics of the seller. Hence, we cannot explore to what extent e-tailer characteristics are driving online price dispersion, as suggested by Pan et al, 2003. Alternatively, we collected several variables related to different dimensions of markets that are expected to play a role in the functioning of digital markets and, hence, helping to sustain online price dispersion. The three dimensions for which we collected data were: supply, demand, and market regulations.

Supply side factors: we ran several regressions with online price dispersion as the dependent variable –derived from our hedonic model in section 4-. The list of independent variables included: i) the number of brands as a measure of competition since they proxy the number of firms in each country and by every product category; ii) the number of different models, to account for product proliferation and product differentiation effects; iii) measures of labour costs and broadband prices to take into account production costs differentials among countries and; iv) the average share e-commerce represents in firms' turnover also by country. No one of these variables was found to be statistically significant in any of the three different estimation methods used, namely, OLS, Tobit and Truncated regression[10]. Even controlling for both country and product category fixed effects, supply side variables were not statistically significant and hence, we do not report these results here[11].

Demand side factors: as in the previous case, we performed several test to check if country level demand factors are relevant in order to explain online price dispersion. In this case, and also controlling for country and product fixed effects, we included the following variables: i) a measure of online purchasing power, by simply multiplying gross domestic product per capita by the broadband penetration rate, by country; ii) the share of individuals that purchased online at least once in 2009[12]; iii) a measure of preference for offline purchases[13], and; iv) since the majority of goods considered are related to houses, we introduced also the value of residential construction as a share of GDP. The more residential construction in a given country, the more demand for household goods -other things equal- and eventually more opportunities to use prices as a strategic tool. As in the

[10] Since the measure of price dispersion we use is the difference between the quality-adjusted prices with respect to the lowest price country, the dependent variable is truncated from below, so we should appropriately take this into account in the estimations. However, we found very little difference in the estimated coefficients among the different results.

[11] Results are, nevertheless, available from the authors upon request.

[12] We also used the share of individuals that purchased household related goods online in 2009, but it was not statistically significant in any regression.

[13] This is referred to, according to Eurostat, individuals who, in the last 12 months, haven't ordered goods or services over the Internet, because they prefer to shop in person, they like to see product, loyalty to shops or force of habit.

previous case, with the exception of the preference for offline goods indicator[14], none of these variables turned out to be statistically significant in any of the different regressions that we did. Apparently, the demand side factors we considered had no impact in the explanation of online price dispersion[15]. Hence, we do not report these regressions results here.

Regulatory and market-wise factors: we built a different set of explanatory variables related to regulation and other market-wise factors. The variables included in this last set of regressions were: i) offline price dispersion, in order to assess the relationship between offline and online markets. This variable also comes from our estimation results on section 4; ii) country level product market regulation indicator as provided by the OECD, ranging from 0 (less restrictive) to 6 (more restrictive); iii) retail distribution regulation also by the OECD in order to check whether a restrictive regulatory burden could influence price dispersion by means of a less competitive environment and, finally; iv) a measure of cross-border e-commerce to take into account the possible price-competition effects derived from more openness to online trade. Results are shown in table 6. Both offline price dispersion and product market regulation are positive and statistically significant across the different estimation methods, suggesting that the results are robust. More offline price dispersion and more restrictive product market regulation are strongly correlated with online price dispersion. This suggests that prices in online markets are to a large extent driven by the extent of competition in the offline world.

Table 6: Determinants of online price dispersion

	OLS	**Tobit**	**Truncated**
Offline price dispersion	0.676***	0.694***	0.577***
	(0.0681)	(0.0654)	(0.0574)
Product market regulations	15.13**	14.79***	14.30***
	(6.514)	(5.531)	(5.313)
Retail regulations	-0.399	-0.392	-0.686
	(1.197)	(1.005)	(1.029)
Share of cross-border e-commerce	0.0896	0.0812	0.106
	(0.113)	(0.0961)	(0.0952)
Constant	-5.667	-5.807	-2.291
	(7.132)	(6.079)	(5.953)

Note: all regressions include country and product category fixed effects. Robust standard errors in parentheses and *** denotes significant at the 99%, ** at the 95% and * at the 90%.

14 The estimated coefficients were positive, indicating that the grater the proportion of people that prefers to buy offline, the greater the price dispersion online.

15 Additional variables should be used from a demand side perspective, in particular, the intensity of search or measures of search costs for consumers. Unfortunately, we didn't find any relevant variable to control for that.

Further research is needed to appropriately take these results into account and to check the causal link of this finding. Moreover, as Shankar et al (2004) indicated, it is going to be very relevant to check if the determinants of online price dispersion change as internet markets are maturing. In this respect, it is worth remembering that in the EU, e-commerce represents only around 6% of total retail.

6. Price elasticity of demand

As it is now well documented, one of the expected outcomes of higher transparency in online markets is an increase in the price elasticity of demand, due to the increased availability of information about competitive offerings (Ghose and Yao, 2010; Lynch and Ariely, 2000; Smith, 2002). Theoretically, the higher the price elasticity, the lower the market price and, as prices are driven down to marginal costs, price dispersion will also erode (Ghose and Yao, 2010).

Consumers will use market information to the extent that it is a valuable input in the purchase process. The effects on demand are normally broken down on consumers' sensitivity to price and product information and on channel selection. Information about prices (Stigler, 1961) allows consumers to find lower prices for a given product or horizontally-differentiated substitutes. Increased information about product attributes allows consumers to ascertain their valuation of a given product with higher precision and also to find products that better fit their tastes or needs (Akerlof, 1970). Finally, the relative information about product offers will also influence channel selection. Different characteristics of the distribution networks and information levels lead to a partially-separable demand sets and to a segmentation of consumers into offline shoppers and online shoppers. In a nutshell, improvements in the availability of market information in the online channel reduce search costs, which can affect price elasticity in three ways. First, price comparison capabilities will make consumers more price-sensitive. Second, product information will make consumers less price-sensitive. Finally, price sensitive consumers will select a channel that offers easier comparison of product offerings and prices (Granados et al., 2010).

We estimate a log-linear demand equation to compute price elasticity differences across channels econometrically. To do so, we break the base elasticity and separately estimate the difference between the price elasticity of the offline channel and that of the corresponding online channel. Specifically, we have

$$lnQ_{ijc} = \alpha + \beta \ln(P_{ijc}) + \gamma[\ln(P_{ijc}) * Online] + \delta * y_c + \theta * OC_c + \vartheta_c * C_c + \omega_j B_j + \varepsilon \quad (2)$$

where Q is the quantity sold of model i of brand j in country c, P_{ijc} its price, y is the mean household income, OC is a measure of operating costs since the use of household appliances requires an increase in demand for energy, for instance. Here we use as a proxy for operating costs the mean household expenditure in electricity, the Cc is a vector of country dummies and Bj is a vector of brand specific fixed effects. Here, β is the price elasticity of offline sales and is the base elasticity. The parameter γ represents the difference between the price elasticity of offline and online sales, so $\varepsilon_{Online} = \beta + \gamma$.In addition, δ is the income elasticity of demand. We estimate this equation separately for each product type.

Since normally price and quantity are endogenous in demand estimation, to properly estimate the model we need to instrument prices. To do so, we use the predicted prices given by the hedonic model of the previous section. Hence, our prices are quality-adjusted prices and are independent of their respective quantities (exogenous)[16]. The results of the estimation of the demand equation by product category are shown in table 7. First of all, the table shows that the model's explanatory power tends to be small (R^2's range from 24% to 34%). As we can see in table 7, all the estimated offline elasticities have the expected negative sign, and they turn out to be quite inelastic with the exception of flat screen TVs (-1.206) and (Mobile PCs). On the other hand, the estimated difference between offline and online price elasticity of demand is always negative and significantly different from zero. Consequently, online demand is more price elastic than offline demand. Hence, online shoppers are more sensitive to prices than offline shoppers. The estimated income elasticity is always positive, as expected, but with heavy variations across the different products. For instance, coffee makers, digital cameras, flat screen TVs, microwave ovens and Mobile PCs show high income elasticities, according to which these products are superior (luxury) goods. A second group would be comprised of Irons, Portable media players and vacuum cleaners, with estimated income elasticity around one. Lastly, two product categories show a low income elasticity of demand, making them necessity goods (refrigerators and washing machines). Finally, the estimated coefficients for the operating costs variable are all negative and statistically significant, as expected, except in the case of microwave ovens –not statistically different from cero- and Mobile PCs, where it is positive.

16 In a robustness exercise, we instrumented prices with typical supply side instruments (wages, degree of market concentration, etc.) and the results remained qualitatively unchanged.

Table 7: Offline vs. online price elasticity

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
ln(P)	-0.235**	-0.248***	-1.206***	-0.258***	-0.641***	-2.283***	-0.575***	-0.703***	-0.267*	-0.775***
	(0.0952)	(0.0936)	(0.0365)	(0.0782)	(0.121)	(0.0650)	(0.126)	(0.104)	(0.154)	(0.295)
ln(P)*Online	-0.396***	-0.413***	-0.261***	-0.564***	-0.328***	-0.300***	-0.477***	-0.276***	-0.446***	-0.298***
	(0.0120)	(0.00672)	(0.00403)	(0.0138)	(0.0120)	(0.00339)	(0.0111)	(0.00586)	(0.00951)	(0.00899)
ln(income)	5.489***	5.733***	2.003***	1.041***	2.029***	1.920***	1.291***	0.156**	0.995***	0.320***
	(1.207)	(0.399)	(0.118)	(0.224)	(0.164)	(0.202)	(0.246)	(0.0714)	(0.193)	(0.104)
Op. costs	-6.485***	-2.219***	-4.127***	-3.658***	0.0967	1.929***	-2.390***	-1.698***	-1.397***	-2.113***
	(1.281)	(0.197)	(0.203)	(0.419)	(0.322)	(0.198)	(0.380)	(0.182)	(0.326)	(0.245)
Constant	-10.97**	-38.64***	13.90***	19.54***	-4.948***	-1.039	7.656***	15.33***	4.749*	18.21***
	(4.528)	(4.227)	(1.391)	(3.142)	(1.258)	(1.960)	(2.744)	(0.813)	(2.553)	(1.494)
Observations	6,798	21,540	31,277	7,537	4,487	36,777	10,961	11,088	10,547	7,042
R-squared	0.247	0.302	0.262	0.276	0.306	0.286	0.335	0.282	0.252	0.244

Note: column numbers refer to the following products: (1) Coffee makers; (2) Digital cameras; (3) Flat screen TVs; (4) Irons; (5) Microwave ovens; (6) Mobile PCs; (7) Portable media player; (8) Refrigerators; (9) Vacuum cleaners; (10) Washing machines. All estimations include country and brand fixed effects to control for country and brand unobservables. In order to recover the online price elasticity we note that ln(P)*Online = offline price elasticity – online price elasticity, so the online price elasticity = offline price elasticity + ln(P)*Online. Robust standard errors in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Our results indicate that price elasticity for all the product categories considered is higher in the online channel than in the offline channel. Online demand is more price-elastic than offline. One of the principles of perfect competition is that consumers are more sensitive to price changes in markets with lower search costs, because they have more access to substitute offerings. The finding that the online channel is more price-elastic than offline demand is consistent with the notion that less friction in the form of lower search costs will lead to higher price elasticity of demand and hence more intense competition. Yet, based on the results, we contend that the price elasticity effect of the online channel is not straightforward. There are multiple forces at play, and the results of this study should be confronted with some arguments and explanations of the drivers of differences in price elasticity across channels. For instance, and to mention just a few issues that should require a more detailed research, some of these forces are the multichannel distribution strategies followed by producers and retailers, the effects of barriers to online trade –such as payment systems, preferences for offline shopping experience, logistics associated to delivery and retraction of physical goods from and to e-tailers, among others-, tax differences among countries, exchange rates fluctuations with no euro-zone Member States, national regulations both for product markets and retail markets, among many others.

7. Consumer welfare

Using the demand curve estimated in the previous section one can deduce the total value of consumer surplus (CS). This approach can also be used to compute the welfare benefits (or losses) from price changes. For instance, a price reduction has the double effect of reducing the price paid for products that would be sold at the previous price, hence increasing consumer surplus, but also brings in to the market consumers that now face a price less than or equal to their reservation price[17].

The methodology to estimate consumer welfare resulting from market interaction, in particular from price changes, can be traced to Hicks (1942). Although the Hicksian demand is unobservable, Hausman (1981) developed a closed-form solution for measuring

[17] Even if the basic concept of consumers' surplus is simple, there are fundamental differences if we consider different demand functions. On the one hand, a Marshallian demand curve plots the relationship between price and quantity holding consumer income constant. The Marshallian surplus is the most common conception of consumers' surplus. On the other hand, the Hicksian (compensated) demand curve refers to the amount the consumer would demand if income were adjusted to maintain utility constant. Nevertheless, the calculation of surplus in conceptually the same and refers to the area defined by the demand curve and the equilibrium price.

the compensating variation[18] (CV) under standard linear or log-linear demand functions. In the log-linear case given by equation (2), the appropriate formula for the CV is:

$$CV = \left[\frac{(1-\delta)}{(1+\alpha)} y^{-\delta}(p_1x_1 - p_0x_0) + y^{(1-\delta)}\right]^{1/(1-\delta)} - y \qquad (3)$$

Where δ is the income-elasticity of demand, α is the price elasticity of demand, y is income and p_1x_1 (p_0x_0) is the revenue spent on the good in period 1 (period 0). Hausman (1997) and Brynjolfsson (1995) have demonstrated that income effects can be ignored for consumer products where purchases represent a small share of the household's annual income. This would imply that $\delta = 0$, and equation (3) can be simplified as[19]

$$CV = -\frac{(p_1x_1 - p_0x_0)}{(1+\alpha)} \qquad (4)$$

which is simply the difference in expenditure from scenario 0 to scenario 1 divided by 1 plus the price elasticity of demand. We use the estimates of the log-linear demand functions for the different product categories of the previous section as shown in table 7. In particular, we rely on the price-elasticity estimates assuming that CV=CS (see footnote 20).

First, we compute the CS in the baseline market situation described by our data. To do so we need to calculate the "virtual" price, that is, the price at which demand is zero, but this price approaches infinity for the log-linear demand function we use. However, actual demand becomes very small at prices less than infinity. For instance, the quantity sold of each product in the database when we select the highest observed price is very small. Hence, this is a "natural" way of specifying this virtual price. Starting from this equilibrium CS, we test some scenarios to calculate the difference between the observed equilibrium in the market and some hypothetical counterfactuals[20]:

[18] Marshallian consumers' surplus is not an exact measure of welfare. Hicks (1956) showed that a price decline of a given good will increase the effective income available to the consumer (that she could spend in buying more of each good in her basket) and therefore shift the consumer to a higher utility level. The compensating variation measure does precisely this, by indicating what would the demand be should utility remained constant through an appropriate modification of income.

[19] In this case, the Marshallian CS and the Hicksian CV are equivalent.

[20] Since we are particularly interested in the counterfactuals we do not report the baseline CS estimations, but are available from the authors upon request.

- A first simulation examines the welfare effects of a scenario with full online price convergence where all countries' average prices converge to the lowest online average price country[21].
- A second scenario estimates the welfare effect of e-commerce (the baseline) compared to a situation without e-commerce (the counterfactual). In this setting, we assume that all the products that are sold online at online prices are instead sold offline at offline prices. We then calculate the change in consumer surplus derived from the substitution of the electronic retail channel.
- A third scenario looks at the effects of displacement between online and offline sales. Since the data do not allow us to estimate substitution directly, we follow an indirect route where we estimate the welfare effects of two extreme situations: (a) full displacement of offline by online sales and (b) zero displacement between the two. Therefore, this scenario is split in two sub-scenarios: First, we estimate the welfare effects of an increase by 10% in online sales online with a corresponding decrease in offline sales. Then, we relax this assumption and simply assume increases of 10% in online sales, maintaining offline sales at their observed levels.

The results of the different scenarios are presented in table 8[22]. From it, we can see that:

- The CS benefits from the online price convergence scenario are estimated to be around €2.6 billion or equivalently a 1% increase in consumer surplus. The biggest gains are concentrated in refrigerators, washing machines and microwave ovens[23]. Overall, these gains represent an increase in CS equivalent to around 0.02% of EU-27 GDP in 2009.
- The second scenario where we assume no e-commerce at all produces an outcome of significant magnitude: a loss in consumer surplus of around €34.4 billion or 14.4% of the estimated baseline CS, which in turn represents about 0.3% of EU-27 GDP in 2009.
- The scenario with a 10% increase in online sales and an equivalent displacement of offline sales generates a net consumer surplus of €3.4 billion, a gain in CS equivalent to 0.03% of EU-27 GDP in 2009. Given the estimates of the log-linear demand function and the corresponding price and income elasticities, in these cases flat screen TVs and

[21] We acknowledge that a more realistic scenario would imply convergence towards an intermediate price level, but this one could be used as an upper bound estimation of potential gains.

[22] These figures should be interpreted with caution for several reasons. First, data coverage is not uniform and some product categories may be overrepresented while others are underrepresented, in terms of brands, models and expenditure. In addition, the country coverage is also heterogeneous, ranging from only 6 countries for refrigerators and washing machines to 21 countries in the case of digital cameras. In addition, the product categories that we consider in this study represent only 3% of annual household expenditure in the EU. Moreover, since the welfare computations come from parametric estimates, this should be interpreted as an estimated value which has statistical upper and lower limits. With this idea in mind, these figures underestimate the true consumer surplus.

[23] According to previous research, higher price dispersion is observed in markets for products that cannot be transported easily (see Pan et al. 2004 and references therein).

Mobile PCs show negative net welfare effects, indicating that crowding out from offline to online sales would hurt consumers more than they would benefit them.

- Our last simulation with a 10% increase in online sales fully additional to offline sales[24] produces welfare gains for consumers of €5 billion or around 0.04% of EU GDP in 2009.

Our results point to important welfare improvements already generated by online sales and still a large welfare potential to be tapped by further shifts to online sales and to price convergence in online markets. Note that the estimated effects are static and constrained to one year. The dynamic welfare gains could be much more important in terms of the accumulation of consumer surplus in different periods and, of course, from the potential competitive effects derived from the pressure that online price put on offline mark-ups.

Table 8.Welfare effects

	Online price convergence	**Non e-commerce**	**10% e-commerce displacement**	**increase**
Coffee makers	76.2	-235.0	23.5	33.5
Digital cameras	71.3	-1,391.8	139.2	234.0
Flat screen TVs	118.9	5,618.0	-561.8	447.3
Irons	28.2	-171.3	17.1	21.8
Microwave Ovens	292.0	-1,804.6	180.5	196.1
Mobile PCs	127.5	265.6	-26.6	103.2
Portable Media Players	22.8	-6,294.3	629.4	691.6
Refrigerators	1,475.9	-26,652.1	2.665.2	2,886.0
Vacuum cleaners	29.8	-276.2	27.6	40.8
Washing machines	362.6	-3,457.9	345.8	520.9
Total	2,605.2	-34,399.6	3.440,0	5,175.0
% EU27 GDP	**0.02**	**0.29**	**0.03**	**0.04**

Note: figures in billion euros. Data refer to differences in CS from the corresponding scenario to the baseline scenario.

8. Conclusions and future research

The findings suggest that, after controlling for quality differences, both online-offline and geographical price dispersion exists in in the European Digital Single Market. We have found that products sold online are between 2% and 10% cheaper than offline, depending on the type of product. Moreover, price dispersion between the 21 countries ranges from

[24] As a matter of fact, in this scenario the change in CS in the offline market is null and the welfare gains corresponds to pure market expansion online.

13% to 38% by product type. Particularly striking are the findings of quality-adjusted brand-price differences, since they can be as high as 350% (the non-adjusted figure is fifteen times larger) suggesting that product differentiation plays a strong role in pricing strategies and should be appropriately taken into account. In addition, we offer evidence on the price elasticity of demand form both offline and online channels. We show that online demand is more price-elastic than offline, which is consistent with explanations based on search costs and information availability online. Our estimates seem reasonable and, in the offline case with the exception of flat screen TVs and Mobile PCs, all fall in the range of inelastic demand. To what extent this is consistent should be a matter of future research, preferably with more statistical data at hand. With these estimates we calculate the consumer surplus. Then, we perform a scenario analysis in which we design some counterfactuals and we evaluate the effects on consumers' welfare from changes in the observed market conditions. Our results indicate that online price convergence across EU member states towards the lowest observed average price would significantly benefit consumers. E-commerce is already estimated to boost consumer welfare by nearly 15%. A further 10% shift to online sales could increase consumer welfare by another 0.03% of EU GDP.

Several issues are conditioning the results. First of all, we have cross-section data for 2009 only for countries, brands and models; there is no time variation. Hence, our computations rely exclusively on country-brand-channel variations. Adding time variation to the model would improve significantly the accuracy of the results. For instance, the explanatory power of the demand equation estimations could be improved with time series data. This should provide interesting insights in the evolution of online product markets in the EU Digital Single Market. Moreover, it would make possible to approximate somehow the dynamic effects of reduced prices and more intense competition. The next step in this research would try to explain the observed price dispersion between countries and examine to what extent price levels are linked to the price elasticity of demand. Among the topics that can be included here are competition and market power effects, costs of production and distribution, product availability by channel, and search intensity.

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Title: Consumer Benefits from the EU Digital Single Market: Evidence from Household Appliances Markets

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Abstract

This paper investigates price differences between online and offline retail channels in the EU Digital Single Market. Using price and sales data for ten household appliances product categories sold both offline and online in 21 EU countries in 2009, and correcting for product characteristics, we find evidence that online prices and price dispersion are lower than offline. Online demand is more price-elastic. We compute consumers' welfare effects for different scenarios. E-commerce increases consumer surplus by €34 billion or 0.3% of EU-27 GDP. Full online price convergence across the EU towards the lowest observed average price would further increase welfare by 0.02% of GDP.

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