This is the author's accepted manuscript without copyediting, formatting, or final corrections. It will be published in its final form in an upcoming issue of Journal of Political Economy Microeconomics, published by The University of Chicago Press. Include the DOI when citing or quoting: https://doi.org/10.1086/725335. Copyright 2023 The University of Chicago.

Incumbency Advantages: Price Dispersion, Price Discrimination and Consumer Search at Online Platforms*

Klaus Gugler† Sven Heim‡ Maarten Janssen§
Mario Liebensteiner¶

March 30, 2023

When lower prices are only available to consumers who search, firms can price discriminate based on search. We study local German electricity retail markets where non-searching consumers pay the incumbent's baseline tariff. To observe other prices, consumers access an online platform. Pricing and search patterns differ substantially across local markets. Using panel data, we show that in local markets with more search, incumbents have higher baseline tariffs, while incumbent's and entrants' online tariffs are lower. In a theoretical model, we discuss when an incumbent has an incentive to differentiate tariffs and the welfare properties of banning such price discrimination practices.

Keywords: Search, Price Dispersion, Price Discrimination, Electricity

JEL Classification: D43, D83, L11, L13, Q40

*Edited by Matt Grennan. We thank the editor and two anonymous reviewers for their insightful comments. We also thank *ene't* for giving us access to their data on consumer search at price comparison websites. We thank Klenio Barbosa, Anette Boom, Tomaso Duso, Daniel Garcia, Alessandro Gavazza, Ulrich Laitenberger, Dieter Pennersdorfer, Steven Puller, Karl Schlag, Philipp Schmidt-Dengler, Nils-Hendrik von der Fehr, Mike Waterson, Matthijs Wildenbeest, Biliana Yontcheva, and Christine Zulehner for valuable comments. We also thank *Acxiom* for giving us data on household characteristics.

†Corresponding author: Vienna University of Economics and Business (WU), klaus.gugler@wu.ac.at

‡Mines Paris - PSL, Paris, and ZEW Center for European Economic Research Mannheim and CEPR, sven.heim@mines-paristech.fr

§University of Vienna and CEPR, maarten.janssen@univie.ac.at

¶Friedrich-Alexander-Universität Erlangen-Nürnberg (FAU), mailto:mario.liebensteiner@fau.de

This is the author's accepted manuscript without copyediting, formatting, or final corrections. It will be published in its final form in an upcoming issue of Journal of Political Economy Microeconomics, published by The University of Chicago Press. Include the DOI when citing or quoting: https://doi.org/10.1086/725335. Copyright 2023 The University of Chicago.

1. Introduction

Many markets are characterized by a substantial asymmetry between an incumbent provider and competing firms in that consumers know the contract with their current provider, but have to pay a search cost to be informed of alternative contracts. Once they observe other contracts, consumers have to pay a transaction cost to switch to alternative providers. This is the case, for instance, in markets such as electricity or gas, where liberalizations have taken place but the former incumbent still serves a large fraction of consumers. The incumbent can use this asymmetry to price discriminate between consumers with high and low search costs.

This paper studies how the optimal pricing policies of the incumbent and entrants depend on consumer search behavior. Our empirical analysis focusses on local retail electricity markets in Germany: each local market has an incumbent from the pre-liberalization era and many retailers that have entered the market since.[1] Consumers may search for tariffs at an online platform and decide whether to switch to a cheaper tariff offered by the incumbent – a form of price discrimination by the incumbent between searching and non-searching consumers – or to an even cheaper rate offered by an entrant retailer. We show that differences in the fraction of searching consumers across local markets explain quite a large part of the observed heterogeneity in pricing behavior: in markets where consumers search more, there is more price discrimination by the incumbent and overall price dispersion is also larger. Our theoretical model shows that the empirical findings are consistent with the strategic incentives of market participants, but that other pricing patterns are also possible, and it also performs a welfare analysis.

By describing the model, the main features of the market become clear. Consumers observe the baseline price of the incumbent at no cost. Having observed this price, consumers decide whether or not to search for alternative tariffs. Search is costly and allows the consumers to observe all other prices in the market by consulting an online price-comparison platform. As consumers are heterogeneous in their search costs, some consumers search the platform, while others do not. At the platform, consumers choose between buying from the lowest-price entrant or staying with the incumbent at the incumbent's online discount price. As the transaction costs of switching suppliers differ across consumers, some consumers who search the platform will stay with the incumbent, even if the incumbent's discount price is not the lowest price on

[1] Many electricity markets around the world have similar characteristics. See, e.g., Cabral (2017) for evidence related to different European countries, Hortacsu et al. (2017) for evidence on the USA, and Byrne et al. (2022) for Australia.

This is the author's accepted manuscript without copyediting, formatting, or final corrections. It will be published in its final form in an upcoming issue of Journal of Political Economy Microeconomics, published by The University of Chicago Press. Include the DOI when citing or quoting: https://doi.org/10.1086/725335. Copyright 2023 The University of Chicago.

the platform. This way, the incumbent can price discriminate between consumers with high search costs (those who do not search) and lower search costs (those who search) and prevent searching consumers (those with high transaction costs) from switching to a retail competitor. We show that by varying the search cost distribution, this simple model can accommodate a rich pattern of pricing behaviors, including the one we find in our empirical analysis, where price dispersion and price discrimination increase with the fraction of consumers who search online, and where the incumbent raises its baseline price to consumers who do not search. In a welfare analysis, we show that banning price discrimination benefits high search cost consumers, but makes low search cost consumers worse off.

The empirical part of our analysis uses a unique data set on retail electricity prices and consumer search intensity at online platforms at the German zip-code level for the period 2011–2014. The German retail electricity market has been liberalized at the end of the previous millennium, where former local monopolies have been replaced by local retail competition. Since then, local incumbent suppliers compete with new entrants. All consumers are by default served by the incumbent at a baseline tariff, which is the most expensive tariff in a local market, but have the freedom to search for cheaper offers. Even though in recent years most consumers use online platforms to search for cheaper rates,[2] in 2015 76% of all households were still served by the incumbent – with 33% remaining at the expensive baseline tariff, while 43% having switched to a cheaper incumbent tariff – and only 24% have switched to an entrant (BNetzA, 2015). Hence, some two decades after liberalization, the incumbent still prices well above costs, strategically price discriminating between different types of consumer groups, thereby having successfully prevented many consumers from switching to entrants.

A key feature of our data is that we can measure the consumer search intensity per zip code and year. In particular, we have data on the actual number of households' search queries at online price comparison platforms, and given that most of the search for lower prices is via these platforms, we interpret these data as a direct measure of search intensity at the local level. With some notable, recent exceptions (such as De los Santos et al., 2012; Blake et al., 2016; Coey et al., 2020), other empirical studies on consumer search markets often have to rely on indirect measures of consumer search activity.[3]

[2] According to a 2011 survey, 80% of the switchers searched online for alternative providers (A.T. Kearney, 2012). This number is likely to have increased in more recent years.

[3] Brynjolfsson and Smith (2014), for example, use access to the internet as a proxy for lower search costs. Similarly, for retail gasoline markets, Pennersdorfer et al. (2020) use commuters versus non-commuters to distinguish between informed and uninformed consumers.

This is the author's accepted manuscript without copyediting, formatting, or final corrections. It will be published in its final form in an upcoming issue of Journal of Political Economy Microeconomics, published by The University of Chicago Press. Include the DOI when citing or quoting: https://doi.org/10.1086/725335. Copyright 2023 The University of Chicago.

In terms of prices, we observe the incumbent's baseline tariff and the incumbent's cheaper online price, as posted at the platform. We also observe the lowest online price, offered by an entrant retailer. Using these data, we empirically show that incumbents increase their baseline rates when consumer search more. Moreover, the incumbent increases the extent of price discrimination and lowers its online tariff significantly when consumers search more at platforms. We also find that entrants reduce their tariffs with more consumer search. We estimate that a one-standard deviation increase in within-zip-code search intensity explains nearly 50% of the observed price discrimination. Hence, one key take-away message of our analysis is that, confronted with competitors entering the market, an incumbent can increase profits by price discriminating between consumers with different search costs. As consumer search intensity may also be a function of price (e.g. Tappata, 2009; Lewis, 2011; Lewis and Marvel, 2011; Byrne and De Roos, 2017; Cabral and Gilbukh, 2020; Heim, 2021), and because retailers' pricing strategies depend on consumers' search efforts, endogeneity may be a concern in the empirical analysis. We thus employ an instrumental variable to address the potential endogeneity of search intensity. In particular, we take the search intensity for *heating gas* tariffs as instrument for electricity search. As the same households or households with similar features search for electricity and heating gas tariffs, these two search intensities are correlated, but search for heating gas tariffs does not directly cause electricity prices.

Many markets where market liberalizations have taken place (including electricity markets in several states of the USA, Canada, other EU Member States) share important features with the German electricity market. In all these markets, new firms have entered, incumbents may engage in price discrimination, and there is an important asymmetry, as consumers know the base price of the incumbent, but have to incur a search cost to learn prices set by entrants. Other liberalized sectors, such as natural gas, telecommunications, health insurance, railways, postal services, and airlines share similar features. A key dividing line between these examples is whether or not consumers have an ongoing relation with their suppliers. Thus, markets, such as electricity, telecommunications, and health insurance markets have the feature that consumers are naturally informed about their current supplier and will automatically continue their contract as long as they do not search for and switch to alternatives. The role of incumbency effects is also of importance to sectors beyond the liberalization context, such as retail banking, where (online) searching consumers may get much better deals than loyal consumers.[4]

[4]For example, the article "American banks pay depositors less than online accounts", in The Economist (2018)

This is the author's accepted manuscript without copyediting, formatting, or final corrections. It will be published in its final form in an upcoming issue of Journal of Political Economy Microeconomics, published by The University of Chicago Press. Include the DOI when citing or quoting: https://doi.org/10.1086/725335. Copyright 2023 The University of Chicago.

Our study contributes to different strands of literature. There is a large and varied theoretical literature on how consumer search affects price dispersion in homogeneous goods markets (see, e.g., Stahl, 1989, and Janssen and Moraga-González, 2004). Several empirical studies focus on price dispersion and search intensity (see, e.g., Sorensen, 2000; De los Santos et al., 2012). Tang et al. (2010) find that an increase in shopbot use reduces average prices and price dispersion in online book retailing. Lach and Moraga-González (2017) show that competition may be more beneficial for consumers who are better informed. Pennersdorfer et al. (2020) find an inverted U-shaped relation between price dispersion and the share of informed consumers (as proxied by the share of commuters) in the Austrian gasoline retail market. This literature does not, however, deal with incumbency effects or the possibility of price discrimination.

A growing literature explicitly deals with search in electricity markets, but most of these papers mainly focus on how consumers search without considering the implications for price setting. Giulietti et al. (2014a) analyze the retail electricity market in the United Kingdom and find that roughly half the households had relatively high search costs. Hortacsu et al. (2017) analyze switching in the Texas retail electricity market and find that even though households rarely switch to alternative retailers, they do switch more after experiencing a "bill shock". Moreover, they also find that households attach a brand advantage to the incumbent. Both papers do not observe the actual search behavior of consumers, however. Dressler and Weiergraeber (2019) use a structural demand model of the Belgian electricity market focusing on switching costs and limited awareness. In contrast, Byrne et al. (2022) use a field experiment to study how heterogeneous search frictions are used by electricity firms in Australia to differentiate between consumers by combining posted prices and sequential bargaining with individual households. There setup is different since private negotiations do not play a role in Germany.[5]

Another related literature argues that entry may lead to higher incumbency prices and/or profits (see, e.g., Perloff et al., 1995; Ishibashi and Matsushima, 2009). In all these models, because of either horizontal or vertical product differentiation, after entry the incumbent will focus on a more targeted group of consumers that are less price sensitive. Using a similar

states that established U.S. banks generally offer substantially lower interest rates on savings accounts compared to online rates offered to clients at internet portals. Allen et al. (2019) show that banks have an incumbency advantage for mortgage services because the large majority of consumers combines day-to-day banking and mortgage services opening the possibility to price discriminate between consumers with different outside options and/or search costs.

[5] In Australia, if customers cancel their contract with the current supplier the supplier may approach these customers with a better offer in order to win them back. This is not the case in Germany where the switching process is different in that a consumer first chooses its new electricity supplier and the new supplier will conduct the whole switching process, including the termination of the contract with the current supplier.

This is the author's accepted manuscript without copyediting, formatting, or final corrections. It will be published in its final form in an upcoming issue of Journal of Political Economy Microeconomics, published by The University of Chicago Press. Include the DOI when citing or quoting: https://doi.org/10.1086/725335. Copyright 2023 The University of Chicago.

logic, Doganoglu (2010) shows that small switching costs may lead to lower prices relative to a situation without switching costs. Even though the mechanism of our theoretical model also relies on the incumbent targeting a specific group of consumers, our focus is different as we take entry as given and analyze the incumbent's price discrimination strategy and how it depends on search and switching behavior.

There is a small literature dealing with price discrimination and incumbency. For the UK retail electricity market, Davies et al. (2014) present evidence suggesting that firms deliberately differentiated their tariff structures, resulting in market segmentation according to consumers' usage. For the US airline industry, Goolsbee and Syverson (2008) indicate that incumbents respond to the threat of entry by substantially reducing average fares on the directly threatened routes, but that they do not cut prices on routes to nearby airports in the same market. This bears some relationship to our result that the incumbent price discriminates between searching consumers who may choose an alternative option and non-searching consumers who do not. Allen et al. (2019) study the Canadian mortgage market, in which firms and consumers individually bargain about contracts, and estimate that search frictions cause an incumbency advantage, which generates significant consumer welfare losses. A difference between their setup and ours is that in Allen et al. (2019) prices are negotiated and each customer gets a different price offer depending on their search costs. In our setup, the incumbent sets two relevant prices, resulting in price discrimination between high and low search-cost consumers. This way, our model predicts that high-search-cost consumers can be worse off the higher the search intensity in a market, while in their setup, the price of a customer with high search cost is not affected by the share of customers with low search cost.

At a theoretical level, the idea that a firm would like to price discriminate against consumers with higher search cost is not new. Salop (1977), for example, studies a monopoly setting and his argument critically depends on the assumption that the monopolist is committed to charging prices according to a price distribution, while consumers can somehow react to changes in the price distribution (assuming they observe the distribution, but not the prices) by adopting a different search strategy. Cabral (2016) analyzes conditions for which switching costs may lead to higher or lower equilibrium prices in markets where sellers discriminate between locked-in and not locked-in consumers. Cabral and Gilbukh (2020) also model firms engaging in price discrimination between active and passive searchers. Unless they pay a search cost, consumers buy from the high price of a firm. The focus of Cabral and Gilbukh (2020) is, however, very

This is the author's accepted manuscript without copyediting, formatting, or final corrections. It will be published in its final form in an upcoming issue of Journal of Political Economy Microeconomics, published by The University of Chicago Press. Include the DOI when citing or quoting: https://doi.org/10.1086/725335. Copyright 2023 The University of Chicago.

different from ours in that they study symmetric firms facing cost shocks, where we focus on how asymmetric pricing is affected by the presence of more searching consumers. Armstrong and Vickers (2019) analyze the welfare effects of price discrimination in the presence of captive consumers who only buy from the incumbent while others choose freely among alternative offers. While Armstrong and Vickers (2019) do not analyze search behavior of consumers, their main result is that the welfare effects of price discrimination depend on the degree of symmetry between firms. With symmetric firms, discrimination against captive customers harms consumers overall because it does not affect profits but widens the variation of profit across consumers (profit varies with consumer surplus and consumers are risk averse). Fabra and Reguant (2020) model price discrimination in a market where sellers compete for buyers, who differ in their search costs and in size, essentially determining their willingness to search. While sellers do not observe buyers' search costs, they form beliefs about them based on observed buyer size. This is different from our setup, where the incumbent sets a cheaper tariff to those consumers who search at a platform, whereas all consumers have the same buyer size (3.5 MWh of electricity per year).

The rest of the paper is structured as follows. Section 2 describes the German retail electricity market in more detail. Section 3 provides a theoretical model to guide the empirical approach and findings. Section 4 describes the empirical identification strategy and Section 5 discusses the data. Section 6 presents the econometric results and Section 7 discusses their robustness. Section 8 concludes.

2. Institutional Details

In 1999, Germany's electricity liberalization brought about the end of local monopolies by allowing entry to local retail markets. While electricity generation continued to be in the hands of a few firms, it was believed that increased retail competition and freedom of consumer choice would result in large economic benefits for consumers. Prior to market liberalization, the local incumbent served all customers in its distribution grid area at a regulated tariff. Since liberalization, the incumbents have been legally obliged to supply electricity at a default baseline tariff to all households which do not proactively choose another supplier. Moreover, a household that moves to another zip code is automatically supplied by the local incumbent at its baseline

This is the author's accepted manuscript without copyediting, formatting, or final corrections. It will be published in its final form in an upcoming issue of Journal of Political Economy Microeconomics, published by The University of Chicago Press. Include the DOI when citing or quoting: https://doi.org/10.1086/725335. Copyright 2023 The University of Chicago.

tariff.[6] However, the incumbents' baseline tariffs are no longer regulated and households are free to switch to alternative tariffs that are offered by one of the many new entrants or by their local incumbent. Consumers can switch away from the *incumbent baseline* tariff at any time with two weeks' notice. Consumers who switch generally take a one-year contract with their new supplier, which is automatically renewed if the consumer does not cancel the contract in time.[7]

Entry in the retail market involves low entry costs and risks. This is also witnessed by the large number of active retailers: there are on average 133 electricity retailers per zip code, with a range of 55 to 192. In contrast to incumbent electricity providers, which are typically vertically integrated (possessing power plants to generate electricity and retailing electricity to end consumers), entrant retailers are typically small, non-integrated resellers/arbitrageurs, buying electricity at the wholesale market and selling it at a margin to final consumers.

Another important market characteristic is that retailers competing in a zip code have almost identical costs: some cost components, such as grid charges and concession fees, differ over time and across zip codes, but are equal for all retailers in a zip code. Other cost components, such as the surcharge for renewable energy subsidies, only change over time but do not have local variation. Costs for purchasing wholesale electricity are also almost identical across retailers since wholesale electricity prices are determined centrally at the European Energy Exchange (EEX).[8] Some other costs, such as administrative or advertisement costs, may differ across retailers but account only for a minor part of the (variation in) retail costs. Thus, while costs are similar for all retailers within a local market, they vary substantially across local markets. Many incumbents operate only at a very local level and 46% of the incumbents only have a single zip code in their incumbency area. These small incumbents are mostly municipal utilities. The incumbency areas of incumbents with more than one zip code cover five zip codes at the median and 32 at the mean. Hence, as the costs differ between zip codes, incumbents serving more than one zip code area face different costs within their incumbency area, and on average they set 3.5 different prices in their incumbency areas. Incumbents operating in more than one price zone set prices that differ, on average, by 10.4 Euro per year for a typical household with

[6] By law, the incumbent in a zip code area is defined as the local retailer with the largest customer base. Thus, even though in theory a different retailer may become incumbent, in practice the original incumbent has hardly ever changed.

[7] According to a market report by the German regulatory authority BNetzA (2013, p. 150), the average contract period is 10 months, suggesting that most consumers choose yearly contracts.

[8] Even if firms buy electricity through direct contracts with electricity producers, the spot price still represents the opportunity costs of purchasing electricity.

This is the author's accepted manuscript without copyediting, formatting, or final corrections. It will be published in its final form in an upcoming issue of Journal of Political Economy Microeconomics, published by The University of Chicago Press. Include the DOI when citing or quoting: https://doi.org/10.1086/725335. Copyright 2023 The University of Chicago.

an annual electricity consumption of 3.5 MWh.[9,10] Thus, retailers set local prices that vary in most cases at the zip-code level.

In recent years, most households, which consider changing their supplier, visit an online price comparison platform. Despite this fairly recent trend of searching via online platforms, in 2011 80% of the switchers had already searched online for alternative providers (A.T. Kearney, 2012). The switching rate has been growing in recent years (see Figure 1), as online price comparison platforms have significantly reduced the costs of searching for cheaper providers (something that is also acknowledged in other markets; e.g., Bar-Isaac et al., 2012). A comparison portal requires a consumer to enter all relevant details (zip code, expected yearly electricity consumption, whether the contract is for private or commercial use). Then, there are several options to choose from, such as whether to only consider "green" electricity, whether prices are guaranteed throughout the year, and whether the listed tariffs should include one-off bonuses. The platform then lists the "personalized" prices of all providers that are active in the indicated zip code, ranked from lowest to highest. For each tariff, the platform also provides information on how much consumers can save over the year compared to the incumbent's baseline price. Thus, the search process costs some time and effort, but for all consumers who are familiar with online shopping, the search costs are relatively small compared to the potential savings of switching from the incumbents' baseline tariff to the overall cheapest tariff, which are, on average, almost 200 Euro per year for a standard two-person household with 3,500 kWh consumption (as shown in the sample statistics presented in Table 1 in the data section).

Not only have search costs declined over time, switching costs have also been significantly reduced, because switching is now an automated process and conducted entirely by the new provider, which automatically arranges all switching activities for new customers, such as unsubscribing from the old supplier and registration, at no additional cost.[11]

There is a tiered pricing system in Germany (two-part tariffs with a fixed and a variable component). The consumption profiles depend on how much consumers heat, if they use air conditioning, how much time they watch TV, etc. For their tariff choice, household consumers

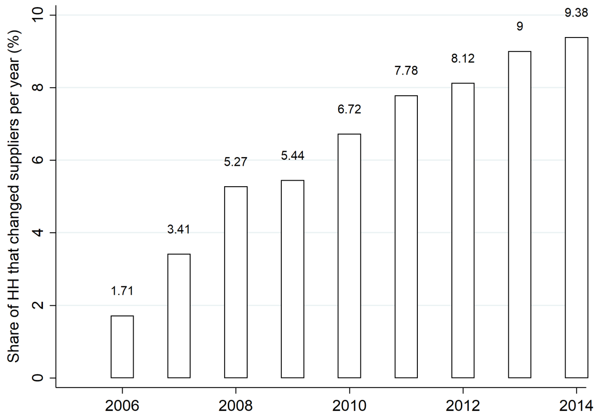
[9]The largest observed difference of the baseline tariffs within the same incumbency area, i.e. 134 Euro/MWh, was offered by E.ON Avacon Vertrieb GmbH in 2012, which served 189 zip codes with 14 different price zones.

[10]As an illustrative example, Online Appendix Figure F1 shows the base tariffs set by Envia Mitteldeutsche Energie within its incumbency area.

[11]In many other countries, the switching process for electricity providers is comparable to the one in Germany's retail electricity markets. E.g., studying the UK market, Giulietti et al. (2014a, p. 561) argue that "search is perceived by consumers as being significantly more difficult than switching." A similar point has been made by Hortacsu et al. (2017) for Texas.

This is the author's accepted manuscript without copyediting, formatting, or final corrections. It will be published in its final form in an upcoming issue of Journal of Political Economy Microeconomics, published by The University of Chicago Press. Include the DOI when citing or quoting: https://doi.org/10.1086/725335. Copyright 2023 The University of Chicago.

Figure 1: Average switching rates of households in German retail electricity markets



Note: Data on supplier changes are obtained from Germany's regulatory authority (BNetzA, 2015), data on the number of German households are from the German Federal Statistical Office.

thus typically consider their average annual electricity consumption (e.g. as stated in their last year's electricity invoice).

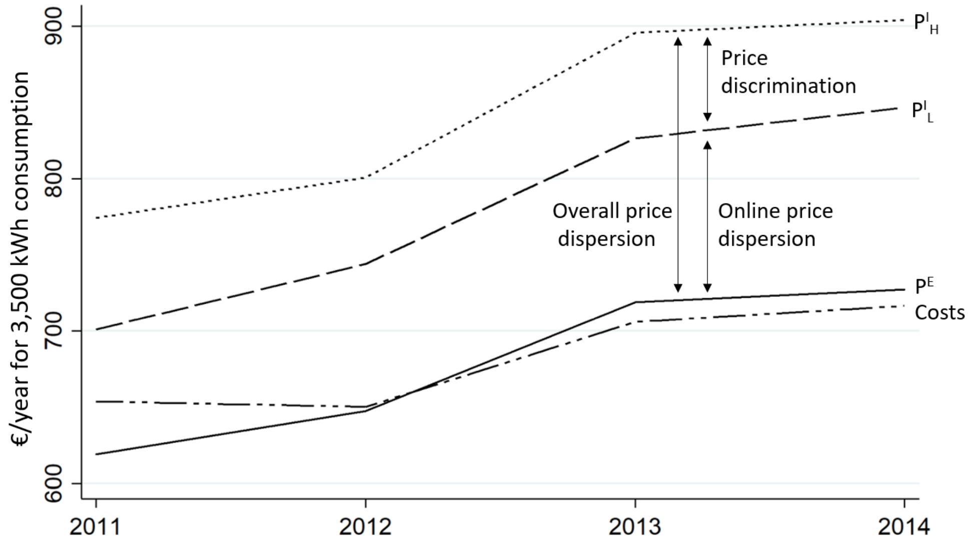
Finally, as there are no retailer specific differences regarding the quality of supply, retail electricity can be considered a fairly homogeneous product, which helps us to rule out product differentiation as a possible explanation for price dispersion. If an entrant fails to deliver, the incumbent provider has the legal obligation to deliver electricity at the baseline tariff without interruption. Not all consumers may be aware of this safety net, however. Hence, even though theoretically it should not matter for the end-consumer which retailer delivers the electricity, it still may matter in practice.

As prices other than the incumbent baseline tariff can only be observed by consumers who proactively search, an incumbent is able to have an online tariff that is lower than the baseline tariff. The incumbent's online tariff is larger than the cheapest overall tariff set by an entrant. Figure 2 shows that there are considerable price differences between the incumbent's baseline tariff P^I_H (Price Incumbent High), the incumbent's lower online tariff P^I_L (Price Incumbent Low), and the overall cheapest entrant tariff P^E (Price Entrant). As consumers who switch away from the incumbent most likely choose the cheapest tariff available, we focus on the cheapest entrant price.[12] As a result, we observe three forms of price dispersion: (i) Overall *price dispersion* $(P^I_H - P^E)$, which is the difference between the incumbent's baseline tariff and the overall cheapest tariff; (ii) *price discrimination* by the incumbent $(P^I_H - P^I_L)$, measured by the difference between the incumbent's baseline tariff and the incumbent's cheaper online tariff;

[12]This is supported, for example, by Baye et al. (2006) in the market for handheld PCs.

This is the author's accepted manuscript without copyediting, formatting, or final corrections. It will be published in its final form in an upcoming issue of Journal of Political Economy Microeconomics, published by The University of Chicago Press. Include the DOI when citing or quoting: https://doi.org/10.1086/725335. Copyright 2023 The University of Chicago.

Figure 2: Average tariffs and costs (€/year for 3,500 kWh)



Note: P^I_H, P^I_L, P^E denote the incumbent's baseline tariff, the incumbent's cheaper online tariff, and the overall cheapest entrant tariff, respectively. Costs and prices are presented net of value added taxes.

and (iii) *online price dispersion* measured by the difference between the incumbent's cheaper online tariff and the cheapest entrant tariff $(P^I_L - P^E)$.[13]

Figure 2 also depicts the (approximated) costs of retailers (see Section 5 for more details). We see that costs and prices have increased over time (mostly due to increased taxes and levies to finance the integration of renewables). Evidently, even nearly two decades after the retail liberalization in the industry, the incumbent baseline tariff remains well above costs. Moreover, the figure emphasizes that incumbents price discriminate with the cheaper incumbent online price, which is still well above cots. By contrast, the cheapest tariffs set by entrants are very close to costs.

3. A Simple Search Theoretic Model

In this section, we consider a simple model that describes the main features of the market and show how the incentives of electricity providers and consumers interact to produce the patterns of price discrimination and price dispersion we find across different local markets. We also perform a welfare analysis. The model features apply to any liberalized market where an incumbent firm competes with entrants for a homogeneous product and the incumbent is able to price discriminate between searching and loyal consumers.

[13] We employ the price range as our dispersion measure, which is a commonly used measure in the literature (Baye et al., 2006). In our case, the price range best reflects the potential gains from search.

This is the author's accepted manuscript without copyediting, formatting, or final corrections. It will be published in its final form in an upcoming issue of Journal of Political Economy Microeconomics, published by The University of Chicago Press. Include the DOI when citing or quoting: https://doi.org/10.1086/725335. Copyright 2023 The University of Chicago.

The model describes how we think of the market interaction between incumbent and entrants and closely follows the institutional details described above. All consumers observe the regular (baseline) price P_H^I of the incumbent at no additional costs and can consult an online price comparison website at a search cost s that differs across consumers. The search cost distribution function in a zip code area is denoted by $F(s; z)$, where we use z to represent exogenous parameters that determine the shape of the search cost distribution in a zip code area. By varying z, we determine how pricing patterns across different local markets depend on exogenous factors affecting the search cost distribution. In the empirical part of the paper, z is an instrument that is exogenous to search and that does not directly affect pricing strategies.[14] The search cost reflects the time it takes consumers to get familiar with the tariff-comparison platform and to enter the required personal information on the price comparison website. At the website, consumers will see potentially many prices, but (in line with the data we have) we are only interested in two of them: the price P^E of the overall cheapest firm (usually an entrant) and the cheapest (online) price P_L^I of the incumbent.

Apart from their search cost, consumers also pay a transaction cost if they want to switch away from the incumbent. These costs also differ between individuals and refer to all the objective and psychological costs consumers face if they switch. As explained in Section 2, the objective switching costs are small, but consumers may perceive the incumbent as more trustworthy. To keep the analysis simple, we assume that these transaction costs are proportional to the search cost, *i.e.*, the transaction cost of a consumer with search cost s is denoted by θs.[15] Thus, once a consumer with search cost s is online and observes both prices P^E and P_L^I, the consumer will continue to buy from the incumbent if $P_L^I - \theta s < P^E$.

We make two further simplifying assumptions. First, in real markets, the following dynamic aspect may play a role: once some consumers have switched to entrants, they gain some incumbency effect as these consumers will have to search at a later moment if they want to switch away from their provider. Thus, over time entrants and incumbents may become more symmetric to each other. In the theoretical model, we have abstracted from these considerations as individual entrants in local German electricity markets typically have a very small market

[14] In the main specification of the empirical model, we use consumer search for heating gas tariffs as this summarizes characteristics that affect search cost in general, such as the local availability of broadband internet without being affected itself by (expected) electricity prices.

[15] For example, consumers with higher search costs may be older and more wealthy and they also have higher transaction cost as they do not want to risk their stable delivery of electricity by switching. If search and transaction costs are independently distributed, then the analysis becomes more complicated, but similar results could be obtained.

This is the author's accepted manuscript without copyediting, formatting, or final corrections. It will be published in its final form in an upcoming issue of Journal of Political Economy Microeconomics, published by The University of Chicago Press. Include the DOI when citing or quoting: https://doi.org/10.1086/725335. Copyright 2023 The University of Chicago.

share.[16] Second, our main model looks at the behavior of one entrant that does not compete with other entrants. We use this as a short-hand approximation for the small incumbency effect entrants may have. It can be shown that qualitatively similar effects continue to hold if entrants engage a la homogeneous Bertrand competition with each other (see footnote 21).

The sequence of actions is as follows. In the first-stage, the incumbent and entrant choose prices P_H^I, P_L^I, and P^E simultaneously.[17] At the beginning of the second-stage, consumers only observe P_H^I and decide whether or not to search based on their expectation regarding online prices. If they do not search, they buy from the incumbent at P_H^I. If they do search, they observe the online prices and buy where it is best for them, taking the transaction cost into account. We use perfect Bayesian equilibrium with passive beliefs as our solution concept. Thus, we look for an equilibrium where consumers have correct beliefs about the online prices and where if consumers observe an unexpected price P_H^I (different from the equilibrium level), they will continue to believe that P_L^I and P^E are at their equilibrium levels.

A natural candidate for an equilibrium is where low search cost consumers with $s < \widehat{s}_2$ search online and all other consumers stay with the baseline price of the incumbent. Moreover, of the consumers that search online, the ones with a transaction cost $\theta s < \theta \widehat{s}_1$, with $\widehat{s}_1 < \widehat{s}_2$, buy from the entrant, while other online consumers, namely those with $\widehat{s}_1 < s < \widehat{s}_2$, buy from the incumbent at its online price. In such an equilibrium, the cut-off values for search costs are $\widehat{s}_1 = \left(P_L^I - P^E\right)/\theta$ and $\widehat{s}_2 = \left(P_H^I - P_L^{I^e}\right)$.[18]

Assuming, without loss of generality, that the firms have no supply cost, the equilibrium prices we derive can be interpreted as firms' margins. Thus, the respective profits of the entrant and incumbent are as follows:

$$\pi_E = F(\widehat{s}_1; z)P^E = F\left(\frac{P_L^I - P^E}{\theta}; z\right) P^E$$

and

[16] As explained in the previous section, there are on average 133 firms active in every zip code, while the incumbent provider continues to have around 76% market share. This implies that on average entrants have less than 0.2% market share.

[17] In Section D of the Online Appendix, we consider an alternative "Stackelberg" version of the model where the incumbent first chooses its baseline price P_H^I, and P_L^I and P^E are chosen at the moment P_H^I is given and observed by the entrant. This model yields the same qualitative predictions.

[18] Note that in the definition of $\widehat{s}_2$ we have the incumbent's online price $P_L^{I^e}$ consumers *expect* to find *if* they search and not the realized price, because when deciding whether or not to search, consumers do not know the online price. Note also that $\widehat{s}_1$ is defined in terms of realized prices as all consumers with an $s < \widehat{s}_2$ visit the platform and decide from whom to buy after observing both prices.

This is the author's accepted manuscript without copyediting, formatting, or final corrections. It will be published in its final form in an upcoming issue of Journal of Political Economy Microeconomics, published by The University of Chicago Press. Include the DOI when citing or quoting: https://doi.org/10.1086/725335. Copyright 2023 The University of Chicago.

$$\begin{aligned}\pi_I &= \left[F(\widehat{s}_2; z) - F(\widehat{s}_1; z)\right] P_L^I + (1 - F(\widehat{s}_2; z))P_H^I \\ &= \left[F(P_H^I - P_L^{I^e}; z) - F\left(\frac{P_L^I - P^E}{\theta}; z\right)\right] P_L^I + (1 - F(P_H^I - P_L^{I^e}); z)P_H^I.\end{aligned}$$

This yields the following F.O.C.s (evaluated at the equilibrium where $P_L^{I^e} = P_L^I$) for the entrant and the incumbent, respectively:

$$F\left(\frac{P_L^I - P^E}{\theta}; z\right) - f\left(\frac{P_L^I - P^E}{\theta}; z\right)\frac{P^E}{\theta} = 0, \tag{1}$$

$$F(P_H^I - P_L^I; z) - F\left(\frac{P_L^I - P^E}{\theta}; z\right) - f\left(\frac{P_L^I - P^E}{\theta}; z\right)\frac{P_L^I}{\theta} = 0, \tag{2}$$

and

$$-f(P_H^I - P_L^I; z)(P_H^I - P_L^I) + (1 - F(P_H^I - P_L^I; z)) = 0, \tag{3}$$

where $f(.)$ is the density function that is associated with $F(.)$. Note that the fraction of actively searching consumers is given by $F(P_H^I - P_L^I; z)$.

For a given z, these three F.O.C.s determine the equilibrium values of $P_H^{I^*}, P_L^{I^*}$ and P^{E^*} and the corresponding levels of price discrimination and price dispersion. To explain our observations, we have to see how these equilibrium price levels change with variations in z. It is clear that a rich set of patterns is possible, and in the Proposition below we focus on the conditions that guarantee that the model generates the patterns we find empirically, namely that price discrimination increases and online price dispersion decreases with the fraction of people in a zip code searching online.

Proposition 1 *The effects of exogeneous changes in the search cost distribution, reflected in changes in z, are as follows. More consumers search and price discrimination increases if, and only if, the inverse hazard rate evaluated at the equilibrium values $\frac{1-F(P_H^{I^*}-P_L^{I^*};z)}{f(P_H^{I^*}-P_L^{I^*};z)}$ is increasing in z. The cheapest online price P^E and online price dispersion are positively related to P_L^I if the density functions are non-increasing, i.e. $\partial f\left(\frac{P_L^I-P^E}{\theta}; z\right)/\partial(P_L^I - P^E) \leq 0$. Finally, online price dispersion and price discrimination are linked by $1 - f(P_H^I - P_L^I; z)(P_H^I - P_L^I) = f\left(\frac{P_L^I-P^E}{\theta}; z\right)\left(\frac{P_L^I+P^E}{\theta}\right)$.*

The economic intuition behind the result on price discrimination is as follows: for a given value of P_L^I the incumbent faces a trade-off in its decision whether or not to increase P_H^I. Raising P_H^I increases the profits over all consumers $1 - F(P_H^{I^*} - P_L^{I^*}; z)$ who stay at the baseline

This is the author's accepted manuscript without copyediting, formatting, or final corrections. It will be published in its final form in an upcoming issue of Journal of Political Economy Microeconomics, published by The University of Chicago Press. Include the DOI when citing or quoting: https://doi.org/10.1086/725335. Copyright 2023 The University of Chicago.

tariff, but a fraction proportional to the density $f(P_H^{I*} - P_L^{I*}; z)$ will decide to search. At the margin, those that decide to search will eventually buy at the incumbent's online price P_L^{I*} as the marginal consumer has a higher search and transaction cost. The incumbent will lose $P_H^{I*} - P_L^{I*}$ per (marginal) consumer who searches. If, evaluated at the equilibrium values, the inverse hazard rate is increasing in z,[19] relatively more consumers will stay at the baseline tariff if z increases, making price discrimination more profitable. Also, in equilibrium, the fraction $F(P_H^{I*} - p_L^{I*})$ of consumers search, which is directly related to the price discrimination strategy of the incumbent. To understand online price dispersion, if P_L^I increases, then there is a larger potential demand for the entrant and, under "normal" demand conditions, it should increase its price, but not to the full extent (thereby also increasing sales).

Combining the effects, consider the special case where the relevant densities remain constant (or are not much affected) and that the change in the search cost distribution is such that the incumbent price discriminates more and more consumers search, then the last equality in the Proposition implies that the sum of online prices must decrease. As the second result implies that online prices and online price dispersion change in the same direction, it must be that they decrease.

The effects outlined in the proposition and the above intuitive explanation rely on the shape of the search cost distribution as the outcome of price discrimination depends on how many consumers continue to stay with the incumbent's baseline price and how many will search and switch to the entrants' and incumbent's online prices. To verify in the data whether this condition holds one needs to know the search cost distribution or access to quantity data on how many consumers buy at which tariff, information we unfortunately do not have.

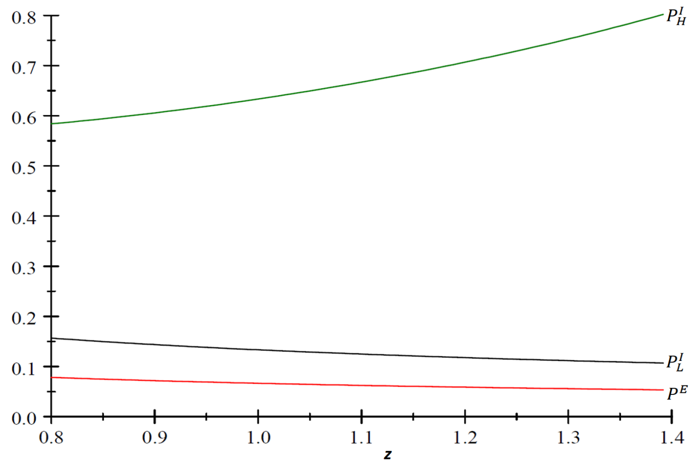
The proposition leaves the effect on the incumbent's baseline price undetermined. In Section C of the Online Appendix, we analyze the case of a piece-wise linear search cost distribution[20] to show that the baseline price may well increase:

[19] Most distributions covered in standard statistics textbooks have an inverse hazard rate $(1-F(x))/f(x)$ that is decreasing in x. We ask, however, the inverse hazard rate to be increasing in an exogenous parameter z on the relevant part of the domain of possible search cost values.

[20] We apply a piece-wise linear search cost distribution for analytic tractability. What is important for our analysis is that the density of the search cost distribution is not constant and this feature is consistent with the estimated search cost distributions for retail electricity as found by Giulietti et al. (2014b). They show (for example their figure 4) that the density is larger at smaller search cost levels, which in our piece-wise linear formulation corresponds to $z > 1$.

This is the author's accepted manuscript without copyediting, formatting, or final corrections. It will be published in its final form in an upcoming issue of Journal of Political Economy Microeconomics, published by The University of Chicago Press. Include the DOI when citing or quoting: https://doi.org/10.1086/725335. Copyright 2023 The University of Chicago.

Figure 3: Model prediction



Note: The figure predicts price changes as a function of z with $\widetilde{s}_2 = 3/5$ and $\widetilde{s}_1 = 1/5$ and $\theta = 2/5$. P_H^I, P_L^I, and P^E denote the incumbents' baseline tariffs, the incumbents' cheapest (online) tariffs, and the overall cheapest entrants' tariffs, respectively.

$$F(s) = \begin{cases} zs & \text{for } s < \widetilde{s}_1 \\ \alpha + \beta s & \text{for } \widetilde{s}_1 \leq \ s < \widetilde{s}_2 \\ s & \text{for } 1 \geq s \geq \widetilde{s}_2 \end{cases}$$

where, to have a proper piece-wise linear distribution function, $\alpha = \frac{(z-1)\widetilde{s}_1\widetilde{s}_2}{\widetilde{s}_2-\widetilde{s}_1}$, $\beta = \frac{\widetilde{s}_2-z\widetilde{s}_1}{\widetilde{s}_2-\widetilde{s}_1}$, $\widetilde{s}_2 > \widetilde{s}_1$, and $z > 0$. If $z = 1$, we have the uniform distribution.

Figure 3 depicts how the different prices change as a function of z when $\widetilde{s}_2 = 3/5$ and $\widetilde{s}_1 = 1/5$ and $\theta = 2/5$. Detailed derivations are given in the online Appendix. As $\partial F(P_H^{I^*} - P_L^{I^*})/\partial z$ is a constant positive number, this figure can also be interpreted as how prices are linked to the fraction of searchers. One can see that the incumbent's baseline price is increasing in the fraction of searchers, whereas the other two prices are decreasing, resulting in more price discrimination and overall price dispersion, while online price dispersion is decreasing. This is also what we find in our empirical analysis (see Section 6).[21]

[21] Similar conclusions about the patterns of the incumbent's prices can be obtained if entrants engage in homogeneous Bertrand competition online. Obviously, in that case $P_E = 0$ and independent of the fraction of consumers that search. This is, however, inconsistent with what we find empirically and the empirical results indicate that entrants also have a small amount of incumbency advantage. The F.O.C.s for the incumbent remain valid, however, in the alternative model and for the piece-wise linear specification with $\widetilde{s}_2 = 3/5$ and $\widetilde{s}_1 = 1/5$ one can show that $P_L^I = \frac{7+3z}{40z}\theta$, while $P_H^I - P_L^I = \frac{13-3z}{10(3-z)}$. It is easy to see that the first expression is decreasing in z, while the second expression is increasing and that P_H^I itself is also increasing for appropriate choices of θ. Thus, if entrants compete a la Bertrand it remains true that if the search intensity increases there is more price discrimination and overall price dispersion, while online price dispersion decreases.

This is the author's accepted manuscript without copyediting, formatting, or final corrections. It will be published in its final form in an upcoming issue of Journal of Political Economy Microeconomics, published by The University of Chicago Press. Include the DOI when citing or quoting: https://doi.org/10.1086/725335. Copyright 2023 The University of Chicago.

3.1. Welfare Effects of Banning Price Discrimination

In this subsection, we briefly consider the welfare implications of banning price discrimination. To this end, we simply force $P_H^I = P_L^I$ (and denote this value by P^I) and solve for the equilibrium values, denoting the price choice of the entrant under "no discrimination" by P_{ND}^E (to distinguish it from the price it chooses when the incumbent can price discriminate). As now we have that

$$\pi_E = F(\widehat{s}_1; z)P^E = F\left(\frac{P^I - P_{ND}^E}{\theta}; z\right) P_{ND}^E$$

and

$$\pi_I = [1 - F(\widehat{s}_1; z)]\, P^I = \left[1 - F\left(\frac{P^I - P_{ND}^E}{\theta}; z\right)\right] P^I,$$

it is easy to see that the two F.O.C.s are given by

$$F\left(\frac{P^I - P_{ND}^E}{\theta}; z\right) - f\left(\frac{P^I - P_{ND}^E}{\theta}; z\right) \frac{P_{ND}^E}{\theta} = 0,$$

and

$$1 - F\left(\frac{P^I - P_{ND}^E}{\theta}; z\right) - f\left(\frac{P^I - P_{ND}^E}{\theta}; z\right) \frac{P^I}{\theta} = 0.$$

Note that these conditions are very close to (1) and (2). In particular, it is clear that as $F(P_H^I - P_L^I; z) < 1$ in (2) in equilibrium $P_L^I < P^I$ and that because of the strategic complementary of the price strategies, $P^E < P_{ND}^E$. Thus, searching consumers are better off with price discrimination. Intuitively, without price discrimination the incumbent has a larger share of "loyal" consumers it serves with the price P^I, compared to when it can price discriminate where P_L^I is meant to compete with the entrant's price and the large share of loyal consumers is "addressed" by P_H^I. Thus, with price discrimination, there is simply more online competition to attract searching consumers.

To compare P_H^I and P^I for the general case (and thus to make an overall comparison of the average price consumers pay[22]) is more difficult. Intuitively, though, it would be natural to have that $P_H^I > P^I$, as under price discrimination the incumbent does not need to directly compete with the entrant's price when setting P_H^I. This is easily confirmed for the uniform distribution of search costs with $\theta < 1$. In that case $P^{E^*} = \frac{\theta}{6}$, $P_L^{I^*} = \frac{\theta}{3}$, and $P_H^{I^*} = \frac{1}{2} + \frac{\theta}{3}$, while $P_{ND}^{E^*} = \frac{\theta}{3}$, $P^{I^*} = \frac{2\theta}{3}$.

For the case of the uniform distribution, it is also easy to calculate the average price consumers

[22] One can also inquire into how the average price depends on the search intensity. The weighted average price is given by $(1 - (F(\widehat{s}_2))P_H^{I^*} + (F(\widehat{s}_2) - F(\widehat{s}_1))P_L^{I^*} + F(\widehat{s}_1)P^{E^*} = P_H^{I^*} - F(\widehat{s}_2)(P_H^{I^*} - P_L^{I^*}) - F(\widehat{s}_1)(P_L^{I^*} - P^{E^*})$.

This is the author's accepted manuscript without copyediting, formatting, or final corrections. It will be published in its final form in an upcoming issue of Journal of Political Economy Microeconomics, published by The University of Chicago Press. Include the DOI when citing or quoting: https://doi.org/10.1086/725335. Copyright 2023 The University of Chicago.

pay. With price discrimination the average price equals $\frac{1}{2}\left(\frac{1}{2}+\frac{\theta}{3}\right)+\frac{1}{3}\frac{\theta}{3}+\frac{1}{6}\frac{\theta}{6}=\frac{1}{4}+\frac{11\theta}{36}$, while without price discrimination, it equals $\frac{2}{3}\frac{2\theta}{3}+\frac{1}{3}\frac{\theta}{3}=\frac{5\theta}{9}$. It follows that as $\theta<1$, on average, the effect of the higher baseline price $P_H^{I^*}$ dominates and that consumers are worse off under price discrimination.[23]

Thus, policy makers generally face a trade-off: banning price discrimination would make people that search online worse off, while it makes those consumers that do not look for lower prices better off. Which effect dominates clearly depends on the distribution of search costs in the population.

4. Identifying the Effect of Consumer Search on Pricing Strategies

To examine the causal effect of consumer search intensity on pricing strategies, we first explain our identification strategy and then describe our data and results.

4.1. Baseline model

The relationship we are interested in can be described by the model:

$$Y_{it}=\beta\cdot\mu_{it}+\gamma\mathbf{X}_{it}+\delta_i+\eta_t+\epsilon_{it}, \tag{4}$$

where the dependent variable Y either denotes an electricity tariff (P_H^I, P_L^I, P^E) or a price difference measure ($P_H^I-P^E$, $P_H^I-P_L^I$, $P_L^I-P^E$) in zip code i and year t, and is a function of consumer search intensity (μ) and a set of control variables ($\mathbf{X}$), which we describe in more detail later. Our data exhibit substantial spatial and temporal variation. This enables us to effectively control for (i) unobserved time-invariant differences across zip codes through zip-code fixed effects (δ_i) and (ii) aggregate shocks across years through year fixed effects (η_t).[24] The error term is denoted by ϵ.

As we only observe consumer search at the online platforms in our sample, but not all consumer search activity, we estimate constant elasticities in a log-log relationship. Thus, our parameter of interest β measures the percentage change in tariffs for a one percent change in search intensity. Assuming that search patterns at other comparison websites are not different

[23] In the online Appendix, we verify that a similar conclusion holds for the piece-wise linear distribution considered above.

[24] Zip-code fixed effects may capture, for example, regional differences in consumer sentiment or price consciousness, which affect electricity tariffs and search behavior. Another example could be that in some areas people have stronger ties to their local incumbent (e.g. a municipal utility). In these regions people are less likely to search and may also accept higher prices by the incumbent, which the incumbent may incorporate in its pricing strategy.

This is the author's accepted manuscript without copyediting, formatting, or final corrections. It will be published in its final form in an upcoming issue of Journal of Political Economy Microeconomics, published by The University of Chicago Press. Include the DOI when citing or quoting: https://doi.org/10.1086/725335. Copyright 2023 The University of Chicago.

from search at the platforms that we observe, the elasticity estimate allows us to make inferences about the whole market.[25]

4.2. Identification

A concern with estimating Equation (4) using ordinary least squares (OLS) is that search intensity is potentially endogenous as consumer search may depend on prices. Indeed, our theoretical model indicates that prices and search intensity are simultaneously determined, while for gasoline markets Byrne and De Roos (2017) find empirical evidence that consumers search more when prices rise or are more dispersed and Heim (2021) finds similar results for electricity retail markets.

Ignoring the simultaneity of pricing and consumer search may bias the OLS estimate of μ. To address this concern, we implement an instrumental variable (IV) strategy. Consistent with our theoretical model, our IV approach relies on the idea that the variation in online search for electricity tariffs is driven by two different sources, one of which is endogenous, while the other is exogenous. The endogenous part is the variation in search intensity caused by changes in prices. The exogenous part is the local variation in search costs. Our identifying assumption requires that (i) the IV is correlated with local search intensity for electricity tariffs through the search cost component (instrument relevance), while (ii) it does not directly affect electricity pricing, but only through its effect on search intensity for electricity tariffs (the exclusion restriction).

We argue that *consumer search for heating gas tariffs* satisfies these conditions and we use this as an IV for *consumer search for electricity tariffs.* As regards (i), consumer search for natural gas tariffs follows a similar procedure in that consumers can visit an online price comparison website. Factors that shift search costs should affect both consumer search for gas tariffs and consumer search for electricity tariffs.[26] The requirement for (ii) is that retail electricity pricing strategies should not cause consumers to search for heating gas prices.

There may be some potential concerns with regard to (ii). First, one may think that electricity prices affect search intensity for gas tariffs because electricity and gas tariffs are correlated. However, while there may be correlation between the wholesale commodity prices of electricity

[25] We also have data on consumer search at the platform *Verivox* for the year 2014 and find a correlation coefficient of 85% between search intensity at Verivox and the platforms in our sample. Verivox's data are only provided as percentages of search in a respective zip code relative to the overall search in Germany, which is why we cannot merge these data with our search data at hand.

[26] In the first stage we find a statistically and economically significant effect (see below). As an example of a factor that may cause variation in local search costs, one may think of the local availability of broadband internet.

This is the author's accepted manuscript without copyediting, formatting, or final corrections. It will be published in its final form in an upcoming issue of Journal of Political Economy Microeconomics, published by The University of Chicago Press. Include the DOI when citing or quoting: https://doi.org/10.1086/725335. Copyright 2023 The University of Chicago.

and gas, our inclusion of year fixed effects controls for such aggregate effects. Moreover, search is driven by price differences between providers at the retail level, not by aggregate wholesale price fluctuations affecting all suppliers. To support this argument, we regress local searches for gas tariffs and local searches for electricity tariffs on local electricity prices, respectively. The estimates indeed suggest that consumer search for electricity tariffs is significantly affected by electricity prices, but consumer search for heating gas tariffs is not. The estimation results for this test and a detailed description are provided in Section B of the Appendix.

Second, one may think that electricity and gas contracts are jointly sold, thereby violating the exclusion restriction. There are indeed some firms selling electricity and gas. However, tied tariffs are not offered at online platforms and at a platform consumers have to decide first whether they want to search for electricity or gas tariffs.

Third, one could also think that gas and electricity are substitutes. This could be a concern for industrial consumers, but our study focuses on households. Households in Germany do not substitute heating gas for electricity in the short-run we consider and certainly not in the time period under consideration. In principle, it would be possible for households to use electric radiators, but this is significantly more expensive than heating with gas. Thus, traditionally electric heating has been rather unusual. Hence, substitution between gas and electricity is no concern for our identification strategy.

Finally, if incumbents have the possibility to raise their rivals' costs, this may be a confounding factor, threatening our identification strategy. Indeed, an incumbent may sell electricity from its power plants to a rival entrant in the retail market, potentially raising rivals' cost. However, as electricity retailers can purchase electricity at wholesale spot or forward markets, via (long-run) bilateral contracts, or in OTC markets, they can always choose to buy anonymously, restricting the possibilities for incumbents to raise their rivals' costs.

As additional control variables, we also include costs and several socio-economic characteristics, such as available income, population density, and average household size, which may confound the impact of search intensity on pricing.

The first-stage equation can be written as

$$\mu_{it} = \alpha \cdot Z_{it} + \gamma^{FS}\mathbf{X}_{it} + \delta_i^{FS} + \eta_t^{FS} + u_{it}, \tag{5}$$

with Z being our instrument, the search intensity for gas tariffs in zip code i in year t. The superscript FS indicates that the parameters concern the first-stage regression. Plugging the

This is the author's accepted manuscript without copyediting, formatting, or final corrections. It will be published in its final form in an upcoming issue of Journal of Political Economy Microeconomics, published by The University of Chicago Press. Include the DOI when citing or quoting: https://doi.org/10.1086/725335. Copyright 2023 The University of Chicago.

first-stage prediction of search intensity for electricity tariffs, $\hat{\mu}$, into (4) yields a causal estimate for the effect of consumer search on price. We further apply several robustness tests. These include, among others, alternative IVs, such as "Hausman-type" instruments or the local availability of broadband internet. These are discussed in Section 7.

5. Data

We use panel data at the German zip code level for the period 2011–2014.[27] As consumers typically have annual contracts, we aggregate all data to the annual level. Table 1 provides summary statistics of the variables in our regressions. Appendix Table B2 additionally reports the between and within standard deviations of our key variables, indicating that we have sufficient temporal and spatial variation. Figures F2–F8 in the Online Appendix provide heat maps of our main variables, search intensity and tariffs, visualizing their between and within variation.

Tariffs. — *ene't*, a German software and data provider for the electricity industry, provided monthly data on retail electricity tariffs and cost components (except for P_L^I, which is already structured annually). In the estimations, we use gross prices (including 19% VAT), which are the relevant prices for end-consumers that are also displayed on the online platforms. We focus on a typical household with an annual consumption level of 3,500 kWh. This is the default consumption level suggested by all major price comparison platforms.[28] The summary statistics in Table 1 show that, on average, a household pays around 1,007 EUR per year for the incumbent's baseline tariff. The incumbent's online tariff is around 8% lower at 931 EUR, while the overall cheapest entrant tariff is around 808 EUR, which is 20% cheaper than the incumbent default tariff. Figure 4 shows the local variation of how much a household can save by switching from the incumbent's baseline tariff to the cheapest entrant across Germany in 2012.

Consumer search intensity. — *ene't* also provided the data on individual consumer search queries for electricity retail tariffs at several online price comparison sites, which enables us to

[27] We have 8,226 zip codes in our data. However, there is an overlap of incumbency areas in some of the zip codes. That is, there may be an incumbent operating one part of a zip code and another incumbent operating another part. We drop all zip codes which have more than one incumbent, reducing the number of zip codes in our data to 7,249.

[28] 3,500 kWh is also the household consumption level that is typically applied by other agencies (e.g. BNetzA, 2015) for comparing retail tariffs. ene't also provided tariff data for other annual consumption levels (2,000 kWh and 4,000 kWh), however only for P_H^I and P^E (but not for P_L^I). Regression estimates using P_H^I and P^E as well as $P_H^I - P^E$ for these alternative consumption levels yield robust results.

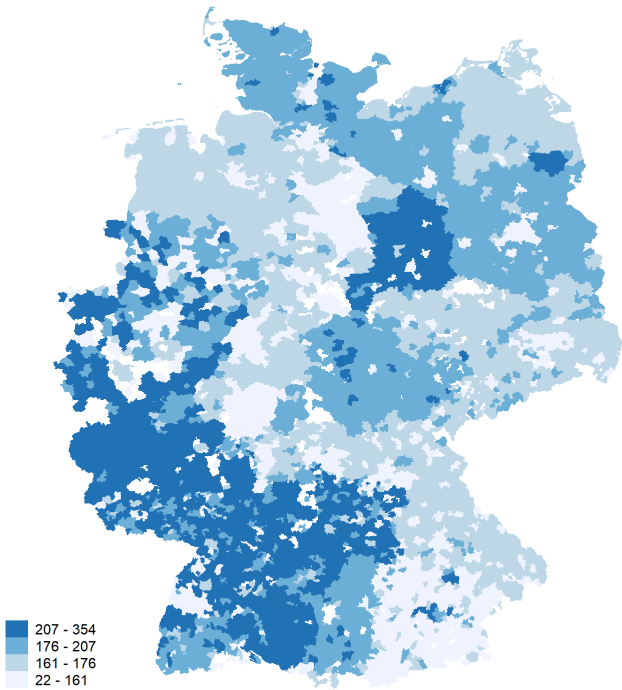
This is the author's accepted manuscript without copyediting, formatting, or final corrections. It will be published in its final form in an upcoming issue of Journal of Political Economy Microeconomics, published by The University of Chicago Press. Include the DOI when citing or quoting: https://doi.org/10.1086/725335. Copyright 2023 The University of Chicago.

Table 1: Summary statistics

Dependent variables					
Incumbent base tariff (P_H^I)	€/a, *ene't*	1006.96	77.71	799.93	1204.15
Incumbent online tariff (P_L^I)	€/a, *ene't*	931.15	84.81	715.90	1117.08
Cheapest entrant tariff (P^E)	€/a, *ene't*	808.20	58.79	667.13	903.03
Price dispersion ($P_H^I - P^E$)	€/a, *ene't*	198.76	38.90	77.16	353.51
Price discrimination ($P_H^I - P_L^I$)	€/a, *ene't*	75.80	40.69	0.00	282.11
Online price dispersion ($P_L^I - P^E$)	€/a, *ene't*	122.96	44.76	0.00	258.97
Variables of interest					
Search for electricity tariffs (μ)	%, *ene't*	9.40	6.47	0.39	36.21
Instruments					
Searches for heating gas tariffs	%, *ene't*	1.97	1.90	0.00	12.07
Control variables					
Costs (net of 19% VAT)	€/a, *ene't* & *EEX*	682.86	42.35	560.31	822.80
Available income	K €/HH, *Acxiom*	43.22	7.55	21.03	110.34
No. households	#, *Acxiom*	4875	4543	132	29891
Household size	Integer, *Acxiom*	2.10	0.19	1.52	2.54
Obs.	25,899				

Notes: "Obs" are zip code-year observations. €/a refers to an annual electricity consumption of 3.5 MWh.

Figure 4: Potential gains from search (2012)



Note: The Figure shows for each zip code the difference between the incumbent's baseline tariff and the cheapest tariff offered by an entrant retailer.

This is the author's accepted manuscript without copyediting, formatting, or final corrections. It will be published in its final form in an upcoming issue of Journal of Political Economy Microeconomics, published by The University of Chicago Press. Include the DOI when citing or quoting: https://doi.org/10.1086/725335. Copyright 2023 The University of Chicago.

construct a direct measure of consumer search intensity for each zip code and year. The database covers detailed information on all search queries conducted at several well-known online price comparison platforms including Toptarif.de, Stromtipp.de, Energie-verbraucherportal.de, and mut-zum-wechseln.de, of which Toptarif.de is by far the largest platform.[29] For each query, we observe a timestamp, the entered zip code for which the offered electricity tariffs are requested, the (expected) yearly consumption entered into the interface, if the search is performed by a household or an industrial customer, and consumer preferences (e.g. only "green" certificated tariffs). In addition, we are also able to track the search history: each platform user obtains a unique search-session ID (created by *ene't*), indicating the order of the queries from the same user).[30] Figure 5 provides a screenshot of the interface of a typical tariff comparison platform. For each tariff the platform shows how much a consumer can save compared to the incumbent's baseline tariff.

In sum, we have information on 35,855,071 search queries from 17,302,530 search sessions of which 96.7% (i.e. 16,778,214 sessions) are conducted by households and the remaining 3.3% (i.e. 524,316 sessions) by industrial customers. As many searchers conduct several search queries within a search session (e.g. comparing prices for different consumption levels) we focus on the number of search *sessions* per year and zip code (rather than on the absolute number of search *queries*). Since our focus is on household consumers, we disregard search by industrial consumers. Furthermore, we exclude 551,256 search sessions, which exclusively consider eco-label (i.e. "green") certified tariffs.[31] Those searches are most likely not predominantly price driven and, on average, €152 more expensive than the cheapest tariff.

We construct our measure of search intensity as the number of search sessions within a zip code per year divided by the number of households:[32] $\mu_{it} = (\text{Search Sessions}_{\text{it}})/(\text{Households}_{\text{it}})$ At the mean, 9.1% of households within a zip code search for retail tariffs at one of our sample comparison platforms, whereas there is substantial variation ranging from 0% to 34.7%.[33]

[29] Toptarif is one of the three major price comparison websites for electricity tariffs, along with Verivox and Check24. It was acquired by Verivox in July 2014 but continues to operate as Toptarif. (Business Insider, 2014, last accessed on May 25, 2021).

[30] We are not able to observe actual switching, because clicking on a certain supplier tariff at the online comparison website redirects the searcher to a website where the switch may be finalized. This limitation is common to online data (see Koulayev, 2014). Yet, switching requires searching, so the impact of consumer search on price strategies seems to be consistently estimable. Bryniolfsson and Smith (2001) confirm this and find that factors that drive clicks are reasonable and unbiased indicators of sales, in their study of online book purchases.

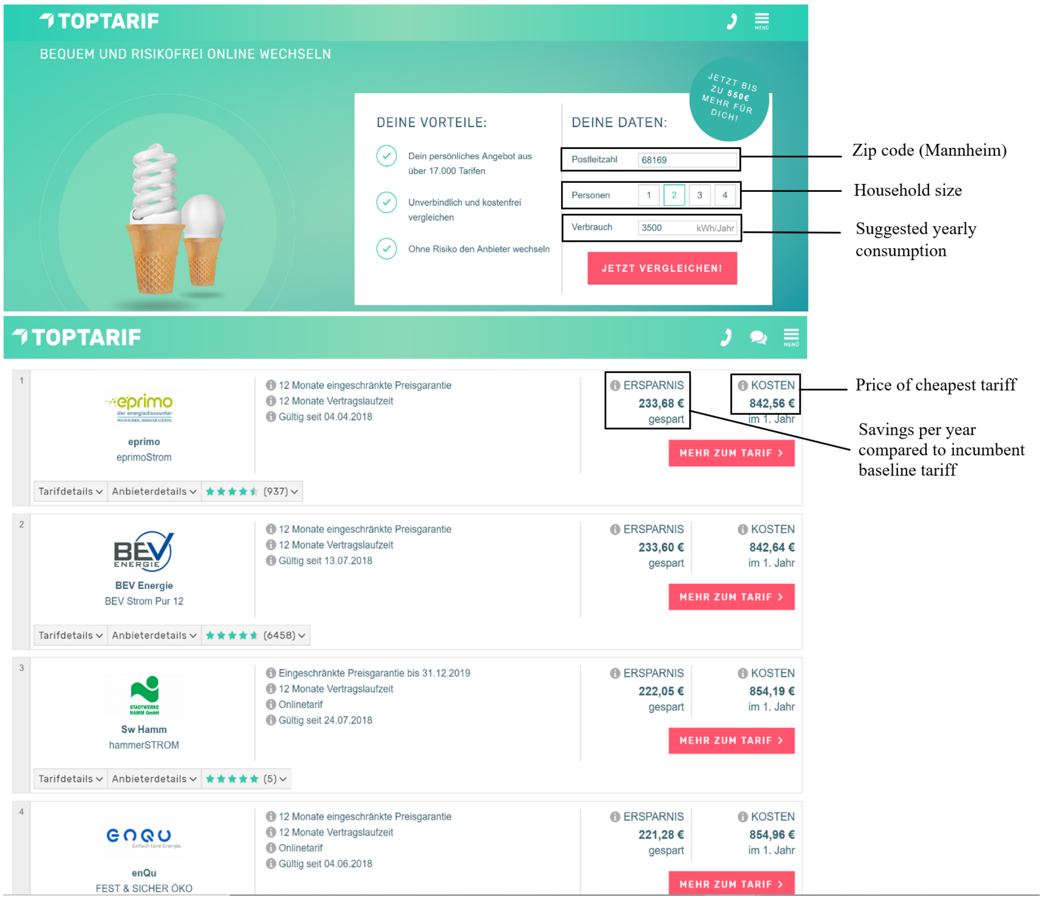
[31] During our sample period 2011–2014, consumers choosing a green-certified tariff only represent 3% of all searching consumers. Nevertheless, our results are fully robust to the inclusion of eco-label searches.

[32] Since we observe some extreme outliers in some zip codes, apparently resulting from price comparing software "bots" or data crawling researchers, we truncate 2% of the upper bound of the sample distribution of our consumer information measure.

[33] This number may slightly overstate the actual search intensity at these platforms because some households

This is the author's accepted manuscript without copyediting, formatting, or final corrections. It will be published in its final form in an upcoming issue of Journal of Political Economy Microeconomics, published by The University of Chicago Press. Include the DOI when citing or quoting: https://doi.org/10.1086/725335. Copyright 2023 The University of Chicago.

Figure 5: Screenshot of a typical online comparison platform



Note: Comparison platforms (here www.toptarif.de) list all available tariffs for a consumer given its expected annual consumption level for its local zip code, starting with the cheapest available tariff (including annual savings compared to the default incumbent baseline tariff). Site accessed on September 18, 2018.

Several factors may cause variation in local search costs. Clearly, an important driver of search intensity is the distribution of search costs, which depend for instance on population characteristics such as income or age (Nishida and Remer, 2018). Another factor is the local development of the broadband internet infrastructure which makes internet usage and online shopping more convenient. Similarly, local advertisements for price comparison platforms, word-of-mouth communication, or discussions about electricity prices and costs in the media may also incentivize consumer search. Of course, retail tariffs also affect search intensity.

Instrument. — Analogously to the construction of our measure for search intensity for electricity tariffs, we construct our measure of search intensity for heating gas tariffs using data on individual search queries for gas tariffs from price comparison websites. Here, we have information on 8,522,591 search queries in total.

---

may search several times per year. We cannot track this as we only observe search sessions by a household per day.

This is the author's accepted manuscript without copyediting, formatting, or final corrections. It will be published in its final form in an upcoming issue of Journal of Political Economy Microeconomics, published by The University of Chicago Press. Include the DOI when citing or quoting: https://doi.org/10.1086/725335. Copyright 2023 The University of Chicago.

Control variables. — We compute a variable reflecting retailers' net costs (excluding VAT) in order to control for spatial and time-variant cost differences. Detailed data on cost components are primarily obtained from *ene't* and include, for example, grid charges, concession fees, renewable energy surcharges (”EEG Umlage”), CHP (combined heat and power) surcharges (”KWK Umlage”) and electricity taxes. Grid charges are paid by the electricity provider to the respective system operator and, thus, vary across grid areas (i.e. clusters of zip codes) and time as they are adjusted annually. The concession fee has to be paid by the system operator to the respective municipality for the right to install and operate electricity cables on public roads. Hence, the concession fees vary at the municipality level and also over time. The remaining cost components only vary over time but not spatially. Moreover, we also add the one-year ahead future prices of electricity at the EEX spot market to our cost variable to proxy for the costs of wholesale electricity, as this one-year ahead price presents the standard purchasing strategy for retailers.[34]

Other control variables refer to structural household characteristics, which we obtained from *Acxiom*, a commercial data service provider. These variables are the available income per household, the average household size, and the number of households per zip code-year pair.

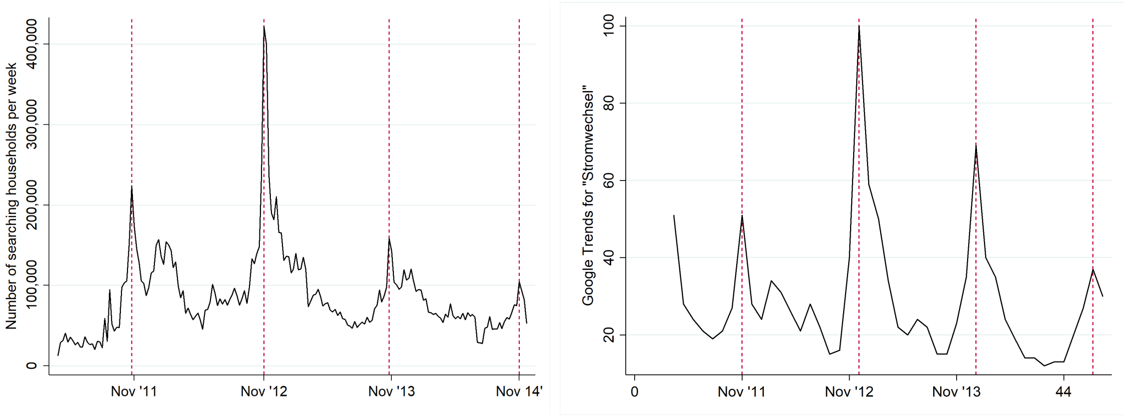
6. Results

Before we present the regression results, we provide some descriptive showing the relationship between consumer search and prices. Every year the German Federal Network Agency (Bundesnetzagentur) announces the adjustment of the renewable energy surcharge (”EEG Umlage”) in midis published in mid-October. The EEG Umlage consitutes a major component of a consumers electricity bill (e.g. 20–22% of the electricity bill in 2014) and electricity retailers have to inform their customers briefly after that – until November 20th – about price changes (BNetzA, 2015, p. 207). The left panel in Figure 6 shows the aggregate weekly search sessions on the online price comparison sites we observe. The vertical solid lines indicates the week of November 20th. It is evident that consumers search more in November immediately after they get informed about price changes. To cross-validate the representativeness of our date we contrast these data with Google Trends data for the word “Stromwechsel” (change of electricity sup-

[34] We do not include potential cost factors such as retention and marketing costs. They are unknown to us but we assume that they do not play a relevant role since consumers simply choose the cheapest tariff on a price comparison platform since electricity is a homogeneous product.

This is the author's accepted manuscript without copyediting, formatting, or final corrections. It will be published in its final form in an upcoming issue of Journal of Political Economy Microeconomics, published by The University of Chicago Press. Include the DOI when citing or quoting: https://doi.org/10.1086/725335. Copyright 2023 The University of Chicago.

Figure 6: Development of the search queries



Left panel: Aggregated number of search sessions on several online price comparison sites. Right panel: Google Trends searches for "Stromwechsel" (change of electricity supplier), base month = November 2012). In both figures the vertical solid line represents the yearly announcement of price adjustments.

plier). The Google Trends data are shown in the right panel of Figure 6 and exhibit very similar search patterns. The significant bumps in consumer search intensity around November 20th is clearly an indication of the endogenous relation between price and search and thus emphasizes the importance to apply an IV strategy for causal identification.

In Table 2, we present the results of our IV estimations for the three retail prices of interest, P^I_H, P^I_L and P^E. As we use a log-log specification the coefficients can be interpreted as elasticities.[35] The instrument is sufficiently strongly correlated with the endogenous variable, as shown by the high values of the first-stage effective F-test, suggested by Olea and Pflueger (2013). Results from the first-stage estimation are reported in Table B3 in the Appendix. Also, the Durbin-Wu-Hausman test for endogeneity (Davidson and MacKinnon, 1993) suggests that the consumer search intensity μ should indeed be treated as endogenous, because the null hypothesis of consumer search being an exogenous regressor is clearly rejected.

The OLS estimates are provided in Tables B4 and B5 in the Appendix. Even though the sign and the significance are similar, the magnitudes of the OLS estimates are much lower, suggesting that neglecting endogeneity leads to a substantial underestimation of the impact of consumer search on prices.

Coming to the results, column 1 of Table 2 provides evidence that the incumbent reacts to a higher search intensity by increasing its baseline tariff. For a change in consumer search

[35] In Table G7 in the Online Appendix, we show that the results are robust to a level-level specification.

This is the author's accepted manuscript without copyediting, formatting, or final corrections. It will be published in its final form in an upcoming issue of Journal of Political Economy Microeconomics, published by The University of Chicago Press. Include the DOI when citing or quoting: https://doi.org/10.1086/725335. Copyright 2023 The University of Chicago.

Table 2: IV estimates of the impact of consumer search on prices (log-log)

	(1) Incumbent Base (P_H^I)	(2) Incumbent Cheapest (P_L^I)	(3) Overall Cheapest (P^E)
Search (μ)	0.0389***	-0.1715***	-0.0382***
	(0.0052)	(0.0221)	(0.0049)
Costs	0.2268***	0.3780***	0.5169***
	(0.0094)	(0.0287)	(0.0090)
Available income	-0.0074	0.0773***	-0.0039
	(0.0055)	(0.0214)	(0.0048)
No. households	0.0295***	-0.0806***	-0.0302***
	(0.0057)	(0.0193)	(0.0053)
Household size	0.0883***	0.0744	-0.0081
	(0.0143)	(0.0514)	(0.0125)
Year FE	Yes	Yes	Yes
Zip code FE	Yes	Yes	Yes
First stage effective F stat.	103.62	103.62	103.62
Durbin-Wu-Hausman test	0.00	0.00	0.00
Obs.	25,899	25,899	25,899

Notes: Standard errors clustered at the zip code level in parentheses. Instrument for μ in the IV estimations is the search intensity for gas tariffs. $^{***}p < 1\%$, $^{**}p < 5\%$, $^{*}p < 10\%$.

intensity by 10%, the incumbent raises its tariff by approximately 0.4%. Column 2 shows that the incumbent reacts to more search activity in its zip code by reducing its online tariff considerably. For a 10% increase in search activity, the incumbent decreases its cheapest tariff by 1.7%. Moreover, column 3 reveals that the overall cheapest tariff in the market provided by an entrant supplier also decreases with more consumer search, but its effect is less pronounced than for the incumbents' online tariffs. For every 10% increase in search intensity in a zip code the overall cheapest tariff in the market decreases by approximately 0.4%. Thus, the incumbents' online tariff reacts more strongly to consumer search than the overall cheapest tariff.

The empirical effects can be explained along the lines of Proposition 1. With more low search cost consumers in a region, there is more competition online yielding lower online prices. To prevent too many consumers from switching to the entrant, the incumbent has to decrease its online price more aggressively than entrants do: the incumbent would lose a larger markup when losing a customer, as the incumbents' online price is still higher than the overall cheapest price offered by an entrant. At the same time, if there is still a considerable fraction of consumers with high enough search costs, the incumbent has an incentive to increase the margin on its baseline tariff as it will not lose too many consumers by doing so. Hence, the incumbency advantage can be exploited by price discriminating between consumers with higher search cost and consumers who search online but have a higher transaction cost.

This is the author's accepted manuscript without copyediting, formatting, or final corrections. It will be published in its final form in an upcoming issue of Journal of Political Economy Microeconomics, published by The University of Chicago Press. Include the DOI when citing or quoting: https://doi.org/10.1086/725335. Copyright 2023 The University of Chicago.

A back-of-the-envelope calculation shows the reasonableness and economic importance of our estimates. Our estimates from Table 2 imply that the incumbent increases its base tariff by 7.5 euro if search intensity in a zip code increases by one within-zip-code standard deviation (which is 5.1 percentage points), taking as starting points the mean values of prices and search intensity (i.e. 1,007 euro and 9.6%, respectively). Moreover, the incumbent decreases its online tariff due to the increased search activity in the zip code by 30.5 euro (mean value is 931 euro). The cheapest entrant decreases its tariff by a further 5.9 euro (mean value is 808 euro). Thus, we would expect from our estimates that price discrimination increases by 38 euro on average (which is 49.7% calculated from the mean value of price discrimination of 76.5 euro) due to a one standard deviation increase in search intensity within a zip code. Thus, increased search activity appears to be a substantial part of the explanation of why incumbents price discriminate in liberalized markets.

With regard to the control variables, it may be noteworthy that our estimate of the cost pass-through to the end-user retail tariffs is much higher in the competitive segments of the electricity retail market. For the incumbents' baseline tariffs, we estimate a pass-through of only around 23%, whereas 38% of cost increases are passed on to consumers for the incumbents' online tariffs and 52% for the cheapest entrants' tariffs. These pass-through patterns are in line with Duso and Szücs (2017), who investigate pass-through in the German electricity retail markets and also find that incumbents pass-through costs to a lesser extent.

Table 3 presents estimates of the impact of consumer search on the three price dispersion measures. Column 1 focuses on *overall price dispersion*, measured as the incumbent's baseline tariff (P_H^I) minus the overall cheapest tariff (P^E). Evidently, price dispersion goes up if more consumers search, since the incumbent slightly increases its baseline tariff and at the same time the overall cheapest price declines with search. For every 10% increase in search intensity, the extent of price dispersion goes up by 3.7%, suggesting that consumers' gain from searching increases with the share of searching consumers.

Incumbents react to increased price pressure from consumer search via *price discrimination*, as they offer a cheaper tariff for searching consumers, which is still above the overall cheapest tariff in the market, and a high incumbent baseline tariff for consumers who do not search. Price discrimination becomes more pronounced with increasing search intensity. An increase in the share of searching consumers by 10% widens the gap between the incumbent's baseline tariff and its cheaper tariff by 24.8%. The extent of price discrimination unambiguously increases

This is the author's accepted manuscript without copyediting, formatting, or final corrections. It will be published in its final form in an upcoming issue of Journal of Political Economy Microeconomics, published by The University of Chicago Press. Include the DOI when citing or quoting: https://doi.org/10.1086/725335. Copyright 2023 The University of Chicago.

Table 3: IV estimates of the impact of consumer search on dispersion (log-log)

	(1) Price Dispersion ($P_H^I - P^E$)	(2) Price Discrimination ($P_H^I - P_L^I$)	(3) Online Price Dispersion ($P_L^I - P^E$)
Search (μ)	0.3696***	2.4776***	-1.7056***
	(0.0419)	(0.3056)	(0.2774)
Costs	-1.0152***	-1.2747***	-1.5596***
	(0.0692)	(0.4042)	(0.3178)
Available income	0.0033	-0.8118***	0.8991***
	(0.0426)	(0.3005)	(0.2393)
No. households	0.2911***	1.2952***	-0.7173***
	(0.0450)	(0.2630)	(0.2090)
Household size	0.4221***	0.3701	1.5223**
	(0.1078)	(0.6982)	(0.5987)
Year FE	Yes	Yes	Yes
Zip code FE	Yes	Yes	Yes
First stage effective F stat.	103.62	103.62	103.62
Durbin-Wu-Hausman test	0.00	0.00	0.00
Obs.	25,899	25,899	25,899

Notes: Standard errors clustered at the zip code level in parentheses. Instrument for μ in the IV estimations is the search intensity for gas tariffs. $^{***}p < 1\%$, $^{**}p < 5\%$, $^{*}p < 10\%$.

if a larger share of consumers searches, predominantly because the incumbent decreases its cheapest tariff significantly as a reaction to consumer search to aggressively prevent existing customers from switching to competitors. This can be explained in line with Proposition 1 of our theoretical model: more searching consumers imply more price discrimination if there are relatively sufficient many consumers left with relatively high search cost who "always" buy at the baseline price of the incumbent.

We also see that *online price dispersion*, measured as the difference between the incumbent's cheapest tariff and the overall cheapest tariff in the market, narrows considerably with search intensity. The more consumers search in a market, the more the incumbent is forced to set the online price closer to the overall cheapest price. For a 10% increase in search intensity, the online price dispersion narrows by 17%.

Overall, we find that the high search cost consumers who stay with the incumbent's baseline tariff get "milked" when there are more searching consumers in a local market. In contrast, those who are willing to search either get a lower incumbent tariff or switch to the entrant. The incumbent reacts to more consumer search with price discrimination by slightly increasing its baseline tariff while at the same time significantly reducing its cheaper online tariff. Entrants react to more search with somewhat lower prices. Intensified consumer search thus increases

This is the author's accepted manuscript without copyediting, formatting, or final corrections. It will be published in its final form in an upcoming issue of Journal of Political Economy Microeconomics, published by The University of Chicago Press. Include the DOI when citing or quoting: https://doi.org/10.1086/725335. Copyright 2023 The University of Chicago.

overall price dispersion and price discrimination, and it leads to fiercer price competition (i.e. an alignment of incumbent and entrant prices) in the competitive online segment.

7. Robustness

Our results are robust to various alternative specifications, such as using alternative instruments, level-level estimation, allowing for a non-linear relationship between search and tariffs, and adding or removing control variables. We present and discuss these specifications below and report the results in Section B in the Appendix and in Section E in the Online Appendix.

"Hausman-type" instruments — As an alternative IV we apply "Hausman-type instruments" in the spirit of Hausman (1996) (see also Berry and Haile, 2016; Hausman et al., 1994; Nevo, 2000). In doing this, we take the average of our instrument – the search intensity for gas tariffs – in the surrounding zip codes as instruments for electricity search intensity in the focal zip code. Surrounding zip codes are identified through the nature of the German zip code system: zip codes in Germany have five digits and are ordered geographically in that zip code 12345 is next to zip code 12346. Thus, we use the average search intensity for heating gas tariffs in the other zip codes with the same first four digits in our Hausman-type IV. As a second condition we only use information from those surrounding zip codes if their prices differ from that in the focal zip code. Thus, if a zip code is only surrounded by zip codes within the same price zone they are dropped from the estimation sample. The idea behind these Hausman-type instruments is that variation in search costs in surrounding zip codes is correlated with search costs in the focal zip code (introducing correlation of heating gas searches across several neighbouring zip codes and electricity search in the focal zip code) while the variation in gas searches in surrounding zip codes is not directly related to electricity prices in the focal zip code. The correlation between our original instrument and the Hausman-type instrument is high with a correlation coefficient of 0.51. This high correlation is also reflected in the high first stage F-test of the excluded instrument. We find that the results stay robust to these alternative instruments, as shown in Tables B6 and B7 in the Appendix.

Alternative clustering of standard errors — Many incumbents operate only locally and 46% of the incumbents only have a single zip code in their incumbency area. These small incumbents are mostly municipal utilities. However, larger incumbents often have several zip codes in their incumbency area and charge locally differing baseline tariffs. The different *price*

This is the author's accepted manuscript without copyediting, formatting, or final corrections. It will be published in its final form in an upcoming issue of Journal of Political Economy Microeconomics, published by The University of Chicago Press. Include the DOI when citing or quoting: https://doi.org/10.1086/725335. Copyright 2023 The University of Chicago.

zones of the larger incumbents are not necessarily at the zip code level as we discussed in Section 2. Hence, as a robustness check, we cluster standard errors at the price zone level instead of at the zip code level. Tables G1 and G2 in the Online Appendix show the results are robust.

Control variables — We also estimate models where we either drop all covariates or include many more. The control variables we include (in logs) are the share of unemployed, the degree of urbanization, the share of households with a household head younger than 40, and between 40 and 60, the share of self-employed, shares of households that moved in or out of the zip code, and shares of households with low or medium social status (based on an index taking into account home ownership, number of cars, and education). Tables G3, G4, G5, and G6 in the Online Appendix show that the results are robust.

Level-level instead of log-log — Instead of a log-log relationship, our results are also robust level-level specifications, as shown in Tables G7 and G8 in the Online Appendix.

Non-linear relationship — We also relax the constant-elasticity assumption and allow for a non-linear relationship between search and prices, by adding a μ^2 in Equation 4 and instrument for μ^2 with the square of the search intensity for gas tariffs. The results remain robust and using the method by Lind and Mehlum (2010) we find that there is no U shaped (or inverse U shaped) relationship within the range of the data. The results are reported in Tables G9 and G10 in the Online Appendix.

8. Conclusion

In markets where consumers have an ongoing relation with their provider, they know the price they pay. To get informed about alternative price offers (by other firms, or other tariffs of the same firm), consumers have to pay a search cost. Firms can effectively use this asymmetry to price discriminate between consumers with different search costs. This is especially true for incumbent firms with a large customer base.

Our empirical analysis of local German retail electricity markets shows that search is an important factor in explaining pricing patterns. In particular,differences in the fraction of searching consumers across local markets explain a large part of the observed heterogeneity in pricing behavior: when consumers search more, the incumbent price discriminates more (with higher baseline and lower online tariffs) and the entrant charges lower prices. This strategy implies that few consumers actually switch, with the incumbent appropriating an important

This is the author's accepted manuscript without copyediting, formatting, or final corrections. It will be published in its final form in an upcoming issue of Journal of Political Economy Microeconomics, published by The University of Chicago Press. Include the DOI when citing or quoting: https://doi.org/10.1086/725335. Copyright 2023 The University of Chicago.

share of market revenue.

Our theoretical model shows that the incumbent's incentive to increase the baseline tariff arises if a lower price would not keep many consumers from searching and catering to high search cost consumers allows the incumbent to siphon off larger rents. Once a consumer has shown a willingness to search (e.g. by conducting a price comparison on an online platform), the incumbent has a strong incentive to prevent consumers from switching to an entrant by setting low online prices. In this way, the incumbent can simultaneously appropriate surplus from high search cost consumers and prevent searching consumers from switching to an entrant.

From a policy perspective, one may wonder whether this type of price discrimination should be banned. It is clear, however, that such a ban has different implications for different types of consumers. Low search cost consumers will be worse off as price discrimination is associated with very competitive behavior in the online segment of the market. High search cost consumers typically would benefit from banning price discrimination as it would allow them to benefit from the fact that the incumbent will charge a lower overall price than the price it charges them when it can target its prices. Whether or not consumers benefit on average depends on the search cost distribution.

Future research should reveal whether similar pricing patterns are found in other markets with similar characteristics. Our theoretical model suggests our results should be relevant in any market where firms can price discriminate between consumers with different search costs. After having acquired a customer base themselves, entrants may also follow a similar strategy of price discrimination and increase their prices for their existing clients, while simultaneously setting a more competitive price to attract new customers. German electricity markets are special in that entrants are very small: it is likely that quantitatively there is almost no effect if they would engage in price discrimination. This may clearly be different in other (e.g. telecommunication) markets where entrants have been able to gain market share. Depending on the available data, such research could also take a more structural approach. We have shown that some of our results depend on the shape of the search cost distribution and progress may partially depend on whether data is available to estimate the search cost distribution, for example by using market share data of the different firms and tariffs.

This is the author's accepted manuscript without copyediting, formatting, or final corrections. It will be published in its final form in an upcoming issue of Journal of Political Economy Microeconomics, published by The University of Chicago Press. Include the DOI when citing or quoting: https://doi.org/10.1086/725335. Copyright 2023 The University of Chicago.

Data Availability

Code replicating the tables and figures in this article can be found in Gugler et al. (2023) in the Harvard Dataverse, https://doi.org/10.7910/DVN/TCZ1QR. The replication package contains a copy of the programs (Stata do-file) used to create the final results and a read-me file with further information.

References

Allen, J., Clark, R., Houde, J.F., 2019. Search frictions and market power in negotiated price markets. Journal of Political Economy 127.

Armstrong, M., Vickers, J., 2019. Discriminating against captive customers. American Economic Review: Insights 1, 257–72.

A.T. Kearney, 2012. Der Strom- und Gasvertrieb im Wandel: Unabhängige Anbieter am Scheideweg. Presentation, Berlin, December 2012.

Bar-Isaac, H., Caruana, G., Cuñat, V., 2012. Search, design, and market structure. American Economic Review 102, 1140–1160.

Baye, M.R., Morgan, J., Scholten, P., 2006. Information, search, and price dispersion, in: Hendershott, T. (Ed.), Handbook of Economics and Information Systems. Elsevier.

Berry, S., Haile, P., 2016. Identification in differentiated products markets. Annual Review of Economics 28, 27–52.

Blake, T., Nosko, C., Tadelis, S., 2016. Returns to consumer search: Evidence from eBay, in: Proceedings of the 2016 ACM Conference on Economics and Computation, ACM Conference.

BNetzA, 2013. Monitoring report 2013. Federal Network Agency of Germany.

BNetzA, 2015. Monitoring report 2015. Federal Network Agency of Germany.

Brynjolfsson, E., Smith, M., 2001. Consumer decision-making at an internet shopbot: Brand still matters. Journal of Industrial Economics 49, 541–558.

Brynjolfsson, E., Smith, M., 2014. Frictionless commerce? A comparison of internet and conventional retailers. Management Science 46, 563–585.

Byrne, D.P., De Roos, N., 2017. Consumer search in retail gasoline markets. The Journal of Industrial Economics 65, 183–193.

This is the author's accepted manuscript without copyediting, formatting, or final corrections. It will be published in its final form in an upcoming issue of Journal of Political Economy Microeconomics, published by The University of Chicago Press. Include the DOI when citing or quoting: https://doi.org/10.1086/725335. Copyright 2023 The University of Chicago.

Byrne, D.P., Martin, L.A., Nah, J.S., 2022. Price Discrimination by Negotiation: a Field Experiment in Retail Electricity. The Quarterly Journal of Economics 137, 2499–2537.

Cabral, L., 2016. Dynamic pricing in customer markets with switching costs. Review of Economic Dynamics 20, 43–62.

Cabral, L., 2017. Switching costs, search costs, and market power: Theory and application to energy markets. Closing Address, V International Academic Symposium, Challenges for the Energy Sector, Barcelona, February 7.

Cabral, L., Gilbukh, S., 2020. Rational buyers search when prices increase. Journal of Economic Theory 187, 104998.

Coey, D., Larsen, B.J., Platt, B.C., 2020. Discounts and deadlines in consumer search. American Economic Review 110, 3748–3785.

Davidson, R., MacKinnon, J.G., 1993. Estimation and Inference in Econometrics. Oxford University Press.

Davies, S., Price, C.W., Wilson, C.M., 2014. Nonlinear pricing and tariff differentiation: Evidence from the British electricity market. The Energy Journal 35, 57–77.

Doganoglu, T., 2010. Switching costs, experience goods and dynamic price competition. Quantitative Marketing and Economics 8, 167–205.

Dressler, L., Weiergraeber, S., 2019. Alert the inert! switching costs and limited awareness in retail electricity markets. Mimeo.

Duso, T., Szücs, F., 2017. Market power and asymmetric pass-through in German electricity retail. European Economic Review 98, 354–372.

Fabra, N., Reguant, M., 2020. A model of search with price discrimination. European Economic Review 129, 103571.

Giulietti, M., Waterson, M., Wildenbeest, M., 2014a. Estimation of search frictions in the British electricity market. The Journal of Industrial Economics 62, 555–590.

Giulietti, M., Waterson, M., Wildenbeest, M., 2014b. Estimation of search frictions in the British electricity market. Journal of Industrial Economics 62, 555–590.

Goolsbee, A., Syverson, C., 2008. How do incumbents respond to the threat of entry? Evidence from the major airlines. Quarterly Journal of Economics 123, 1611–1633.

This is the author's accepted manuscript without copyediting, formatting, or final corrections. It will be published in its final form in an upcoming issue of Journal of Political Economy Microeconomics, published by The University of Chicago Press. Include the DOI when citing or quoting: https://doi.org/10.1086/725335. Copyright 2023 The University of Chicago.

Gugler, K., Heim, S., Janssen, M., Liebensteiner, M., 2023. Replication Package for "Incumbency Advantages: Price Dispersion, Price Discrimination and Consumer Search at Online Platforms". URL: https://doi.org/10.7910/DVN/TCZ1QR, doi:10.7910/DVN/TCZ1QR.

Hausman, J., Leonard, G., Zona, J.D., 1994. Competitive analysis with differenciated products. Annales d'Économie et de Statistique , 159.

Hausman, J.A., 1996. Valuation of new goods under perfect and imperfect competition, in: Bresnahan, T.F., Gordon, R.J. (Eds.), The Economics of New Goods. University of Chicago Press, pp. 207–248.

Heim, S., 2021. Asymmetric cost pass-through and consumer search: empirical evidence from online platforms. Quantitative Marketing and Economics 19, 227–260.

Hortacsu, A., Madanizadeh, S., Puller, S., 2017. Power to choose? An analysis of consumer inertia in the residential electricity market. American Economic Journal: Economic Policy 9, 192–226.

Ishibashi, I., Matsushima, N., 2009. The existence of low-end firms may help high-end firms. Marketing Science 28, 136–147.

Janssen, C.W., Moraga-González, J.L., 2004. Strategic pricing, consumer search and the number of firms. Review of Economic Studies 71, 1089–1118.

Koulayev, S., 2014. Search for differentiated products: Identification and estimation. RAND Journal of Economics 45, 553–575.

Lach, S., Moraga-González, J.L., 2017. Asymmetric price effects of competition. The Journal of Industrial Economics , 767–803.

Lewis, M., 2011. Price dispersion and competition with spatially differentiated sellers. Journal of Industrial Economics 56, 654–678.

Lewis, M.S., Marvel, H.P., 2011. When do consumers search? The Journal of Industrial Economics 59, 457–483.

Lind, J.T., Mehlum, H., 2010. With or without u? the appropriate test for a u-shaped relationship*. Oxford Bulletin of Economics and Statistics 72, 109–118.

Nevo, A., 2000. Mergers with differentiated products: The case of the ready-to-eat cereal industry. RAND Journal of Economics 31, 395.

Nishida, M., Remer, M., 2018. The determinants and consequences of search cost heterogeneity: Evidence from local gasoline markets. Journal of Marketing Research 55, 305–320.

This is the author's accepted manuscript without copyediting, formatting, or final corrections. It will be published in its final form in an upcoming issue of Journal of Political Economy Microeconomics, published by The University of Chicago Press. Include the DOI when citing or quoting: https://doi.org/10.1086/725335. Copyright 2023 The University of Chicago.

Olea, J.L.M., Pflueger, C., 2013. A robust test for weak instruments. Journal of Business & Economic Statistics 31, 358–369.

Pennersdorfer, D., Schmidt-Dengler, P., Schutz, N., Weiss, C., Yontcheva, B., 2020. Information and price dispersion: Theory and evidence. International Economic Review 61, 871–899.

Perloff, J.M., Suslow, V.Y., Seguin, P.J., 1995. Higher prices from entry: Pricing of brand-name drugs. CUDARE Working Papers 25104, University of California, Berkeley, Department of Agricultural and Resource Economics.

Salop, S., 1977. The noisy monopolist: Imperfect information, price dispersion and price discrimination. Review of Economic Studies 44, 393–406.

De los Santos, B., Hortacsu, A., Wildenbeest, M., 2012. Testing models of consumer search using data on web browsing and purchasing behavior. American Economic Review 102, 2955–2980.

Sorensen, A.T., 2000. Equilibrium price dispersion in retail markets for prescription drugs. Journal of Political Economy 108, 833–850.

Stahl, D.O., 1989. Oligopolistic pricing with sequential consumer search. American Economic Review 79, 700–712.

Tang, Z., Smith, M.D., Montgomery, A., 2010. The impact of shopbot use on prices and price dispersion: Evidence from online book retailing. International Journal of Industrial Organization 28, 579–590.

Tappata, M., 2009. Rockets and feathers: Understanding asymmetric pricing. RAND Journal of Economics 40, 673–687.

The Economist, 2018. American banks pay depositors less than online accounts. The Economist, February 17, https://www.economist.com/news/finance-and-economics/21737031-they-seem-be-relying-power-inertia-retain-their-customersa-risky.

This is the author's accepted manuscript without copyediting, formatting, or final corrections. It will be published in its final form in an upcoming issue of Journal of Political Economy Microeconomics, published by The University of Chicago Press. Include the DOI when citing or quoting: https://doi.org/10.1086/725335. Copyright 2023 The University of Chicago.

Appendix

A. Proof of Proposition

To understand the effects of changes in z, we first consider the result on price discrimination. Taking the total differential of (3) with respect to $P_H^I - P_L^I$ and z yields

$$\left[-2f(P_H^I - P_L^I; z) - \frac{\partial f(P_H^I - P_L^I; z)}{\partial (P_H^I - P_L^I)}(P_H^I - P_L^I)\right] d(P_H^I - P_L^I) \tag{6}$$
$$= \left[\frac{\partial f(P_H^I - P_L^I; z)}{\partial z}(P_H^I - P_L^I) + \frac{F(P_H^I - P_L^I; z)}{\partial z}\right] dz.$$

As profit maximization implies that the second-order condition of (3) with respect to $P_H^I - P_L^I$ is negative, it should be that in an equilibrium,

$$-2f(P_H^I - P_L^I; z) - \frac{\partial f(P_H^I - P_L^I; z)}{\partial (P_H^I - P_L^I)}(P_H^I - P_L^I) < 0.$$

On the other hand, the inverse hazard rate $\frac{1 - F(P_H^{I*} - P_L^{I*}; z)}{f(P_H^{I*} - P_L^{I*}; z)}$ is increasing in z if and only if

$$-\frac{\partial f(P_H^I - P_L^I; z)}{\partial z}(1 - F(P_H^I - P_L^I; z)) - \frac{F(P_H^I - P_L^I; z)}{\partial z} f(P_H^I - P_L^I) > 0,$$

which using (3) can be rewritten as

$$-f(P_H^I - P_L^I; z)\left[\frac{\partial f(P_H^I - P_L^I; z)}{\partial z}(P_H^I - P_L^I) + \frac{F(P_H^I - P_L^I; z)}{\partial z}\right] > 0.$$

Thus, if the inverse hazard rate is increasing in z, then in any equilibrium both square bracket terms in (6) are negative, implying $\frac{d(P_H^I - P_L^I)}{dz} > 0$.

To investigate online price dispersion, we take the total differential of (1) with respect to P_L^I and P^E to obtain

$$0 = \frac{1}{\theta}\left[f\left(\frac{P_L^I - P^E}{\theta}; z\right) - f'\left(\frac{P_L^I - P^E}{\theta}; z\right)\frac{P^E}{\theta}\right] dP_L^I$$
$$+ \frac{1}{\theta}\left[-2f\left(\frac{P_L^I - P^E}{\theta}; z\right) + f'\left(\frac{P_L^I - P^E}{\theta}; z\right)\frac{P^E}{\theta}\right] dP^E,$$

where f' is the derivative of the density function with respect to prices. From the second-order condition for profit maximization by the entrant, we know that the second term in square brackets must be negative. If $f'\left(\frac{P_L^I - P^E}{\theta}; z\right) \leq 0$, then the first term in square brackets is positive, and its absolute value is smaller than the first term in square brackets. Thus, $0 < dP^E/dP_L^I < 1$. Therefore, $0 < d(P_L^I - P^E)/dP_L^I < 1$.

This is the author's accepted manuscript without copyediting, formatting, or final corrections. It will be published in its final form in an upcoming issue of Journal of Political Economy Microeconomics, published by The University of Chicago Press. Include the DOI when citing or quoting: https://doi.org/10.1086/725335. Copyright 2023 The University of Chicago.

Finally, to understand how price discrimination and online price dispersion are related, we substitute (1) and (3) into (2) to get the condition stated in the Proposition.

B. Additional Tables and Figures

In Table B1 we estimate the effect of local electricity tariffs on local searches for electricity tariffs and gas tariffs, respectively. As discussed in Section 4.2 the relation between pricing strategies of electricity retailers and consumers' efforts to search for electricity tariffs is likely endogenous due to simultaneity. Thus, in order to get the causal effect of the electricity tariffs on the two search intensities we instrument for the electricity tariffs with the local electricity costs (see Heim, 2021). Our estimates suggest that search intensity for electricity tariffs is indeed a function of local electricity prices but search intensity for gas tariffs is not. This in turn points towards the validity of gas searches as an instrument for electricity searches.

Table B1: Regressions of electricity tariff searches and gas tariff searches on electricity tariffs (log-log)

	Electricity searches			Gas searches		
	(1)	(2)	(3)	(4)	(5)	(6)
Incumbent Base (P_H^I)	0.078***			-0.001		
	(0.006)			(0.002)		
Incumbent Cheapest (P_L^I)		0.057***			-0.001	
		(0.005)			(0.002)	
Overall Cheapest (P^E)			0.049***			-0.001
			(0.003)			(0.002)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Zip code FE	Yes	Yes	Yes	Yes	Yes	Yes
First stage F stat.	1037.34	676.04	3598.34	1037.34	676.04	3598.34
Obs.	25,899	25,899	25,899	25,899	25,899	25,899

Notes: Standard errors clustered at the zip code level in parentheses. Instruments for electricity tariffs are the local electricity costs. $^{***}p < 1\%$, $^{**}p < 5\%$, $^{*}p < 10\%$.

This is the author's accepted manuscript without copyediting, formatting, or final corrections. It will be published in its final form in an upcoming issue of Journal of Political Economy Microeconomics, published by The University of Chicago Press. Include the DOI when citing or quoting: https://doi.org/10.1086/725335. Copyright 2023 The University of Chicago.

Table B2: Decomposition of standard deviations between and within zip codes

Variable	Mean	SD overall	SD between	SD within
Incumbents baseline tariff (P_H^I)	1,007	77.7	36.6	68.6
Incumbents cheaper online tariff (P_L^I)	931	84.8	36.6	76.7
Cheapest entrant tariff (P^E)	808	58.8	20.8	55.3
Overall price dispersion ($P_H^I - P^E$)	198.8	38.9	33.3	19.7
Price discrimination ($P_H^I - P_L^I$)	75.8	40.7	24.5	32.5
Onlince price dispersion ($P_L^I - P^E$)	123.0	44.8	28.5	34.5
Consumer search intensity for electricity tariffs (μ)	9.4	6.5	3.5	5.5
Consumer search intensity for gas tariffs	1.97	1.90	1.46	1.26
Net costs	683.0	42.3	28.4	31.4

Table B3: First-stage regressions of consumer search (μ) (log-log)

	(1) Search (μ)	(2) Search (μ)
Searches for gas tariffs	0.0363***	0.0350***
	(0.0025)	(0.0025)
Costs		0.3879***
		(0.1181)
Available income		0.3532***
		(0.0753)
No. households		-0.5549***
		(0.0570)
Household size		0.3860*
		(0.2128)
Year FE	Yes	Yes
Zip code FE	Yes	Yes
Obs.	25,899	25,899

Notes: Standard errors clustered at the zip code level in parentheses. $^{***}p < 1\%$, $^{**}p < 5\%$, $^{*}p < 10\%$.

This is the author's accepted manuscript without copyediting, formatting, or final corrections. It will be published in its final form in an upcoming issue of Journal of Political Economy Microeconomics, published by The University of Chicago Press. Include the DOI when citing or quoting: https://doi.org/10.1086/725335. Copyright 2023 The University of Chicago.

Table B4: OLS estimates of the impact of consumer search on prices (log-log)

	(1) Incumbent Base (P_H^I)	(2) Incumbent Cheapest (P_L^I)	(3) Overall Cheapest (P^E)
Search (μ)	0.0033***	0.0004	-0.0008**
	(0.0004)	(0.0013)	(0.0003)
Costs	0.2382***	0.3230***	0.5049***
	(0.0077)	(0.0150)	(0.0072)
Available income	0.0059	0.0129	-0.0180***
	(0.0044)	(0.0114)	(0.0028)
No. households	0.0082**	0.0221**	-0.0078**
	(0.0037)	(0.0102)	(0.0033)
Household size	0.0990***	0.0229	-0.0193**
	(0.0122)	(0.0325)	(0.0088)
Year FE	Yes	Yes	Yes
Zip code FE	Yes	Yes	Yes
Obs.	25,899	25,899	25,899

Notes: Standard errors clustered at the zip code level in parentheses.$^{***}p < 1\%$, $^{**}p < 5\%$, $^{*}p < 10\%$.

Table B5: OLS estimates of the impact of consumer search on price dispersion measures (log-log)

	(1) Price Dispersion ($P_H^I - P^E$)	(2) Price Discrimination ($P_H^I - P_L^I$)	(3) Online Price Dispersion ($P_L^I - P^E$)
Search (μ)	0.0165***	0.0079	0.0296
	(0.0026)	(0.0167)	(0.0182)
Costs	-0.9021***	-0.4836**	-2.1154***
	(0.0465)	(0.2067)	(0.1973)
Available income	0.1358***	0.1147	0.2482*
	(0.0273)	(0.1501)	(0.1388)
No. households	0.0801***	-0.1805	0.3196***
	(0.0230)	(0.1172)	(0.0957)
Household size	0.5279***	1.1105***	1.0021**
	(0.0741)	(0.4153)	(0.4363)
Year FE	Yes	Yes	Yes
Zip code FE	Yes	Yes	Yes
Obs.	25,899	25,899	25,899

Notes: Standard errors clustered at the zip code level in parentheses.$^{***}p < 1\%$, $^{**}p < 5\%$, $^{*}p < 10\%$.

This is the author's accepted manuscript without copyediting, formatting, or final corrections. It will be published in its final form in an upcoming issue of Journal of Political Economy Microeconomics, published by The University of Chicago Press. Include the DOI when citing or quoting: https://doi.org/10.1086/725335. Copyright 2023 The University of Chicago.

Table B6: IV estimates of the impact of consumer search on prices (log-log) – Hausman-type instruments for search

	Incumbent Base (P_H^I) (1)	Incumbent Cheapest (P_L^I) (2)	Overall Cheapest (P^E) (3)
Search (μ)	0.0816***	-0.2748***	-0.0551***
	(0.0172)	(0.0615)	(0.0123)
Costs	0.2239***	0.2653***	0.6048***
	(0.0164)	(0.0510)	(0.0122)
Available income	-0.0254**	0.1018***	0.0050
	(0.0110)	(0.0390)	(0.0079)
No. households	0.0578***	-0.1612***	-0.0463***
	(0.0124)	(0.0424)	(0.0090)
Household size	0.0904***	0.1381	0.0103
	(0.0263)	(0.0890)	(0.0187)
Year FE	Yes	Yes	Yes
Zip code FE	Yes	Yes	Yes
First stage effective F stat.	31.31	31.31	31.31
Obs.	18,712	18,712	18,712

Notes: Standard errors clustered at the zip code level in parentheses. Instrumented for μ by the mean search intensity for gas tariffs in surrounding zip codes conditional on those zip codes being in different price zones. $^{***}p < 1\%$, $^{**}p < 5\%$, $^{*}p < 10\%$.

Table B7: IV estimates of the impact of consumer search on dispersion (log-log) – Hausman-type instruments for search

	(1) Price Dispersion ($P_H^I - P^E$)	(2) Price Discrimination ($P_H^I - P_L^I$)	(3) Online Price Dispersion ($P_L^I - P^E$)
Search (μ)	0.6567***	4.7791***	-2.4696***
	(0.1341)	(1.0136)	(0.6157)
Costs	-1.4403***	0.1947	-3.5994***
	(0.1249)	(0.8472)	(0.4824)
Available income	-0.1345	-1.3813**	1.1252***
	(0.0859)	(0.6439)	(0.3834)
No. households	0.5008***	2.9514***	-1.3110***
	(0.0949)	(0.6928)	(0.4184)
Household size	0.3096	-0.4651	1.7625**
	(0.1993)	(1.4504)	(0.8777)
Year FE	Yes	Yes	Yes
Zip code FE	Yes	Yes	Yes
First stage effective F stat.	31.31	31.31	31.31
Obs.	18,712	18,712	18,712

Notes: Standard errors clustered at the zip code level in parentheses. Instrumented for μ by the mean search intensity for gas tariffs in surrounding zip codes conditional on those zip codes being in different price zones. $^{***}p < 1\%$, $^{**}p < 5\%$, $^{*}p < 10\%$.

This is the author's accepted manuscript without copyediting, formatting, or final corrections. It will be published in its final form in an upcoming issue of Journal of Political Economy Microeconomics, published by The University of Chicago Press. Include the DOI when citing or quoting: https://doi.org/10.1086/725335. Copyright 2023 The University of Chicago.

Online Appendix

Incumbency Advantages: Price Dispersion, Price Discrimination and Consumer Search at Online Platforms

Klaus Gugler[†] Sven Heim[‡] Maarten Janssen[§] Mario Liebensteiner[¶]

February 24, 2023

This document contains additional results, which are not included in the main paper.

[†]Vienna University of Economics and Business (WU), klaus.gugler@wu.ac.at

[‡]Mines Paris – PSL, Paris, ZEW Center for European Economic Research Mannheim and CEPR, sven.heim@mines-paristech.fr

[§]University of Vienna, National Research University Higher School of Economics Moscow and CEPR, maarten.janssen@univie.ac.at

[¶]Friedrich-Alexander-Universität Erlangen-Nürnberg (FAU), mario.liebensteiner@fau.de

This is the author's accepted manuscript without copyediting, formatting, or final corrections. It will be published in its final form in an upcoming issue of Journal of Political Economy Microeconomics, published by The University of Chicago Press. Include the DOI when citing or quoting: https://doi.org/10.1086/725335. Copyright 2023 The University of Chicago.

C A piece-wise linear search cost distribution

In this part of the online Appendix, we analyze the impact of changes of the search cost distribution on prices and the fraction of searchers for the piece-wise linear search cost distribution. We focus on parameter values such that $\widehat{s}_1 < \widetilde{s}_1 < \widehat{s}_2 < \widetilde{s}_2$, i.e., the consumer that is indifferent between two online offers is in the first interval of the search cost distribution, while the consumer that is indifferent between searching and not searching is in the second interval of the search cost distribution. With this formulation, an increase in z unambiguously leads the search cost distribution to have a larger fraction of consumers with lower search cost and a smaller fraction of consumers with intermediate search cost.

It is important to note that the number of active searchers $F(P_H^{I^*} - P_L^{I^e})$ is endogenously determined by the equilibrium prices. To dethermine the number of active searchers, we first determine the level of price discrimination $P_H^{I^*} - P_L^{I^*}$. Using (3) it is easy to see that for the case where the search cost distribution is piece-wise linear the equilibrium level of price discrimination equals

$$P_H^{I^*} - P_L^{I^*} = \frac{\widetilde{s}_2 - \widetilde{s}_1 - (z-1)\widetilde{s}_1\widetilde{s}_2}{2\left(\widetilde{s}_2 - z\widetilde{s}_1\right)} \tag{7}$$

and thus that the equilibrium fraction of online searchers equals

$$F(P_H^{I^*} - P_L^{I^*}) = \frac{(z-1)\widetilde{s}_1\widetilde{s}_2 + \widetilde{s}_2 - \widetilde{s}_1}{2\left(\widetilde{s}_2 - \widetilde{s}_1\right)}.$$

Applying the piece-wise linear search cost distribution to (1) and (2), it is easy to see that the relation between the equilibrium online prices is given by $P^{E^*} = \frac{1}{2} P_L^{I^*}$ so that

$$P_L^{I^*} = \frac{\widetilde{s}_2 - \widetilde{s}_1 + (z-1)\widetilde{s}_1\widetilde{s}_2}{3z\left(\widetilde{s}_2 - \widetilde{s}_1\right)}\theta,$$

which implies that

$$P^{E^*} = \frac{\widetilde{s}_2 - \widetilde{s}_1 + (z-1)\widetilde{s}_1\widetilde{s}_2}{6z\left(\widetilde{s}_2 - \widetilde{s}_1\right)}\theta$$

and

$$P_H^{I^*} = \frac{\widetilde{s}_2 - \widetilde{s}_1 + (z-1)\widetilde{s}_1\widetilde{s}_2}{3z\left(\widetilde{s}_2 - \widetilde{s}_1\right)}\theta + \frac{\widetilde{s}_2 - \widetilde{s}_1 - (z-1)\widetilde{s}_1\widetilde{s}_2}{2\left(\widetilde{s}_2 - z\widetilde{s}_1\right)}.$$

Using Proposition 1 and the fact that for a piece-wise linear distribution $f' = 0$ in the interior of the intervals, online equilibrium prices always change in the same direction and the level of online price dispersion $P_L^{I^*} - P^{E^*}$ positively correlates with both prices. Using the expressions

This is the author's accepted manuscript without copyediting, formatting, or final corrections. It will be published in its final form in an upcoming issue of Journal of Political Economy Microeconomics, published by The University of Chicago Press. Include the DOI when citing or quoting: https://doi.org/10.1086/725335. Copyright 2023 The University of Chicago.

for the different prices, it is easy to see that the condition $\widehat{s}_1 < \widetilde{s}_1 < \widehat{s}_2 < \widetilde{s}_2$ is satisfied if

$$\frac{\widetilde{s}_2 - \widetilde{s}_1 - \widetilde{s}_1\widetilde{s}_2}{\widetilde{s}_1(5\widetilde{s}_2 - 6\widetilde{s}_1)} < z < \frac{\widetilde{s}_2^2 - (\widetilde{s}_2 - \widetilde{s}_1)(1 - \widetilde{s}_2)}{\widetilde{s}_1\widetilde{s}_2}. \tag{8}$$

The proposition below contains the comparative statics properties of our model in terms of price discrimination and dispersion using the piece-wise linear search cost distribution.

Proposition 2 (price levels). If (8) holds, then an increase in the fraction of online searchers $F(P_H^{I^*} - P_L^{I^*})$, initiated by an increase in z, coincides with a decrease in online prices P^{E^*} and $P_L^{I^*}$ if and only if $\widetilde{s}_2 - \widetilde{s}_1 > \widetilde{s}_2\widetilde{s}_1$, while it coincides with an increase in the baseline price $P_H^{I^*}$ if θ is small enough, z is large enough, or $\widetilde{s}_2 - \widetilde{s}_1$ is small enough.

Proof. It is clear that

$$\frac{\partial(P_H^{I^*} - P_L^{I^*})}{\partial z} = \frac{(\widetilde{s}_2 - \widetilde{s}_1)\widetilde{s}_1(1 - \widetilde{s}_2)}{2\left(\widetilde{s}_2 - z\widetilde{s}_1\right)^2} > 0.$$

From the expressions determining equilibrium prices, it follows that

$$2\frac{\partial P^{E^*}}{\partial z} = \frac{\partial P_L^{I^*}}{\partial z} = -\frac{\theta}{3z^2}\left(\frac{\widetilde{s}_2 - \widetilde{s}_1 - \widetilde{s}_1\widetilde{s}_2}{\widetilde{s}_2 - \widetilde{s}_1}\right),$$

which is clearly negative if and only if $\widetilde{s}_2 - \widetilde{s}_1 > \widetilde{s}_2\widetilde{s}_1$. Also,

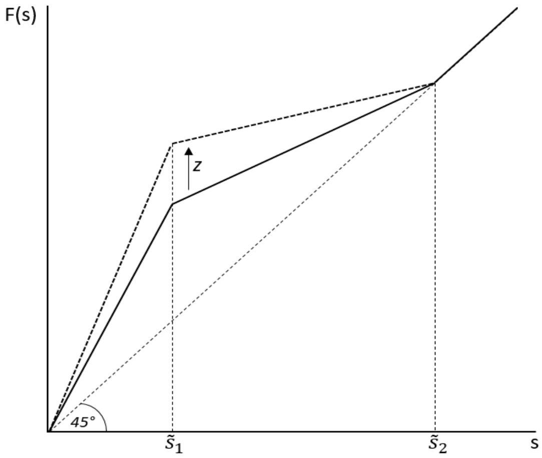
$$\frac{\partial P_H^{I^*}}{\partial z} = \frac{\theta}{3z^2}\left(-1 + \frac{\widetilde{s}_1\widetilde{s}_2}{\widetilde{s}_2 - \widetilde{s}_1}\right) + \frac{(\widetilde{s}_2 - \widetilde{s}_1)\widetilde{s}_1(1 - \widetilde{s}_2)}{2\left(\widetilde{s}_2 - z\widetilde{s}_1\right)^2}.$$

As the second term is positive, this is clearly positive if either the first term is small enough (θ is small enough or z is large enough), or the first term is positive ($\widetilde{s}_2 - \widetilde{s}_1$ is small enough). *Q.E.D.*

These results demonstrate that price discrimination maximizes an incumbent firm's profits, as long as it is possible to charge searching and loyal consumers different tariffs. The results can be explained as follows. First, Proposition 1 already stated that price discrimination increases if the inverse hazard condition is satisfied, which is the case for the piece-wise linear distribution. Second, if $\widetilde{s}_2 - \widetilde{s}_1 > \widetilde{s}_2\widetilde{s}_1$, then $\widetilde{s}_1$ is relatively far away from $\widetilde{s}_2$. In this case, if z increases, there are relatively many online consumers that have a relatively low transaction cost to switch away from the incumbent. This gives the incumbent little market power on the online platform, resulting in a lower online price. The result then follows as Proposition 1 already indicated

This is the author's accepted manuscript without copyediting, formatting, or final corrections. It will be published in its final form in an upcoming issue of Journal of Political Economy Microeconomics, published by The University of Chicago Press. Include the DOI when citing or quoting: https://doi.org/10.1086/725335. Copyright 2023 The University of Chicago.

Figure C1: A piece-wise linear search cost distribution



Notes: An increase in z shifts the piece-wise linear search cost distribution such that there is more mass of consumers with lower search costs.

that online price dispersion is positively correlated with the incumbent's online price. Finally, overall price dispersion is closely related to the incumbent's baseline price. That price (and overall price dispersion) is increasing under two broad set of conditions. First, if θ is relatively small, there is fierce competition online and the more consumers search online, the more the incumbent wants to extract surplus from the consumers with high search costs. Second, if z is relatively large, or $\widetilde{s}_2 - \widetilde{s}_1$ is relatively small, there are relatively few consumers that have their decision on whether or not to search be influenced by the base line price, giving the incumbent an incentive to increase its baseline price.

Proposition 3 (price discrimination and dispersion). If (8) holds, then an increase in the fraction of online searchers $F(P_H^{I^*} - P_L^{I^*})$, initiated by an increase in z, coincides with (i) an increase in price discrimination $P_H^{I^*} - P_L^{I^*}$ and (ii) a decrease in online price dispersion $P_L^{I^*} - P^{E^*}$, if and only if $\widetilde{s}_2 - \widetilde{s}_1 > \widetilde{s}_1\widetilde{s}_2$ and (iii) an increase in overall price dispersion $P_H^{I^*} - P^{E^*}$ if θ is small enough, z is large enough, or $\widetilde{s}_2 - \widetilde{s}_1$ is small enough.

Proof. The proof simply follows from calculating the different partial derivatives. As

$$\frac{\partial(P_H^{I^*} - P_L^{I^*})}{\partial z} = \frac{(\widetilde{s}_2 - \widetilde{s}_1)\widetilde{s}_1(1 - \widetilde{s}_2)}{2\left(\widetilde{s}_2 - z\widetilde{s}_1\right)^2} > 0$$

and

$$\frac{\partial F(P_H^{I^*} - P_L^{I^*})}{\partial z} = \frac{\widetilde{s}_1\widetilde{s}_2}{2\left(\widetilde{s}_2 - \widetilde{s}_1\right)} > 0,$$

an increase in the fraction of online searchers, initiated by an increase in z, certainly leads to

This is the author's accepted manuscript without copyediting, formatting, or final corrections. It will be published in its final form in an upcoming issue of Journal of Political Economy Microeconomics, published by The University of Chicago Press. Include the DOI when citing or quoting: https://doi.org/10.1086/725335. Copyright 2023 The University of Chicago.

an increase in price discrimination $P_H^{I^*} - P_L^{I^*}$. As

$$\frac{\partial(P_L^{I^*} - P^{E^*})}{\partial z} = -\frac{\theta}{6z^2}\left(\frac{\widetilde{s}_2 - \widetilde{s}_1 - \widetilde{s}_1\widetilde{s}_2}{\widetilde{s}_2 - \widetilde{s}_1}\right)$$

it leads to a decrease in online price dispersion if $\widetilde{s}_2 - \widetilde{s}_1 - \widetilde{s}_1\widetilde{s}_2 > 0$. Finally, as

$$\frac{\partial(P_H^{I^*} - P^{E^*})}{\partial z} = \frac{\theta}{6z^2}\left(-1 + \frac{\widetilde{s}_1\widetilde{s}_2}{\widetilde{s}_2 - \widetilde{s}_1}\right) + \frac{(\widetilde{s}_2 - \widetilde{s}_1)\widetilde{s}_1(1 - \widetilde{s}_2)}{2\left(\widetilde{s}_2 - z\widetilde{s}_1\right)^2},$$

and the second term is positive, it leads to an increase in price discrimination if either the first term is small enough (θ is small enough or z is large enough), or the first term is positive ($\widetilde{s}_2 - \widetilde{s}_1$ is small enough). *Q.E.D*

D Sequential price setting game

When the firms compete in a sequential price setting game, in which the incumbent sets its baseline rate first, the respective profits of the entrant and incumbent do not change and are as given in the main text:

$$\pi_E = F(\widehat{s}_1; z)P^E = F\left(\frac{P_L^I - P^E}{\theta}; z\right)P^E$$

and

$$\begin{aligned}\pi_I &= \left[F(\widehat{s}_2; z) - F(\widehat{s}_1; z)\right]P_L^I + (1 - F(\widehat{s}_2; z))P_H^I \\ &= \left[F(P_H^I - P_L^{I^e}; z) - F\left(\frac{P_H^I - P^E}{\theta}; z\right)\right]P_L^I + (1 - F(P_H^I - P_L^{I^e}); z)P_H^I.\end{aligned}$$

In taking the first-order conditions, one has to be careful in this "Stackelberg" environment where, in the second stage, the incumbent sets the online price P_L^I simultaneously with the entrant choosing P^E, and the incumbent chooses the baseline price P_H^I in the first stage. In this case, when setting online prices, both players have to take the number of consumers who search online, i.e., $F(P_H^I - P_L^{I^e})$, as given. Thus, if (as explained in the main text) both online prices react to the incumbent baseline price, the F.O.C.s (evaluated at the equilibrium where

This is the author's accepted manuscript without copyediting, formatting, or final corrections. It will be published in its final form in an upcoming issue of Journal of Political Economy Microeconomics, published by The University of Chicago Press. Include the DOI when citing or quoting: https://doi.org/10.1086/725335. Copyright 2023 The University of Chicago.

$P_L^{I^e} = P_L^{I^*}$) for the online prices (for given P_H^I), do not change either, so that they are given by:

$$F\left(\frac{P_L^I - P^E}{\theta}; z\right) - f\left(\frac{P_L^I - P^E}{\theta}; z\right)\frac{P^E}{\theta} = 0$$

and

$$F(P_H^I - P_L^I; z) - F\left(\frac{P_L^I - P^E}{\theta}; z\right) - f\left(\frac{P_L^I - P^E}{\theta}; z\right)\frac{P_H^I}{\theta} = 0,$$

respectively. This determines the online prices for given $P_H^I : P^E(P_H^I)$ and $P_L^I(P_H^I)$.

However, in determining the baseline price under "Stackelberg", the incumbent and the consumers take these reactions into account. Thus, when observing P_H^I, consumers realize that the second stage prices will be affected by a change in P_H^I. Thus, the incumbent sets P_H^I such that

$$0 = -f(P_H^I - P_L^I; z)(P_H^I - P_L^I)(1 - \frac{\partial P_L^I}{\partial P_H^I}) - \frac{P_H^I}{\theta} f\left(\frac{P_L^I - P^E}{\theta}; z\right)\frac{\partial (P_L^I - P^E)}{\partial P_H^I}$$
$$+ \left[F(P_H^I - P_L^I; z) - F\left(\frac{P_L^I - P^E}{\theta}; z\right)\right]\frac{\partial P_L^I}{\partial P_H^I} + (1 - F(P_H^I - P_L^I; z))$$

This expression has several new terms compared to the F.O.C. for P_H^I in the simultaneous choice model analyzed in the main text as, when setting P_H^I the incumbent (and the consumers) now consider how both online prices and the market shares change in response to changes in P_H^I.

For general distribution functions, it is not possible to solve these three equations in a meaningful way. Thus, in the rest of this appendix we consider the piece-wise linear distribution, where (as in the main text) we consider $\frac{P_L^I - P^E}{\theta} < \widetilde{s}_1 < P_H^I - P_L^I < \widetilde{s}_2$. As in the main text, the solution to (1) yields $P^E = P_L^I/2$, while in combination with (2) we have

$$\left(\frac{3z}{2\theta} + \frac{\widetilde{s}_2 - z\widetilde{s}_1}{\widetilde{s}_2 - \widetilde{s}_1}\right)P_L^I = \frac{\widetilde{s}_2 - z\widetilde{s}_1}{\widetilde{s}_2 - \widetilde{s}_1}P_H^I + \frac{(z-1)\widetilde{s}_1\widetilde{s}_2}{\widetilde{s}_2 - \widetilde{s}_1}.$$

Note from this equation it is clear that online prices are increasing in P_H^I but not to the full extent. In particular, $0 < \frac{\partial (P_L^I - P^E)}{\partial P_H^I} < \frac{\partial P_L^I}{\partial P_H^I} < 1$. Thus, if $\frac{P_L^I - P^E}{\theta} < \widetilde{s}_1 < P_H^I - P_L^I < \widetilde{s}_2$ the incumbent

This is the author's accepted manuscript without copyediting, formatting, or final corrections. It will be published in its final form in an upcoming issue of Journal of Political Economy Microeconomics, published by The University of Chicago Press. Include the DOI when citing or quoting: https://doi.org/10.1086/725335. Copyright 2023 The University of Chicago.

base line price solves

$$0 = -\frac{\widetilde{s}_2 - z\widetilde{s}_1}{\widetilde{s}_2 - \widetilde{s}_1}(P_H^I - P_L^I)\left(1 - \frac{\frac{\widetilde{s}_2 - z\widetilde{s}_1}{\widetilde{s}_2 - \widetilde{s}_1}}{\frac{3z}{2\theta} + \frac{\widetilde{s}_2 - z\widetilde{s}_1}{\widetilde{s}_2 - \widetilde{s}_1}}\right) - \frac{z}{2\theta}\frac{\frac{\widetilde{s}_2 - z\widetilde{s}_1}{\widetilde{s}_2 - \widetilde{s}_1}}{\frac{3z}{2\theta} + \frac{\widetilde{s}_2 - z\widetilde{s}_1}{\widetilde{s}_2 - \widetilde{s}_1}}P_H^I$$
$$+\left[\frac{(z-1)\widetilde{s}_1\widetilde{s}_2}{\widetilde{s}_2 - \widetilde{s}_1} - \frac{\widetilde{s}_2 - z\widetilde{s}_1}{\widetilde{s}_2 - \widetilde{s}_1}(P_H^I - P_L^I) - z\frac{P_L^I - P^E}{\theta}\right]\frac{\frac{\widetilde{s}_2 - z\widetilde{s}_1}{\widetilde{s}_2 - \widetilde{s}_1}}{\frac{3z}{2\theta} + \frac{\widetilde{s}_2 - z\widetilde{s}_1}{\widetilde{s}_2 - \widetilde{s}_1}}$$
$$+1 - \frac{(z-1)\widetilde{s}_1\widetilde{s}_2}{\widetilde{s}_2 - \widetilde{s}_1} - \frac{\widetilde{s}_2 - z\widetilde{s}_1}{\widetilde{s}_2 - \widetilde{s}_1}(P_H^I - P_L^I),$$

or as

$$\left(\frac{3z}{2\theta} + \frac{\widetilde{s}_2 - z\widetilde{s}_1}{\widetilde{s}_2 - \widetilde{s}_1}\right)P_L^I = \frac{\widetilde{s}_2 - z\widetilde{s}_1}{\widetilde{s}_2 - \widetilde{s}_1}P_H^I + \frac{(z-1)\widetilde{s}_1\widetilde{s}_2}{\widetilde{s}_2 - \widetilde{s}_1}$$

we have that

$$0 = -2\left(\frac{3z}{2\theta}P_L^I - \frac{(z-1)\widetilde{s}_1\widetilde{s}_2}{\widetilde{s}_2 - \widetilde{s}_1}\right) - \frac{z}{\theta}\frac{\frac{\widetilde{s}_2 - z\widetilde{s}_1}{\widetilde{s}_2 - \widetilde{s}_1}}{\frac{3z}{2\theta} + \frac{\widetilde{s}_2 - z\widetilde{s}_1}{\widetilde{s}_2 - \widetilde{s}_1}}P_L^I$$
$$+1 - \frac{(z-1)\widetilde{s}_1\widetilde{s}_2}{\widetilde{s}_2 - \widetilde{s}_1}\left(1 - \frac{\frac{\widetilde{s}_2 - z\widetilde{s}_1}{\widetilde{s}_2 - \widetilde{s}_1}}{\frac{3z}{2\theta} + \frac{\widetilde{s}_2 - z\widetilde{s}_1}{\widetilde{s}_2 - \widetilde{s}_1}}\right),$$

which can be simplified to

$$\frac{z}{\theta}\left(3 + \frac{\frac{\widetilde{s}_2 - z\widetilde{s}_1}{\widetilde{s}_2 - \widetilde{s}_1}}{\frac{3z}{2\theta} + \frac{\widetilde{s}_2 - z\widetilde{s}_1}{\widetilde{s}_2 - \widetilde{s}_1}}\right)P_L^I = 1 + \frac{(z-1)\widetilde{s}_1\widetilde{s}_2}{\widetilde{s}_2 - \widetilde{s}_1}\left(1 + \frac{\frac{\widetilde{s}_2 - z\widetilde{s}_1}{\widetilde{s}_2 - \widetilde{s}_1}}{\frac{3z}{2\theta} + \frac{\widetilde{s}_2 - z\widetilde{s}_1}{\widetilde{s}_2 - \widetilde{s}_1}}\right).$$

Thus, we have that the different equilibrium prices for the incumbent are given by

$$P_L^I = \frac{1 + \frac{(z-1)\widetilde{s}_1\widetilde{s}_2}{\widetilde{s}_2 - \widetilde{s}_1}\left(1 + \frac{\frac{\widetilde{s}_2 - z\widetilde{s}_1}{\widetilde{s}_2 - \widetilde{s}_1}}{\frac{3z}{2\theta} + \frac{\widetilde{s}_2 - z\widetilde{s}_1}{\widetilde{s}_2 - \widetilde{s}_1}}\right)}{\frac{z}{\theta}\left(3 + \frac{\frac{\widetilde{s}_2 - z\widetilde{s}_1}{\widetilde{s}_2 - \widetilde{s}_1}}{\frac{3z}{2\theta} + \frac{\widetilde{s}_2 - z\widetilde{s}_1}{\widetilde{s}_2 - \widetilde{s}_1}}\right)}$$

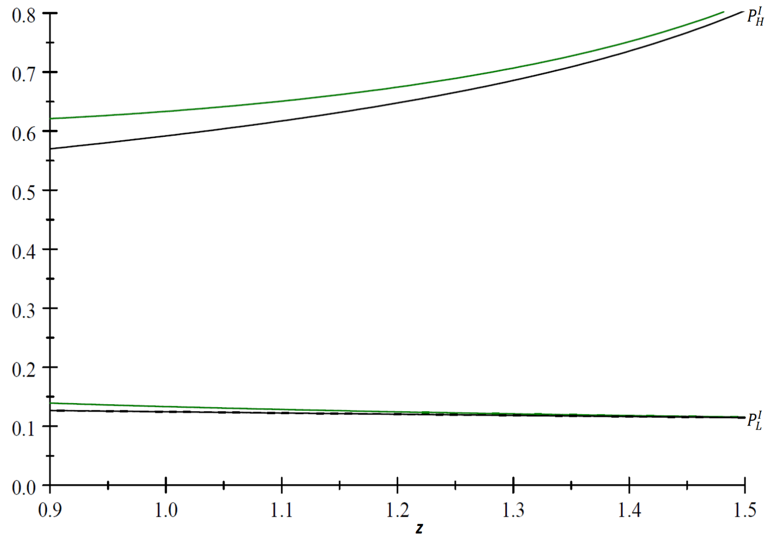
so that

$$P_H^I = \frac{1 + \frac{(z-1)\widetilde{s}_1\widetilde{s}_2}{\widetilde{s}_2 - \widetilde{s}_1}\left(1 + \frac{\frac{\widetilde{s}_2 - z\widetilde{s}_1}{\widetilde{s}_2 - \widetilde{s}_1}}{\frac{3z}{2\theta} + \frac{\widetilde{s}_2 - z\widetilde{s}_1}{\widetilde{s}_2 - \widetilde{s}_1}}\right)}{\frac{z}{\theta}\left(3 + \frac{\frac{\widetilde{s}_2 - z\widetilde{s}_1}{\widetilde{s}_2 - \widetilde{s}_1}}{\frac{3z}{2\theta} + \frac{\widetilde{s}_2 - z\widetilde{s}_1}{\widetilde{s}_2 - \widetilde{s}_1}}\right)}\left(1 + \frac{3z}{2\theta}\frac{\widetilde{s}_2 - \widetilde{s}_1}{\widetilde{s}_2 - z\widetilde{s}_1}\right) - \frac{(z-1)\widetilde{s}_1\widetilde{s}_2}{\widetilde{s}_2 - z\widetilde{s}_1}.$$

For the parameter values we considered before, where $\theta = 2/5$, $\widetilde{s}_1 = 3/10$ and $\widetilde{s}_2 = 3/5$, this

This is the author's accepted manuscript without copyediting, formatting, or final corrections. It will be published in its final form in an upcoming issue of Journal of Political Economy Microeconomics, published by The University of Chicago Press. Include the DOI when citing or quoting: https://doi.org/10.1086/725335. Copyright 2023 The University of Chicago.

Figure E1: Price patterns: simultaneous versus sequential game



Notes: The figure predicts price changes under sequential price setting (green) and simultaneous price setting (black) as a function of z with $\widetilde{s}_2 = 3/5$ and $\widetilde{s}_1 = 1/5$ and $\theta = 2/5$. Since the entrants' online tariffs (P^E) are half of the incumbents' cheaper online tariffs (P^I_L), P^E is not shown for better clarity.

results in

$$P^I_L = \frac{1 + \frac{.18(z-1)}{.3}\left(1 + \frac{6-3z}{\frac{9z}{0.8}+6-3z}\right)}{\frac{5z}{2}\left(3 + \frac{6-3z}{\frac{9z}{0.8}+6-3z}\right)}$$

and

$$P^I_H = \frac{1 + \frac{.18(z-1)}{.3}\left(1 + \frac{6-3z}{\frac{9z}{0.8}+6-3z}\right)}{\frac{5z}{2}\left(3 + \frac{6-3z}{\frac{9z}{0.8}+6-3z}\right)}\left(1 + \frac{.9z}{0.8(.6-.3z)}\right) - \frac{.18(z-1)}{.6-.3z}.$$

Figure E1 plots these prices under sequential price setting as a function of z together with the corresponding prices for the simultaneous move game analyzed in the main text. The figure shows that the two different analyses (simultaneous versus sequential choice of offline and online prices) show that equilibrium outcomes are very close to each other. The reason is twofold. First, as indicated above, for given and identical P^I_H, the online market is governed by the same incentives and F.O.C.s. Second, if in the sequential setting the incumbent wants to increase its baseline tariff compared to the simultaneous choice setting, the incumbent not only gains because all prices will increase, but also loses as more consumers will switch to the entrant instead of buying from the online incumbent's price. These opposing forces are such that the net effect is that the baseline price is almost identical in the two cases.

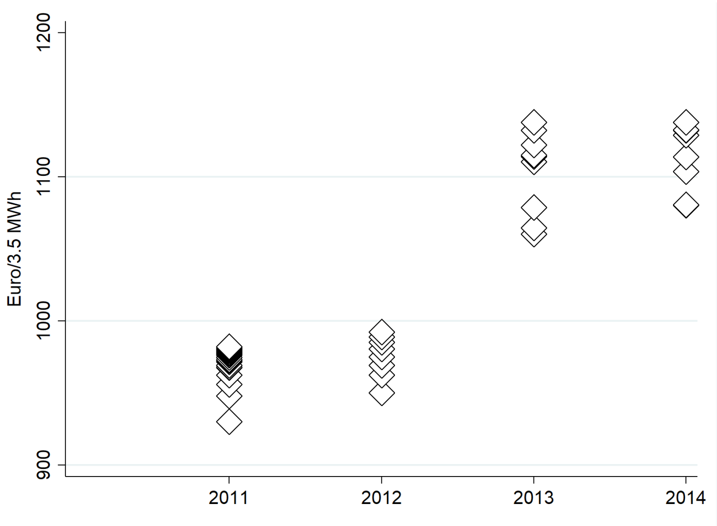
The figure shows that if online prices react to the baseline price, the same pattern with respect to changes in z emerges, namely that if z increases (and therefore, more consumers

This is the author's accepted manuscript without copyediting, formatting, or final corrections. It will be published in its final form in an upcoming issue of Journal of Political Economy Microeconomics, published by The University of Chicago Press. Include the DOI when citing or quoting: https://doi.org/10.1086/725335. Copyright 2023 The University of Chicago.

search online), online prices decrease, while the incumbent's baseline price increases. Thus, price discrimination between loyal and searching consumers increases and online price dispersion decreases.

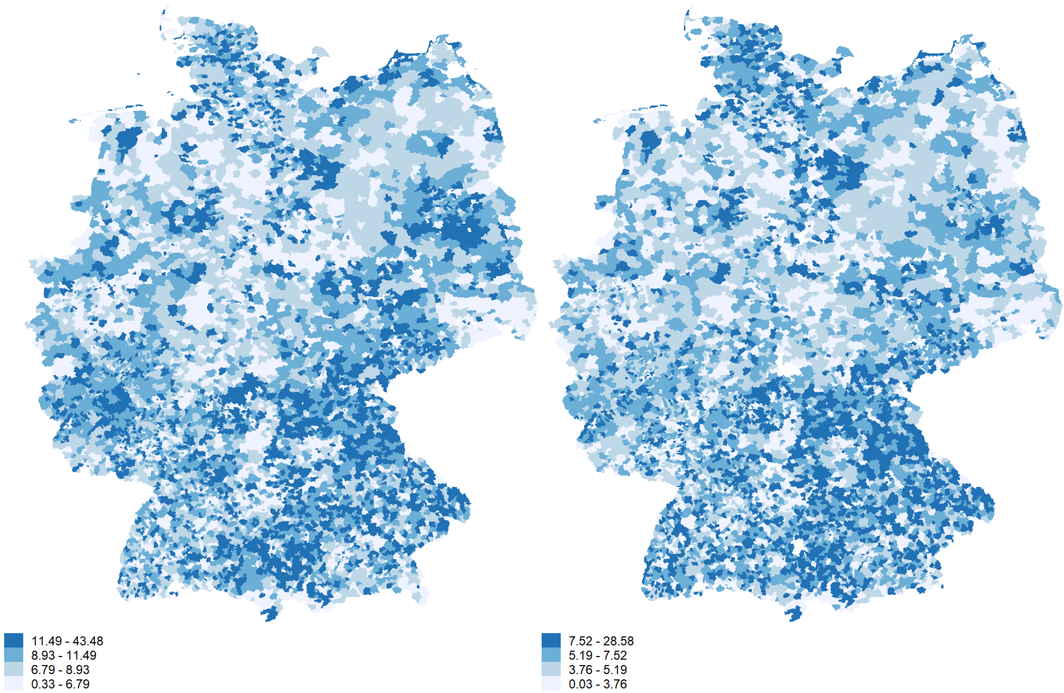
E Additional Figures and Tables

Figure F1: Price zones of "Envia Mitteldeutsche Energie GmbH"



This is the author's accepted manuscript without copyediting, formatting, or final corrections. It will be published in its final form in an upcoming issue of Journal of Political Economy Microeconomics, published by The University of Chicago Press. Include the DOI when citing or quoting: https://doi.org/10.1086/725335. Copyright 2023 The University of Chicago.

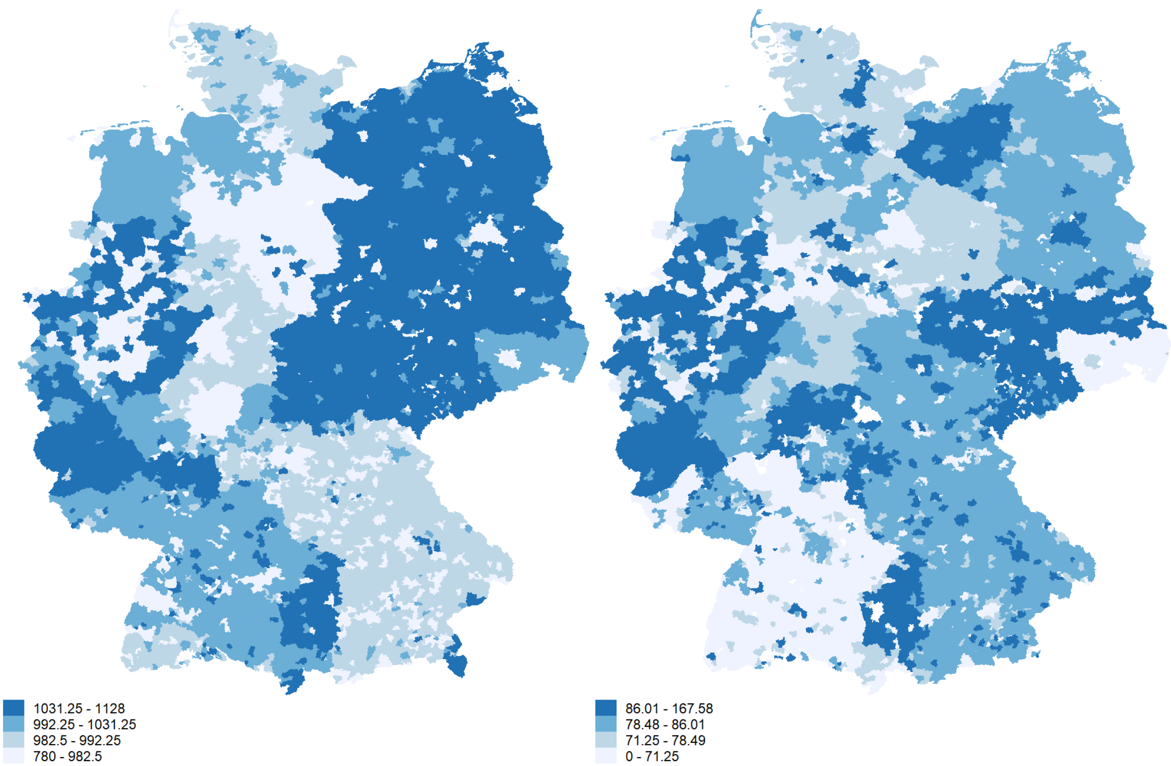
Figure F2: Between and within variation of consumer search intensity



Notes: The left panel presents the between variation in consumer search intensity computed as the average search intensity per zip code during our observation period. The right panel presents the within variation per zip code computed as the standard deviation per zip code during our observation period.

This is the author's accepted manuscript without copyediting, formatting, or final corrections. It will be published in its final form in an upcoming issue of Journal of Political Economy Microeconomics, published by The University of Chicago Press. Include the DOI when citing or quoting: https://doi.org/10.1086/725335. Copyright 2023 The University of Chicago.

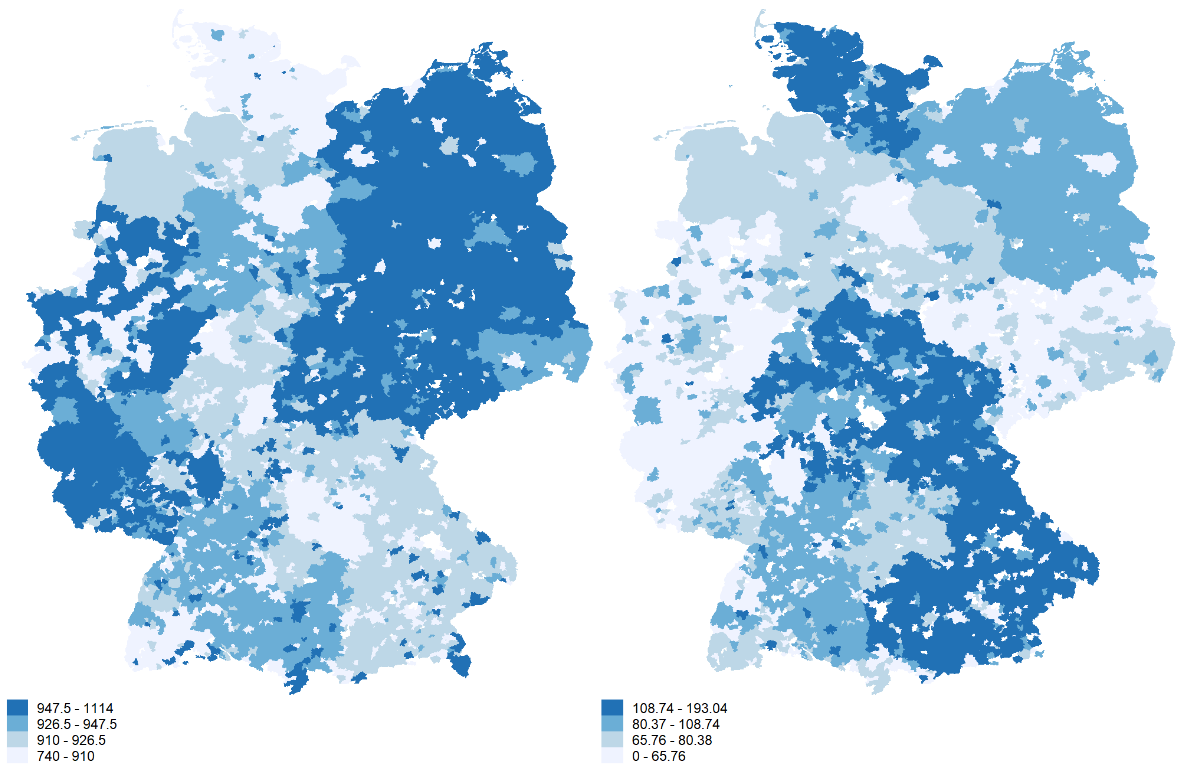
Figure F3: Between and within variation of incumbents' base prices



Notes: The left panel presents the between variation in incumbent base prices computed as the average incumbent base price per zip code during our observation period. The right panel presents the within variation per zip code computed as the standard deviation per zip code during our observation period.

This is the author's accepted manuscript without copyediting, formatting, or final corrections. It will be published in its final form in an upcoming issue of Journal of Political Economy Microeconomics, published by The University of Chicago Press. Include the DOI when citing or quoting: https://doi.org/10.1086/725335. Copyright 2023 The University of Chicago.

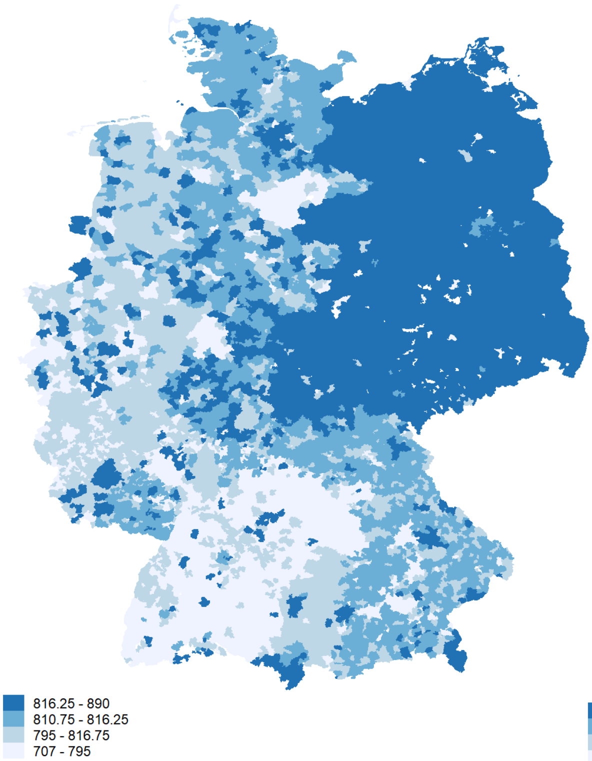
Figure F4: Between and within variation of incumbents' cheaper online prices

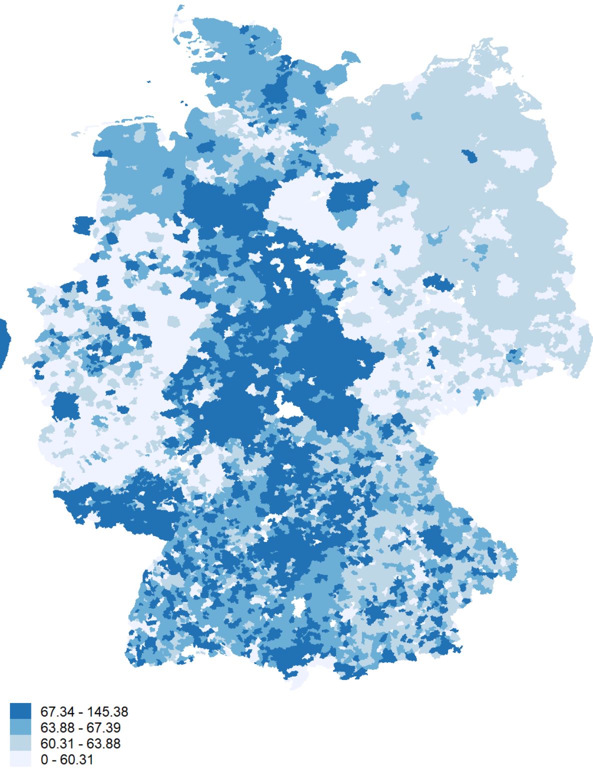


Notes: The left panel presents the between variation in incumbents' cheaper online prices computed as the average incumbents' cheapest price per zip code during our observation period. The right panel presents the within variation per zip code computed as the standard deviation per zip code during our observation period.

This is the author's accepted manuscript without copyediting, formatting, or final corrections. It will be published in its final form in an upcoming issue of Journal of Political Economy Microeconomics, published by The University of Chicago Press. Include the DOI when citing or quoting: https://doi.org/10.1086/725335. Copyright 2023 The University of Chicago.

Figure F5: Between and within variation of the overall cheapest prices

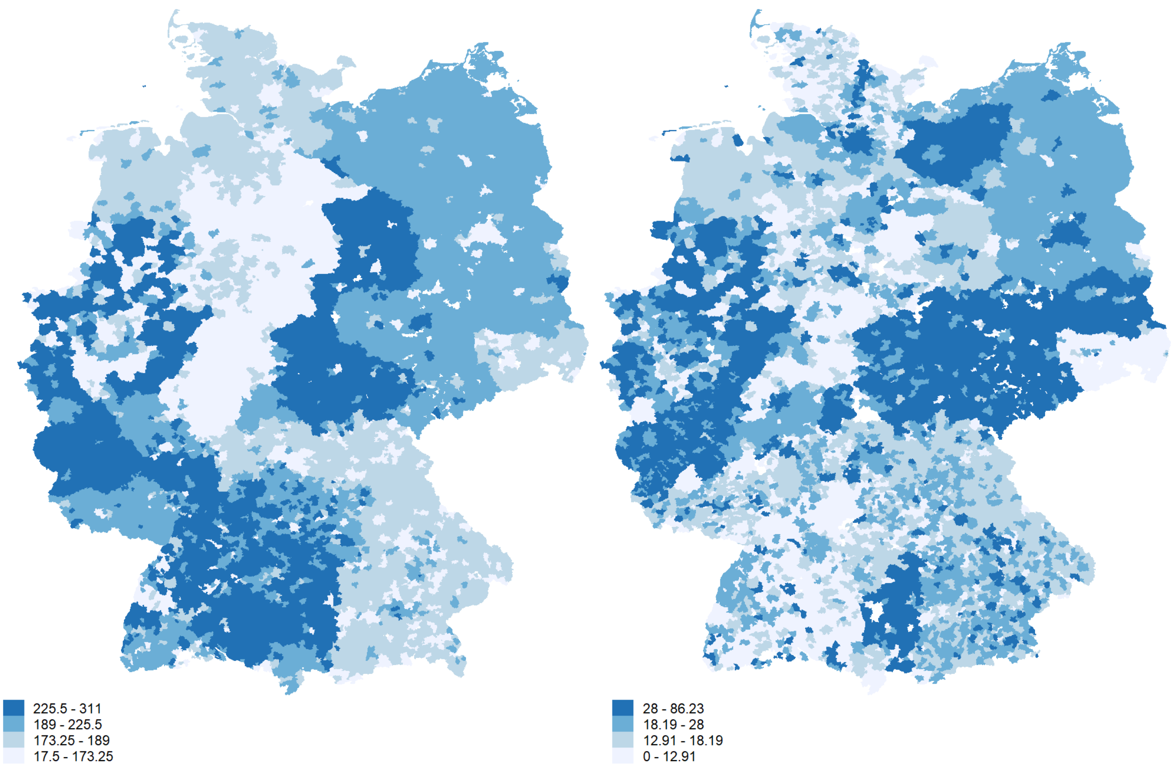




Notes: The left panel presents the between variation in the overall cheapest prices computed as the average cheapest price per zip code during our observation period. The right panel presents the within variation per zip code computed as the standard deviation per zip code during our observation period.

This is the author's accepted manuscript without copyediting, formatting, or final corrections. It will be published in its final form in an upcoming issue of Journal of Political Economy Microeconomics, published by The University of Chicago Press. Include the DOI when citing or quoting: https://doi.org/10.1086/725335. Copyright 2023 The University of Chicago.

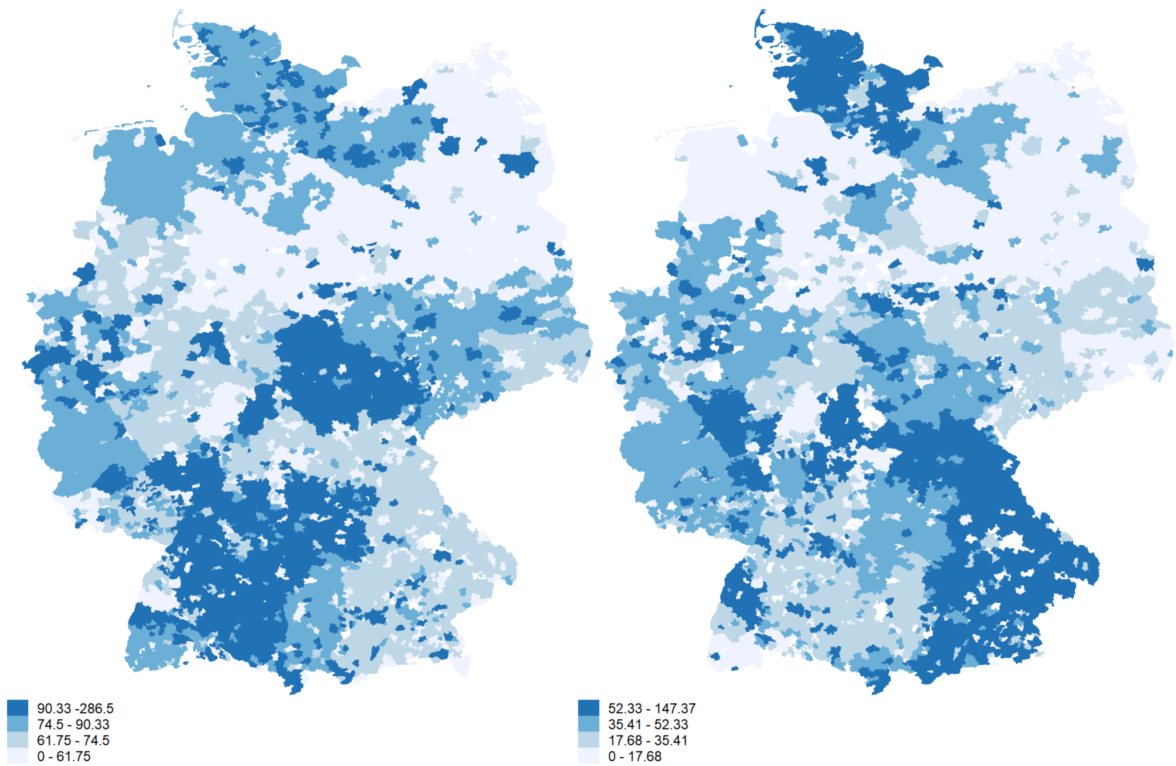
Figure F6: Between and within variation of price dispersion



Notes: The left panel presents the between variation in the price dispersion computed as the average price dispersion per zip code during our observation period. The right panel presents the within variation per zip code computed as the standard deviation per zip code during our observation period.

This is the author's accepted manuscript without copyediting, formatting, or final corrections. It will be published in its final form in an upcoming issue of Journal of Political Economy Microeconomics, published by The University of Chicago Press. Include the DOI when citing or quoting: https://doi.org/10.1086/725335. Copyright 2023 The University of Chicago.

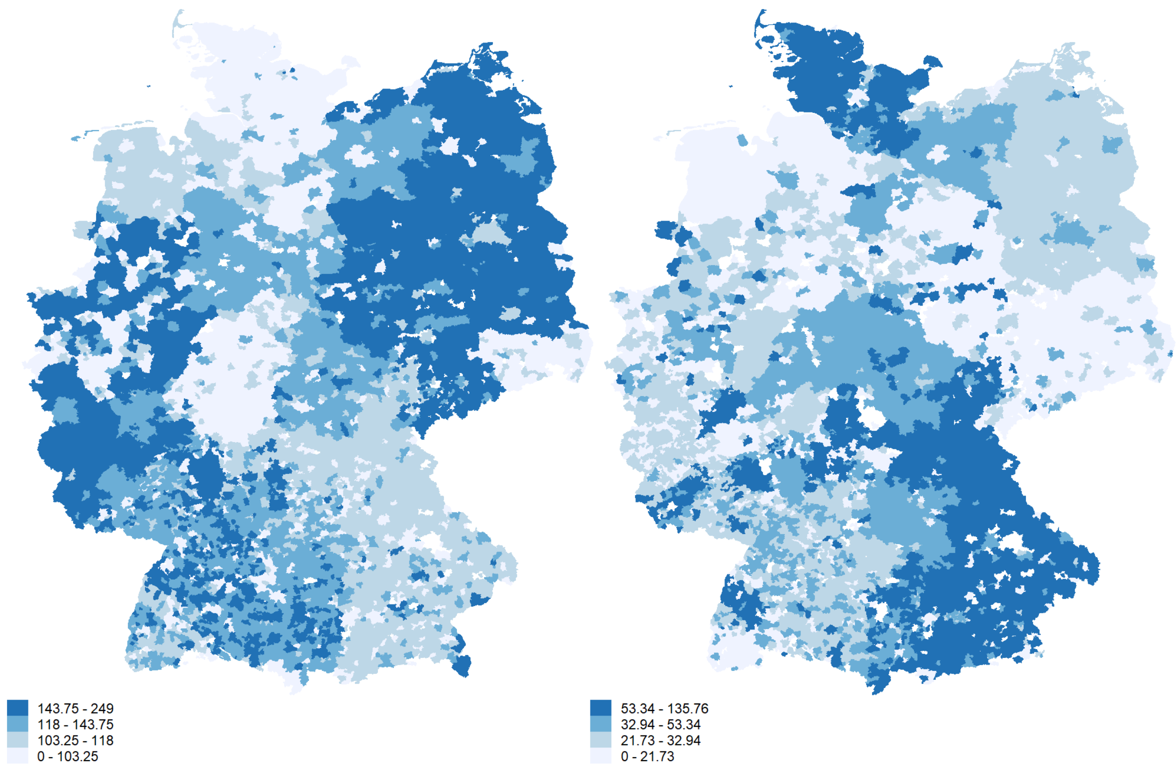
Figure F7: Between and within variation of price discrimination



Notes: The left panel presents the between variation in the price discrimination computed as the average price discrimination per zip code during our observation period. The right panel presents the within variation per zip code computed as the standard deviation per zip code during our observation period.

This is the author's accepted manuscript without copyediting, formatting, or final corrections. It will be published in its final form in an upcoming issue of Journal of Political Economy Microeconomics, published by The University of Chicago Press. Include the DOI when citing or quoting: https://doi.org/10.1086/725335. Copyright 2023 The University of Chicago.

Figure F8: Between and within variation of online price dispersion



Notes: The left panel presents the between variation in the online price dispersion computed as the average online price dispersion per zip code during our observation period. The right panel presents the within variation per zip code computed as the standard deviation per zip code during our observation period.

This is the author's accepted manuscript without copyediting, formatting, or final corrections. It will be published in its final form in an upcoming issue of Journal of Political Economy Microeconomics, published by The University of Chicago Press. Include the DOI when citing or quoting: https://doi.org/10.1086/725335. Copyright 2023 The University of Chicago.

F Robustness

Table G1: IV estimates of the impact of consumer search on prices (log-log) – alternative clustering of standard errors

	(1) ln Incumbent Base (P_H^I)	(2) ln Incumbent Cheapest (P_L^I)	(3) ln Overall Cheapest (P^E)
Search (μ)	0.0389***	-0.1715**	-0.0382***
	(0.0132)	(0.0705)	(0.0128)
Costs	0.2268***	0.3780***	0.5169***
	(0.0290)	(0.0764)	(0.0321)
Available income	-0.0074	0.0773**	-0.0039
	(0.0092)	(0.0303)	(0.0070)
No. households	0.0295***	-0.0806**	-0.0302***
	(0.0101)	(0.0373)	(0.0080)
Household size	0.0883***	0.0744	-0.0081
	(0.0323)	(0.0995)	(0.0297)
Year FE	Yes	Yes	Yes
Zip code FE	Yes	Yes	Yes
First stage effective F stat.	92.63	92.63	92.63
Obs.	25,899	25,899	25,899

Notes: Standard errors clustered at the price zone level in parentheses. Instrumented for μ by the search intensity for gas tariffs. $^{***}p < 1\%$, $^{**}p < 5\%$, $^{*}p < 10\%$.

Table G2: IV estimates of the impact of consumer search on dispersion (log-log) – alternative clustering of standard errors

	(1) Price Dispersion ($P_H^I - P^E$)	(2) Price Discrimination ($P_H^I - P_L^I$)	(3) Online Price Dispersion ($P_L^I - P^E$)
Search (μ)	0.3696***	2.4776***	-1.7056*
	(0.0947)	(0.7747)	(0.9622)
Costs	-1.0152***	-1.2747	-1.5596*
	(0.2087)	(1.2706)	(0.9312)
Available income	0.0033	-0.8118*	0.8991**
	(0.0712)	(0.4176)	(0.3580)
No. households	0.2911***	1.2952***	-0.7173
	(0.0812)	(0.4236)	(0.4937)
Household size	0.4221	0.3701	1.5223
	(0.2630)	(1.2851)	(1.2558)
Year FE	Yes	Yes	Yes
Zip code FE	Yes	Yes	Yes
First stage effective F stat.	92.63	92.63	92.63
Obs.	25,899	25,899	25,899

Notes: Standard errors clustered at the price zone level in parentheses. Instrumented for μ by the search intensity for gas tariffs. $^{***}p < 1\%$, $^{**}p < 5\%$, $^{*}p < 10\%$.

This is the author's accepted manuscript without copyediting, formatting, or final corrections. It will be published in its final form in an upcoming issue of Journal of Political Economy Microeconomics, published by The University of Chicago Press. Include the DOI when citing or quoting: https://doi.org/10.1086/725335. Copyright 2023 The University of Chicago.

Table G3: IV estimates of the impact of consumer search on prices (log-log) – estimations without covariates

	(1) ln Incumbent Base (P^I_H)	(2) ln Incumbent Cheapest (P^I_L)	(3) ln Overall Cheapest (P^E)
Search (μ)	0.0312***	-0.1728***	-0.0482***
	(0.0047)	(0.0213)	(0.0056)
Year FE	Yes	Yes	Yes
Zip code FE	Yes	Yes	Yes
First stage effective F stat.	110.55	110.55	110.55
Obs.	25,899	25,899	25,899

Notes: Standard errors clustered at the zip code level in parentheses. Instrumented for μ by the search intensity for gas tariffs. $^{***}p < 1\%$, $^{**}p < 5\%$, $^{*}p < 10\%$.

Table G4: IV estimates of the impact of consumer search on dispersion (log-log) – estimations without covariates

	(1) Price Dispersion ($P^I_H - P^E$)	(2) Price Discrimination ($P^I_H - P^I_L$)	(3) Online Price Dispersion ($P^I_L - P^E$)
Search (μ)	0.3720***	2.3955***	-1.5998***
	(0.0410)	(0.2887)	(0.2622)
Year FE	Yes	Yes	Yes
Zip code FE	Yes	Yes	Yes
First stage effective F stat.	110.55	110.55	110.55
Obs.	25,899	25,899	25,899

Notes: Standard errors clustered at the zip code level in parentheses. Instrumented for μ by the search intensity for gas tariffs. $^{***}p < 1\%$, $^{**}p < 5\%$, $^{*}p < 10\%$.

This is the author's accepted manuscript without copyediting, formatting, or final corrections. It will be published in its final form in an upcoming issue of Journal of Political Economy Microeconomics, published by The University of Chicago Press. Include the DOI when citing or quoting: https://doi.org/10.1086/725335. Copyright 2023 The University of Chicago.

Table G5: IV estimates of the impact of consumer search on prices (log-log) – estimations with additional covariates

	(1) ln Incumbent Base (P_H^I)	(2) ln Incumbent Cheapest (P_L^I)	(3) ln Overall Cheapest (P^E)
Search (μ)	0.0344***	-0.1608***	-0.0321***
	(0.0054)	(0.0235)	(0.0049)
Costs	0.2315***	0.3677***	0.5090***
	(0.0092)	(0.0285)	(0.0085)
Available income	-0.0071	0.0686***	0.0023
	(0.0052)	(0.0202)	(0.0044)
No. households	0.0264***	-0.0752***	-0.0277***
	(0.0055)	(0.0207)	(0.0052)
Household size	0.0829***	0.0936*	-0.0297**
	(0.0149)	(0.0543)	(0.0127)
Unemployement	0.0022**	-0.0243***	-0.0031***
	(0.0009)	(0.0038)	(0.0008)
High urbanization	-0.0001	0.0010	0.0007**
	(0.0004)	(0.0016)	(0.0003)
Household head younger than 40 yo	0.0191***	0.0845***	0.0284***
	(0.0054)	(0.0207)	(0.0047)
Household head between 40 and 60 yo	0.0504***	0.1179***	0.0805***
	(0.0097)	(0.0340)	(0.0076)
Share of self-employed	-0.0071*	0.0232*	-0.0111*
	(0.0038)	(0.0136)	(0.0064)
Moved HH	0.0024**	-0.0019	-0.0014
	(0.0012)	(0.0049)	(0.0010)
New HH	-0.0034***	0.0066	0.0052***
	(0.0012)	(0.0053)	(0.0011)
Low social status	0.0005***	0.0000	-0.0003***
	(0.0001)	(0.0003)	(0.0001)
Mediocre social status	0.0004**	0.0007	0.0005***
	(0.0002)	(0.0006)	(0.0002)
Year FE	Yes	Yes	Yes
Zip code FE	Yes	Yes	Yes
First stage effective F stat.	84.62	84.62	84.62
Obs.	25,899	25,899	25,899

Notes: Standard errors clustered at the zip code level in parentheses. Instrumented for μ by the search intensity for gas tariffs. $^{***}p < 1\%$, $^{**}p < 5\%$, $^{*}p < 10\%$.

This is the author's accepted manuscript without copyediting, formatting, or final corrections. It will be published in its final form in an upcoming issue of Journal of Political Economy Microeconomics, published by The University of Chicago Press. Include the DOI when citing or quoting: https://doi.org/10.1086/725335. Copyright 2023 The University of Chicago.

Table G6: IV estimates of the impact of consumer search on dispersion (log-log) – estimations with additional covariates

	(1) Price Dispersion ($P^I_H - P^E$)	(2) Price Discrimination ($P^I_H - P^I_L$)	(3) Online Price Dispersion ($P^I_L - P^E$)
Search (μ)	0.3254***	2.3257***	-1.6763***
	(0.0423)	(0.3250)	(0.3059)
Costs	-0.9644***	-1.1078***	-1.5548***
	(0.0661)	(0.4019)	(0.3279)
Available income	-0.0101	-0.6819**	0.6983***
	(0.0392)	(0.2833)	(0.2314)
No. households	0.2652***	1.2368***	-0.6838***
	(0.0434)	(0.2740)	(0.2292)
Household size	0.4500***	0.0871	2.1811***
	(0.1101)	(0.7488)	(0.6666)
Unemployement	0.0230***	0.3081***	-0.2363***
	(0.0071)	(0.0507)	(0.0436)
High urbanization	-0.0038	-0.0045	-0.0015
	(0.0031)	(0.0223)	(0.0187)
Household head younger than 40 yo	-0.0134	-1.2160***	0.6467**
	(0.0400)	(0.2955)	(0.2524)
Household head between 40 and 60 yo	-0.0236	-1.6211***	0.0926
	(0.0717)	(0.4819)	(0.3967)
Share of self-employed	-0.0018	-0.5311**	0.3792**
	(0.0250)	(0.2618)	(0.1792)
Moved HH	0.0237***	0.0579	-0.0566
	(0.0091)	(0.0672)	(0.0561)
New HH	-0.0474***	-0.0941	0.0622
	(0.0099)	(0.0725)	(0.0610)
Low social status	0.0031***	0.0034	0.0051
	(0.0006)	(0.0041)	(0.0038)
Mediocre social status	0.0006	-0.0001	-0.0017
	(0.0012)	(0.0082)	(0.0077)
Year FE	Yes	Yes	Yes
Zip code FE	Yes	Yes	Yes
First stage effective F stat.	84.62	84.62	84.62
Obs.	25,899	25,899	25,899

Notes: Standard errors clustered at the zip code level in parentheses. Instrumented for μ by the search intensity for gas tariffs. $^{***}p < 1\%$, $^{**}p < 5\%$, $^{*}p < 10\%$.

This is the author's accepted manuscript without copyediting, formatting, or final corrections. It will be published in its final form in an upcoming issue of Journal of Political Economy Microeconomics, published by The University of Chicago Press. Include the DOI when citing or quoting: https://doi.org/10.1086/725335. Copyright 2023 The University of Chicago.

Table G7: IV estimates of the impact of consumer search on prices (level-level)

	(1) Incumbent Base (P_H^I)	(2) Incumbent Cheapest (P_L^I)	(3) Overall Cheapest (P^E)
Search (μ)	1.8442***	-3.7013***	-0.7755***
	(0.1790)	(0.4486)	(0.1052)
Costs	0.3081***	0.5869***	0.5877***
	(0.0125)	(0.0234)	(0.0099)
Available income	-0.3913***	1.4234***	0.0770
	(0.1029)	(0.2718)	(0.0614)
No. households	0.0007	-0.0053***	-0.0019***
	(0.0010)	(0.0020)	(0.0006)
Household size	41.9541***	-41.2177***	-14.7634***
	(6.1180)	(14.5864)	(3.5902)
Year FE	Yes	Yes	Yes
Zip code FE	Yes	Yes	Yes
First stage effective F stat.	466.47	466.47	466.47
Obs.	25,899	25,899	25,899

Notes: Standard errors clustered at the zip code level in parentheses. Instrumented for μ by the search intensity for gas tariffs. $^{***}p < 1\%$, $^{**}p < 5\%$, $^{*}p < 10\%$.

Table G8: IV estimates of the impact of consumer search on dispersion (level-level)

	(1) Price Dispersion ($P_H^I - P^E$)	(2) Price Discrimination ($P_H^I - P_L^I$)	(3) Online Price Dispersion ($P_L^I - P^E$)
Search (μ)	2.6196***	5.5454***	-2.9258***
	(0.2196)	(0.4866)	(0.4215)
Costs	-0.2796***	-0.2788***	-0.0008
	(0.0153)	(0.0240)	(0.0231)
Available income	-0.4683***	-1.8147***	1.3464***
	(0.1257)	(0.2876)	(0.2578)
No. households	0.0026**	0.0060***	-0.0034*
	(0.0012)	(0.0020)	(0.0020)
Household size	56.7175***	83.1718***	-26.4543*
	(7.3430)	(15.1707)	(14.0269)
Year FE	Yes	Yes	Yes
Zip code FE	Yes	Yes	Yes
First stage effective F stat.	466.47	466.47	466.47
Obs.	25,899	25,899	25,899

Notes: Standard errors clustered at the zip code level in parentheses. Instrumented for μ by the search intensity for gas tariffs. $^{***}p < 1\%$, $^{**}p < 5\%$, $^{*}p < 10\%$.

This is the author's accepted manuscript without copyediting, formatting, or final corrections. It will be published in its final form in an upcoming issue of Journal of Political Economy Microeconomics, published by The University of Chicago Press. Include the DOI when citing or quoting: https://doi.org/10.1086/725335. Copyright 2023 The University of Chicago.

Table G9: IV estimates of a non-linear impact of consumer search on prices (log-log)

	(1) Incumbent Base (P^I_H)	(2) Incumbent Cheapest (P^I_L)	(3) Overall Cheapest (P^E)
Search (μ)	0.0532***	-0.2610***	-0.0612***
	(0.0104)	(0.0447)	(0.0101)
Search^2	-0.0057**	0.0355***	0.0091***
	(0.0025)	(0.0107)	(0.0024)
Costs	0.2500***	0.2325***	0.4796***
	(0.0126)	(0.0451)	(0.0120)
Available income	0.0014	0.0225	-0.0180***
	(0.0058)	(0.0202)	(0.0048)
No. households	0.0246***	-0.0503***	-0.0225***
	(0.0049)	(0.0180)	(0.0051)
Household size	0.0753***	0.1553***	0.0127
	(0.0152)	(0.0558)	(0.0134)
Year FE	Yes	Yes	Yes
Zip code FE	Yes	Yes	Yes
Kleibergen-Paap F-stat.	57.29	57.29	57.29
Durbin-Wu-Hausman test	0.00	0.00	0.00
Obs.	25,899	25,899	25,899

Notes: Standard errors clustered at the zip code level in parentheses. Instrumented for μ and μ^2 by the search intensity for gas tariffs and its square. $^{***}p < 1\%$, $^{**}p < 5\%$, $^{*}p < 10\%$.

Table G10: IV estimates of a non-linear impact of consumer search on dispersion (log-log)

	(1) Price Dispersion ($P^I_H - P^E$)	(2) Price Discrimination ($P^I_H - P^I_L$)	(3) Online Price Dispersion ($P^I_L - P^E$)
Search (μ)	0.5142***	3.8373***	-2.3848***
	(0.0840)	(0.6358)	(0.5860)
Search^2	-0.0574***	-0.5394***	0.2695*
	(0.0200)	(0.1538)	(0.1387)
Costs	-0.7803***	0.9339	-2.6630***
	(0.0957)	(0.6704)	(0.5623)
Available income	0.0919**	0.0208	0.4832**
	(0.0433)	(0.2857)	(0.2331)
No. households	0.2422***	0.8353***	-0.4875***
	(0.0389)	(0.2464)	(0.1650)
Household size	0.2914**	-0.8581	2.1358***
	(0.1139)	(0.7660)	(0.6898)
Year FE	Yes	Yes	Yes
Zip code FE	Yes	Yes	Yes
Kleibergen-Paap F-stat.	57.29	57.29	57.29
Durbin-Wu-Hausman test	0.00	0.00	0.00
Obs.	25,899	25,899	25,899

Notes: Standard errors clustered at the zip code level in parentheses. Instrumented for μ and μ^2 by the search intensity for gas tariffs and its square. $^{***}p < 1\%$, $^{**}p < 5\%$, $^{*}p < 10\%$.