

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

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When lower prices are available only to consumers who search, firms can price discriminate based on search. We study local German electricity retail markets in which nonsearching 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

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search, incumbents have higher baseline tariffs, while incumbents' 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.

I. 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 focuses 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 nonsearching 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.

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¹ Many electricity markets around the world have similar characteristics. See, e.g., Cabral (2017) for evidence related to different European countries, Hortaçsu, Madanizadeh, and Puller (2017) for evidence on the USA, and Byrne, Martin, and Nah (2022) for Australia.

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 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 dataset on retail electricity prices and consumer search intensity at online platforms at the German zip code level for the period 2011–14. The German retail electricity market was liberalized at the end of the previous millennium, when former local monopolies were replaced by local retail competition. Since then, local incumbent suppliers have competed 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% have 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,

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.

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, Hortaçsu, and Wildenbeest 2012; Blake, Nosko, and Tadelis 2016; Coey, Larsen, and Platt 2020), other empirical studies on consumer search markets often have to rely on indirect measures of consumer search activity.³

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 consumers 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 1 standard deviation increase in within-zip-code search intensity explains nearly 50% of the observed price discrimination. Hence, one key takeaway 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., Lewis 2008; Tappata 2009; 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 an 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 United States, Canada, and 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

³ Brynjolfsson and Smith (2014), e.g., use access to the internet as a proxy for lower search costs. Similarly, for retail gasoline markets, Pennersdorfer et al. (2020) use commuters vs. noncommuters to distinguish between informed and uninformed consumers.

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

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; Janssen and Moraga-González 2004). Several empirical studies focus on price dispersion and search intensity (see, e.g., Sorensen 2000; De Los Santos, Hortaçsu, and Wildenbeest 2012). Tang, Smith, and Montgomery (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, Waterson, and Wildenbeest (2014) analyze the retail electricity market in the United Kingdom and find that roughly half the households had relatively high search costs. Hortaçsu, Madanizadeh, and Puller (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, Martin, and Nah (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

⁴ For example, the *Economist* (2018) states that established US banks generally offer substantially lower interest rates on savings accounts compared to online rates offered to clients at internet portals. Allen, Clark, and Houde (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.

bargaining with individual households. Their 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, Suslow, and Seguin 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 who are less price sensitive. Using a similar 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, Price, and Wilson (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 nonsearching consumers who do not. Allen, Clark, and Houde (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, Clark, and Houde (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

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.

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 in which 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 different from ours in that they study symmetric firms facing cost shocks, whereas 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 in which 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 II describes the German retail electricity market in more detail. Section III provides a theoretical model to guide the empirical approach and findings. Section IV describes the empirical identification strategy and section V discusses the data. Section VI presents the econometric results and section VII discusses their robustness. Section VIII concludes.

II. 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 that 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 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 2 weeks' notice. Consumers who switch generally take a 1 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, nonintegrated 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

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, 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.

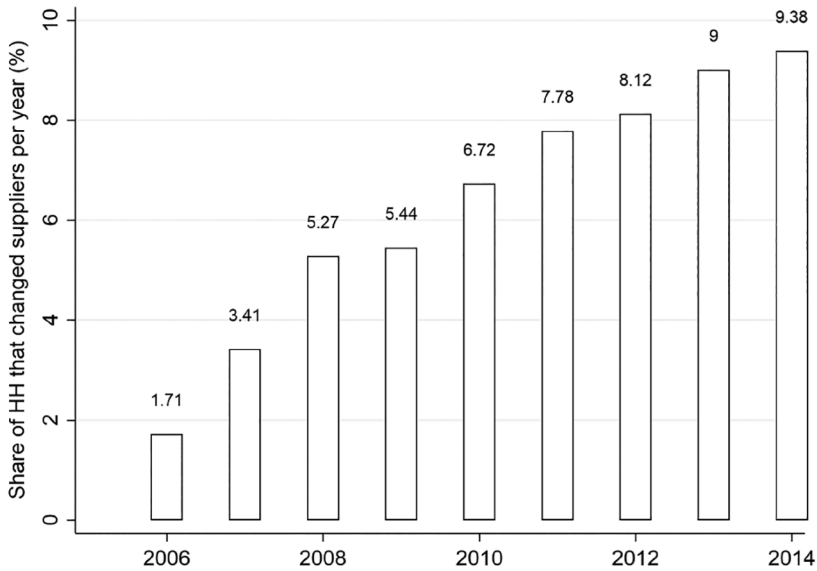


FIG. 1.—Average switching rates of households in German retail electricity markets. Data on supplier changes are obtained from Germany's regulatory authority (BNetzA 2015); data on the number of German households (HH) are from the German Federal Statistical Office.

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 euros per year for a typical household with an annual electricity consumption of 3.5 MWh.⁹ 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 fig. 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, Caruana, and Cuat 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

⁹ The largest observed difference of the baseline tariffs within the same incumbency area, i.e., 134 euros/MWh, was offered by E.ON Avacon Vertrieb GmbH in 2012, which served 189 zip codes with 14 different price zones. As an illustrative example, fig. F1 shows the base tariffs set by Envia Mitteldeutsche Energie within its incumbency area.

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 incumbent’s baseline tariff to the overall cheapest tariff, which are, on average, almost 200 euros 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.¹⁰

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, whether they use air conditioning, how much time they watch TV, and so forth. For their tariff choice, household consumers 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

¹⁰ In many other countries, the switching process for electricity providers is comparable to the one in Germany’s retail electricity markets. For example, studying the UK market, Giulietti, Waterson, and Wildenbeest (2014, 561) argue that “search is perceived by consumers as being significantly more difficult than switching.” A similar point has been made by Hortaçsu, Madanizadeh, and Puller (2017) for Texas.

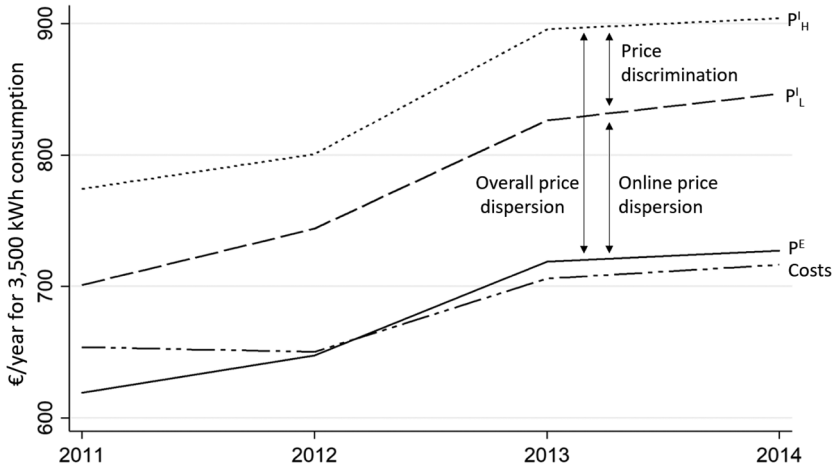


FIG. 2.—Average tariffs and costs (€/year for 3,500 kWh). Here P_H^I , P_L^I , and P^E denote the incumbent’s baseline tariff, the incumbent’s cheaper online tariff, and the overall cheapest entrant tariff, respectively. Costs and prices are presented net of value added taxes.

baseline tariff P_H^I (price incumbent high), the incumbent’s lower online tariff P_L^I (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.¹¹ As a result, we observe three forms of price dispersion: (i) overall price dispersion ($P_H^I - P^E$), which is the difference between the incumbent’s baseline tariff and the overall cheapest tariff; (ii) price discrimination by the incumbent ($P_H^I - P_L^I$), measured by the difference between the incumbent’s baseline tariff and the incumbent’s cheaper online tariff; and (iii) online price dispersion measured by the difference between the incumbent’s cheaper online tariff and the cheapest entrant tariff ($P_L^I - P^E$).¹²

Figure 2 also depicts the (approximated) costs of retailers (see sec. V 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

¹¹ This is supported, e.g., by Baye, Morgan, and Scholten (2006) in the market for hand-held PCs.

¹² We employ the price range as our dispersion measure, which is a commonly used measure in the literature (Baye, Morgan, and Scholten 2006). In our case, the price range best reflects the potential gains from search.

costs. By contrast, the cheapest tariffs set by entrants are very close to costs.

III. A Simple Search Theoretical Model

A. 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 in which an incumbent firm competes with entrants for a homogeneous product and the incumbent is able to price discriminate between searching and loyal consumers.

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.¹³ 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 II, 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; that is, the transaction

¹³ 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.

cost of a consumer with search cost s is denoted by θs .¹⁴ 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 share.¹⁵ Second, our main model looks at the behavior of one entrant that does not compete with other entrants. We use this as a shorthand approximation for the small incumbency effect entrants may have. It can be shown that qualitatively similar effects continue to hold if entrants engage à la homogeneous Bertrand competition with each other (see n. 20).

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.¹⁶ 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 in which consumers have correct beliefs about the online prices and in which, 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 $s < \hat{s}_2$ search online and all other consumers stay with the baseline price of the incumbent. Moreover, of the consumers who search online, the ones with a transaction cost $\theta s < \theta \hat{s}_1$, with $\hat{s}_1 < \hat{s}_2$, buy from the entrant, while other online consumers, namely those with $\hat{s}_1 < s < \hat{s}_2$, buy

¹⁴ 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.

¹⁵ 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.

¹⁶ In app. D, we consider an alternative “Stackelberg” version of the model in which 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.

from the incumbent at its online price. In such an equilibrium, the cutoff values for search costs are $\hat{s}_1 = (P_L^I - P^E)/\theta$ and $\hat{s}_2 = (P_H^I - P_L^I)$.¹⁷

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:

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

and

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

This yields the following first-order conditions (FOCs; evaluated at the equilibrium at which $P_L^I = P_L^I$) for the entrant and the incumbent, respectively:

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

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

and

$$-f(P_H^I - P_L^I; z)(P_H^I - P_L^I) + [1 - F(P_H^I - P_L^I; z)] = 0, \quad (3)$$

where $f(\cdot)$ is the density function that is associated with $F(\cdot)$. 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 FOCs 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.

¹⁷ Note that in the definition of \hat{s}_2 we have the incumbent's online price P_L^I that 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 \hat{s}_1 is defined in terms of realized prices as all consumers with an $s < \hat{s}_2$ visit the platform and decide from whom to buy after observing both prices.

PROPOSITION 1. The effects of exogenous 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 $[1 - F(P_H^* - P_L^*; z)]/f(P_H^* - P_L^*; z)$ 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 nonincreasing; that is, $\partial f((P_L^I - P^E)/\theta; z)/\partial(P_L^I - P^E) \leq 0$. Finally, online price dispersion and price discrimination are linked by $1 - f(P_H^I - P_L^I; z)(P_H^I - P_L^I) = f((P_L^I - P^E)/\theta; z)[(P_L^I + P^E)/\theta]$.

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 $1 - F(P_H^* - P_L^*; z)$ who stay at the baseline tariff, but a fraction proportional to the density $f(P_H^* - P_L^*; z)$ 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 ,¹⁸ relatively more consumers will stay at the baseline tariff if z increases, making price discrimination more profitable. Also, in equilibrium, the fraction $F(P_H^* - P_L^*)$ 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 in which the relevant densities remain constant (or are not much affected) and the change in the search cost distribution is such that the incumbent price discriminates more and more consumers search; then the last equality in proposition 1 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

¹⁸ 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.

access to quantity data on how many consumers buy at which tariff, information that we unfortunately do not have.

The proposition leaves the effect on the incumbent's baseline price undetermined. In appendix C, we analyze the case of a piecewise linear search cost distribution¹⁹ to show that the baseline price may well increase:

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

where, to have a proper piecewise linear distribution function, $\alpha = [(z - 1)\tilde{s}_1\tilde{s}_2]/(\tilde{s}_2 - \tilde{s}_1)$, $\beta = (\tilde{s}_2 - z\tilde{s}_1)/(\tilde{s}_2 - \tilde{s}_1)$, $\tilde{s}_2 > \tilde{s}_1$, 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 $\tilde{s}_2 = 3/5$, $\tilde{s}_1 = 1/5$, and $\theta = 2/5$. Detailed derivations are given in the online appendix. As $\partial F(P_H^* - P_L^*)/\partial z$ 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 sec. VI).²⁰

B. 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

¹⁹ We apply a piecewise 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, Waterson, and Wildenbeest (2014). They show (e.g., their fig. 4) that the density is larger at smaller search cost levels, which in our piecewise linear formulation corresponds to $z > 1$.

²⁰ 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 is 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 FOCs for the incumbent remain valid, however, in the alternative model, and for the piecewise linear specification with $\tilde{s}_2 = 3/5$ and $\tilde{s}_1 = 1/5$ one can show that $P_L^I = [(7 + 3z)/40z]\theta$ while $P_H^I - P_L^I = (13 - 3z)/10(3 - z)$. 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 à 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.

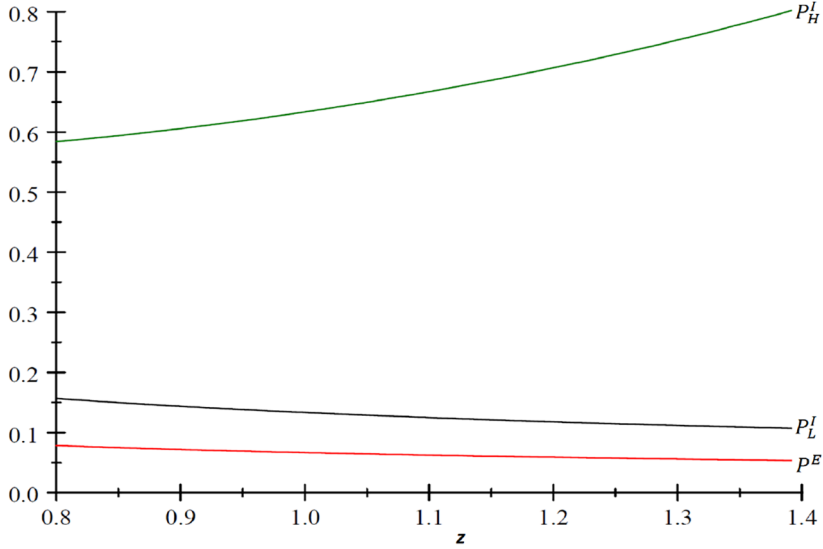


FIG. 3.—Model prediction. The figure predicts price changes as a function of z with $\tilde{s}_2 = 3/5$, $\tilde{s}_1 = 1/5$, and $\theta = 2/5$. Here P_H^I , P_L^I , and P^E denote the incumbents' baseline tariffs, the incumbents' cheapest (online) tariffs, and the overall cheapest entrants' tariffs,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

it from the price it chooses when the incumbent can price discriminate). As now we have that

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

and

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

it is easy to see that the two FOCs 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 complementarity 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^l , compared to when it can price discriminate where P_L^l is meant to compete with the entrant’s price and the large share of loyal consumers is “addressed” by P_H^l . Thus, with price discrimination, there is simply more online competition to attract searching consumers.

To compare P_H^l and P^l for the general case (and thus to make an overall comparison of the average price consumers pay)²¹ is more difficult. Intuitively, though, it would be natural to have that $P_H^l > P^l$, as under price discrimination the incumbent does not need to directly compete with the entrant’s price when setting P_H^l . This is easily confirmed for the uniform distribution of search costs with $\theta < 1$. In that case $P^{E*} = \theta/6$, $P_L^{I*} = \theta/3$, and $P_H^{I*} = 1/2 + \theta/3$, while $P_{ND}^{E*} = \theta/3$, $P^{I*} = 2\theta/3$.

For the case of the uniform distribution, it is also easy to calculate the average price consumers pay. With price discrimination the average price equals $(1/2)(1/2 + \theta/3) + (1/3)(\theta/3) + (1/6)(\theta/6) = 1/4 + 11\theta/36$, while without price discrimination, it equals $(2/3)(2\theta/3) + (1/3)(\theta/3) = 5\theta/9$. 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.²²

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.

IV. 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.

A. Baseline Model

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

$$Y_{it} = \beta\mu_{it} + \gamma\mathbf{X}_{it} + \delta_i + \eta_t + \epsilon_{it}, \quad (4)$$

²¹ One can also inquire into how the average price depends on the search intensity. The weighted average price is given by $[1 - F(\hat{s}_2)]P_H^{I*} + [F(\hat{s}_2) - F(\hat{s}_1)]P_L^{I*} + F(\hat{s}_1)P^{E*} = P_H^{I*} - F(\hat{s}_2)(P_H^{I*} - P_L^{I*}) - F(\hat{s}_1)(P_L^{I*} - P^{E*})$.

²² In the online appendix, we verify that a similar conclusion holds for the piecewise linear distribution considered above.

where the dependent variable Y denotes either 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).²³ 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 1% change in search intensity. Assuming that search patterns at other comparison websites are not different from search at the platforms that we observe, the elasticity estimate allows us to make inferences about the whole market.²⁴

B. 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 (i) that the IV be correlated with local search intensity for electricity tariffs

²³ Zip code fixed effects may capture, e.g., 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.

²⁴ 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.

through the search cost component (instrument relevance), while (ii) that it not affect electricity pricing directly, 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 condition 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.²⁵ 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 condition 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 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. 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 appendix B.

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,

²⁵ 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.

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 over-the-counter 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 socioeconomic 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

$$\mu_{it} = \alpha Z_{it} + \gamma^{\text{FS}} \mathbf{X}_{it} + \delta_i^{\text{FS}} + \eta_i^{\text{FS}} + u_{it}, \quad (5)$$

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 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 VII.

V. Data

We use panel data at the German zip code level for the period 2011–14.²⁶ 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. 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 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_t^l , 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

²⁶ 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 that have more than one incumbent, reducing the number of zip codes in our data to 7,249.

TABLE 1
SUMMARY STATISTICS

		(1)	(2)	(3)	(4)
Dependent variables:					
Incumbent base tariff (P_H^I)	€/a, <i>ene't</i>	1,006.96	77.71	799.93	1,204.15
Incumbent online tariff (P_L^I)	€/a, <i>ene't</i>	931.15	84.81	715.90	1,117.08
Cheapest entrant tariff (P^E)	€/a, <i>ene't</i>	808.20	58.79	667.13	903.03
Price dispersion ($P_H^I - P^E$)	€/a, <i>ene't</i>	198.76	38.90	77.16	353.51
Price discrimination ($P_H^I - P_L^I$)	€/a, <i>ene't</i>	75.80	40.69	.00	282.11
Online price dispersion ($P_H^I - P^E$)	€/a, <i>ene't</i>	122.96	44.76	.00	258.97
Variable of interest:					
Search for electricity tariffs (μ)	%, <i>ene't</i>	9.40	6.47	.39	36.21
Instruments:					
Searches for heating gas tariffs	%, <i>ene't</i>	1.97	1.90	.00	12.07
Control variables:					
Costs (net of 19% VAT)	€/a, <i>ene't</i> and EEX	682.86	42.35	560.31	822.80
Available income	K €/household, Acxiom	43.22	7.55	21.03	110.34
Number of households	Number, Acxiom	4,875	4,543	132	29,891
Household size	Integer, Acxiom	2.10	.19	1.52	2.54
Observations		25,899			

NOTE.—Observations are zip code–year observations; €/a refers to an annual electricity consumption of 3.5 MWh.

price comparison platforms.²⁷ The summary statistics in table 1 show that, on average, a household pays around 1,007 euros per year for the incumbent's baseline tariff. The incumbent's online tariff is around 8% lower at 931 euros, while the overall cheapest entrant tariff is around 808 euros, 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 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,

²⁷ The level 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.

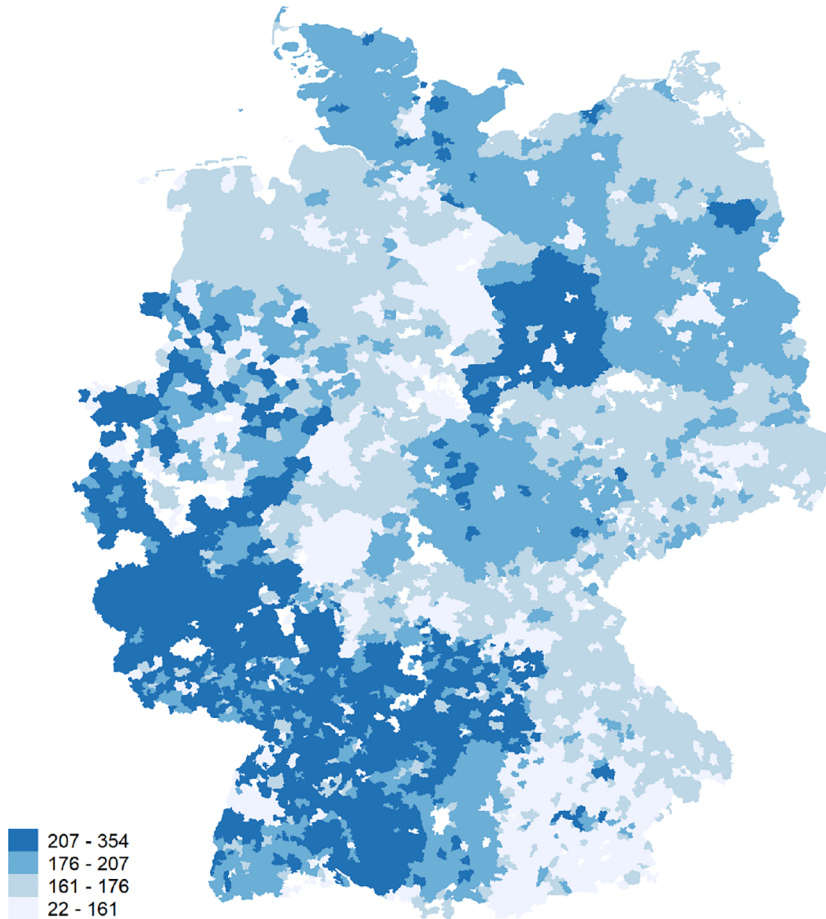


FIG. 4.—Potential gains from search (2012). The figure shows for each zip code the difference between the incumbent's baseline tariff and the cheapest tariff offered by an entrant retailer.

of which Toptarif.de is by far the largest platform.²⁸ 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, whether the search is performed by a household or an industrial customer, and consumer preferences (e.g., only “green” certified tariffs). In addition, we are also able to track the search history: each

²⁸ 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*, July 1, 2014; last accessed on May 25, 2021).

TOPTARIF
BEQUEM UND RISIKOFREI ONLINE WECHSELN

DEINE VORTEILE:

- Dein persönliches Angebot aus über 17.000 Tarifen
- Unverbindlich und kostenfrei vergleichen
- Ohne Risiko den Anbieter wechseln

DEINE DATEN:

Postleitzahl: 68169

Personen: 1 2 3 4

Verbrauch: 3500 kWh/Jahr

JETZT VERGLEICHEN!

TOPTARIF

Tariff	Anbieter	ERSPARNIS	KOSTEN
1	eprimo	233,69 € gespart	842,56 € im 1. Jahr
2	BEV Energie	233,69 € gespart	842,64 € im 1. Jahr
3	Sa Haarm hammerSTROM	222,05 € gespart	354,19 € im 1. Jahr
4	eno	221,28 € gespart	854,96 € im 1. Jahr

FIG. 5.—Screenshot of a typical online comparison platform. Comparison platforms (here 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.

platform user obtains a unique search session ID (created by *ene't*), indicating the order of the queries from the same user.²⁹ 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

²⁹ 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. Brynjolfsson 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.

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 that exclusively consider eco-label (i.e., “green”) certified tariffs.³⁰ 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:³¹ $\mu_{it} = (\text{Search Sessions}_{it}) / (\text{Households}_{it})$. 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%.³² 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 that 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.

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

³⁰ During our sample period 2011–14, 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.

³¹ 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.

³² This number may slightly overstate the actual search intensity at these platforms because some households may search several times per year. We cannot track this as we only observe search sessions by a household per day.

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 1 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 1 year ahead price presents the standard purchasing strategy for retailers.³³

Other control variables refer to structural household characteristics, which we obtained from Axiom, 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.

VI. Results

Before we present the regression results, we provide some descriptions 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 mid-October. The EEG Umlage constitutes a major component of a consumer’s electricity bill (e.g., 20%–22% of the electricity bill in 2014) and electricity retailers have to inform their customers shortly after that—until November 20—about price changes (BNetzA 2015, 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 indicate the week of November 20. It is evident that consumers search more in November immediately after they get informed about price changes. To cross-validate the representativeness of our data we contrast these data with Google Trends data for the word “Stromwechsel” (change of electricity supplier). 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 20 are clearly an indication of the endogenous relation between price and search and thus emphasize the importance of applying 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_H^I , P_L^I , and P^E . As we use a log-log specification the coefficients can be interpreted as elasticities.³⁴ The instrument is sufficiently strongly correlated with the endogenous variable, as shown by the

³³ 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.

³⁴ In table G7, we show that the results are robust to a level-level specification.

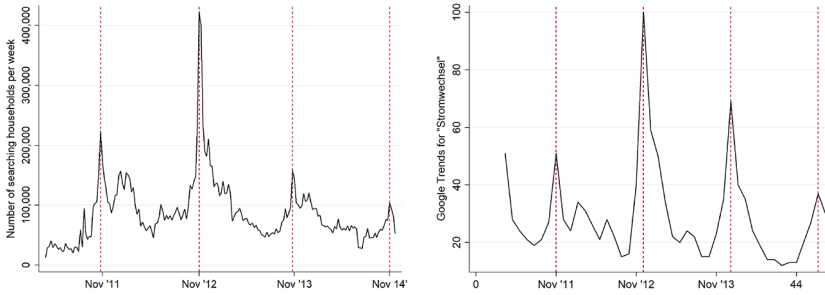


FIG. 6.—Development of the search queries. *Left*, aggregated number of search sessions on several online price comparison sites. *Right*, Google Trends searches for “Stromwechsel” (change of electricity supplier); base month = November 2012. In both panels the vertical solid line represents the yearly announcement of price adjustments.

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. 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.

TABLE 2
IV ESTIMATES OF THE IMPACT OF CONSUMER SEARCH ON PRICES (log-log)

	Incumbent Base (P_H^I) (1)	Incumbent Cheapest (P_L^I) (2)	Overall Cheapest (P^E) (3)
Search (μ)	.0389*** (.0052)	-.1715*** (.0221)	-.0382*** (.0049)
Costs	.2268*** (.0094)	.3780*** (.0287)	.5169*** (.0090)
Available income	-.0074 (.0055)	.0773*** (.0214)	-.0039 (.0048)
Number of households	.0295*** (.0057)	-.0806*** (.0193)	-.0302*** (.0053)
Household size	.0883*** (.0143)	.0744 (.0514)	-.0081 (.0125)
Year fixed effects	Yes	Yes	Yes
Zip code fixed effects	Yes	Yes	Yes
First-stage effective			
F -statistic	103.62	103.62	103.62
Durbin-Wu-Hausman test	.00	.00	.00
Observations	25,899	25,899	25,899

NOTE.—Standard errors clustered at the zip code level in parentheses. Instrument for μ in the IV estimations is the search intensity for gas tariffs.

*** $p < 1\%$.

The OLS estimates are provided in tables B4 and B5. 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 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 incumbent's 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 incumbent's 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.

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 euros if search intensity in a zip code increases by 1 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 euros and 9.6%, respectively). Moreover, the incumbent decreases its online tariff due to the increased search activity in the zip code by 30.5 euros (mean value is 931 euros). The cheapest entrant decreases its tariff by a further 5.9 euros (mean value is 808 euros). Thus, we would expect from our estimates that price discrimination increases by 38 euros on average (which is 49.7% calculated from the mean value of price discrimination of 76.5 euros) due to a 1 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.

TABLE 3
IV ESTIMATES OF THE IMPACT OF CONSUMER SEARCH ON DISPERSION (log-log)

	Price Dispersion ($P_H^I - P^E$) (1)	Price Discrimination ($P_H^I - P_L^I$) (2)	Online Price Dispersion ($P_L^I - P^E$) (3)
Search (μ)	.3696*** (.0419)	2.4776*** (.3056)	-1.7056*** (.2774)
Costs	-1.0152*** (.0692)	-1.2747*** (.4042)	-1.5596*** (.3178)
Available income	.0033 (.0426)	-.8118*** (.3005)	.8991*** (.2393)
Number of households	.2911*** (.0450)	1.2952*** (.2630)	-.7173*** (.2090)
Household size	.4221*** (.1078)	.3701 (.6982)	1.5223** (.5987)
Year fixed effects	Yes	Yes	Yes
Zip code fixed effects	Yes	Yes	Yes
First-stage effective			
F -statistic	103.62	103.62	103.62
Durbin-Wu-Hausman test	.00	.00	.00
Observation	25,899	25,899	25,899

NOTE.—Standard errors clustered at the zip code level in parentheses. Instrument for μ in the IV estimations is the search intensity for gas tariffs.

** $p < 5\%$.
*** $p < 1\%$.

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 if a larger share of consumers search, 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 sufficiently 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 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.

VII. Robustness

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

Hausman-type instruments.—As an alternative IV we apply "Hausman-type instruments" in the spirit of Hausman (1996; see also Hausman, Leonard, and Zona 1994; Nevo 2000; Berry and Haile 2016). In doing this, we take the average of our instrument—the search intensity for gas

tariffs—in the surrounding zip codes as the instrument 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 neighboring 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 .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.

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 zones of the larger incumbents are not necessarily at the zip code level as we discussed in section II. 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 show that the results are robust.

Control variables.—We also estimate models in which we either drop all covariates or include many more. The control variables we include (in logarithms) 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–G6 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.

Nonlinear relationship.—We also relax the constant-elasticity assumption and allow for a nonlinear 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.

VIII. Conclusion

In markets in which 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 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 in which 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 would be almost no effect if they engaged in price discrimination. This may clearly be different in other (e.g., telecommunication) markets in which 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 are available to estimate the search cost distribution, for example by using market share data of the different firms and tariffs.

Appendix A

Proof of Proposition 1

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

$$\begin{aligned} & \left[-2f(P_H^I - P_L^I; z) - \frac{\partial f(P_H^I - P_L^I; z)}{\partial (P_H^I - P_L^I)} (P_H^I - P_L^I) \right] d(P_H^I - P_L^I) \\ & = \left[\frac{\partial f(P_H^I - P_L^I; z)}{\partial z} (P_H^I - P_L^I) + \frac{F(P_H^I - P_L^I; z)}{\partial z} \right] dz. \end{aligned} \tag{A1}$$

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 $[1 - F(P_H^{I*} - P_L^{I*}; z)]/f(P_H^{I*} - P_L^{I*}; z)$ 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 (A1) are negative, implying $d(P_H^I - P_L^I)/dz > 0$.

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 $f'((P_L^I - P^E)/\theta; z) \leq 0$, 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, $0 < d(P_L^I - P^E)/dP_L^I < 1$.

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 proposition 1.

Appendix B

Additional Tables

In table B1 we estimate the effect of local electricity tariffs on local searches for electricity tariffs and gas tariffs. As discussed in section IV.B 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 toward 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)	.078*** (.006)			-.001 (.002)		
Incumbent cheapest (P_L^I)		.057*** (.005)			-.001 (.002)	
Overall cheapest (P^E)			.049*** (.003)			-.001 (.002)
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Zip code fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
First-stage F -statistic	1,037.34	676.04	3,598.34	1,037.34	676.04	3,598.34
Observations	25,899	25,899	25,899	25,899	25,899	25,899

NOTE.—Standard errors clustered at the zip code level in parentheses. Instruments for electricity tariffs are the local electricity costs.

*** $p < 1\%$.

TABLE B2
DECOMPOSITION OF STANDARD DEVIATIONS BETWEEN AND WITHIN ZIP CODES

Variable	Mean	Standard Deviation Overall	Standard Deviation Between	Standard Deviation Within
Incumbent's baseline tariff (P_H^I)	1,007	77.7	36.6	68.6
Incumbent's 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
Online 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)

	SEARCH (μ)	
	(1)	(2)
Searches for gas tariffs	.0363*** (.0025)	.0350*** (.0025)
Costs		.3879*** (.1181)
Available income		.3532*** (.0753)
Number of households		-.5549*** (.0570)
Household size		.3860* (.2128)
Year fixed effects	Yes	Yes
Zip code fixed effects	Yes	Yes
Observations	25,899	25,899

NOTE.—Standard errors clustered at the zip code level in parentheses.

* $p < 10\%$.

*** $p < 1\%$.

TABLE B4
OLS ESTIMATES OF THE IMPACT OF CONSUMER SEARCH ON PRICES (log-log)

	Incumbent Base (P_H^I) (1)	Incumbent Cheapest (P_L^I) (2)	Overall Cheapest (P^E) (3)
Search (μ)	.0033*** (.0004)	.0004 (.0013)	-.0008** (.0003)
Costs	.2382*** (.0077)	.3230*** (.0150)	.5049*** (.0072)
Available income	.0059 (.0044)	.0129 (.0114)	-.0180*** (.0028)
Number of households	.0082** (.0037)	.0221** (.0102)	-.0078** (.0033)
Household size	.0990*** (.0122)	.0229 (.0325)	-.0193** (.0088)
Year fixed effects	Yes	Yes	Yes
Zip code fixed effects	Yes	Yes	Yes
Observations	25,899	25,899	25,899

NOTE.—Standard errors clustered at the zip code level in parentheses.

** $p < 5\%$.

*** $p < 1\%$.

TABLE B5
OLS ESTIMATES OF THE IMPACT OF CONSUMER SEARCH ON PRICE
DISPERSION MEASURES (log-log)

	Price Dispersion ($P_H^I - P^E$) (1)	Price Discrimination ($P_H^I - P_L^I$) (2)	Online Price Dispersion ($P_L^I - P^E$) (3)
Search (μ)	.0165*** (.0026)	.0079 (.0167)	.0296 (.0182)
Costs	-.9021*** (.0465)	-.4836** (.2067)	-2.1154*** (.1973)
Available income	.1358*** (.0273)	.1147 (.1501)	.2482* (.1388)
Number of households	.0801*** (.0230)	-.1805 (.1172)	.3196*** (.0957)
Household size	.5279*** (.0741)	1.1105*** (.4153)	1.0021** (.4363)
Year fixed effects	Yes	Yes	Yes
Zip code fixed effects	Yes	Yes	Yes
Observations	25,899	25,899	25,899

NOTE.—Standard errors clustered at the zip code level in parentheses.

* $p < 10\%$.

** $p < 5\%$.

*** $p < 1\%$.

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)	.0816*** (.0172)	-.2748*** (.0615)	-.0551*** (.0123)
Costs	.2239*** (.0164)	.2653*** (.0510)	.6048*** (.0122)
Available income	-.0254** (.0110)	.1018*** (.0390)	.0050 (.0079)
Number of households	.0578*** (.0124)	-.1612*** (.0424)	-.0463*** (.0090)
Household size	.0904*** (.0263)	.1381 (.0890)	.0103 (.0187)
Year fixed effects	Yes	Yes	Yes
Zip code fixed effects	Yes	Yes	Yes
First-stage effective F-statistic	31.31	31.31	31.31
Observations	18,712	18,712	18,712

NOTE.—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.

** $p < 5\%$.

*** $p < 1\%$.

TABLE B7
 IV ESTIMATES OF THE IMPACT OF CONSUMER SEARCH ON DISPERSION (log-log):
 HAUSMAN-TYPE INSTRUMENTS FOR SEARCH

	Price Dispersion ($P_H^I - P^E$) (1)	Price Discrimination ($P_H^I - P_L^I$) (2)	Online Price Dispersion ($P_L^I - P^E$) (3)
Search (μ)	.6567*** (.1341)	4.7791*** (1.0136)	-2.4696*** (.6157)
Costs	-1.4403*** (.1249)	.1947 (.8472)	-3.5994*** (.4824)
Available income	-.1345 (.0859)	-1.3813** (.6439)	1.1252*** (.3834)
Number of households	.5008*** (.0949)	2.9514*** (.6928)	-1.3110*** (.4184)
Household size	.3096 (.1993)	-.4651 (1.4504)	1.7625** (.8777)
Year fixed effects	Yes	Yes	Yes
Zip code fixed effects	Yes	Yes	Yes
First-stage effective F-statistic	31.31	31.31	31.31
Observations	18,712	18,712	18,712

NOTE.—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.

** $p < 5\%$.

*** $p < 1\%$.

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