Discussion Paper No. 16-070

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First version: October 16, 2016
This version: March 13, 2019

Abstract

In many markets prices react stronger to rising than to falling costs. This asymmetric cost pass-through is still not fully understood, but recent theories suggest that asymmetric adjustments of consumers' search efforts to rising and to falling prices may help to explain this. I use novel panel data to investigate the interaction of consumer search intensity, pricing and cost pass-through in the German residential electricity markets. I find that consumers search slightly more when prices rise but drastically decrease search efforts when they fall. Moreover, I find direct evidence that cost pass-through heavily depends on consumers' search efforts.

Keywords: Consumer Search, Cost Pass-Through, Rockets and Feathers
JEL Class: D83, L11

*I thank *ene't* (enet.eu) for providing data on consumer search queries, retail costs and prices. I also thank Acxiom (acxiom.de) for providing data on household characteristics. For helpful comments and discussions I thank Nic de Roos, Pierre Fleckinger, Christos Genakos, Matthew Lewis, Andras Niedermayer, Kathleen Nosal, Bettina Peters, Dennis Rickert, Philipp Schmidt-Dengler, Nicolas Schutz, Joel Stiebale and Michael Waterson, and the audiences at the Jornadas de Economia Industrial 2016, EARIE 2016 and seminars at the University of Mannheim, Mines ParisTech and the OECD. Financial support by the State Government of Baden-Württemberg, Germany, through the research program "Strengthening Efficiency and Competitiveness in the European Knowledge Economies (SEEK)" is gratefully acknowledged.

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Prices rise more strongly (or quickly) when costs increase than they fall when costs decrease. This stylized fact is well-known as *rockets and feathers* pricing and arguably gasoline retail markets present the most prominent example for such asymmetric cost pass-through patterns [e.g. Bacon, 1991; Borenstein et al., 1997; Deltas, 2008]. The non-competitive market structure in these local markets suggests that collusion may be a plausible explanation for rockets and feathers. On these grounds, Borenstein et al. [1997] argue that "prices are sticky downward because when input prices fall the old output price offers a natural focal point for oligopolistic sellers".

However, this explanation is challenged in recent years, especially since Peltzman [2000] analyzed cost pass-through for 242 diverse producer and consumer goods and documented asymmetry in two out of three cases. Counterintuitively to the collusion argument, he finds that costs are passed through asymmetrically in atomistic markets to the same extent. Collusion thus may not always be a convincing explanation for asymmetric cost pass-through. This finding led Peltzman [2000] to draw a very strong conclusion by stating that the observed asymmetry "suggests a gap in an essential part of economic theory".

Seeking for alternative explanations for asymmetric price transmission in order to fill this gap, some more recent theoretical approaches aim at relating asymmetric price adjustments to consumers' search efforts. However, the papers differ strongly in their predictions. Some suggest that consumers search more when costs (and hence prices) are low as there will be more price dispersion and less when they are high [Yang and Ye, 2008; Tappata, 2009]. Firms therefore are reluctant to reduce prices when costs go down. Others suggest that rising prices induce search and consumers search less when prices fall, hence, giving firms less incentives to reduce prices when costs decrease [Lewis, 2011; Cabral and Gilbukh, 2017].[1] In Cabral and Fishman [2012] asymmetric price adjustments results if the direction of a cost shock is correlated between firms and consumers know this. A price increase then signals that costs have also increased for the other firms and so have their prices. Gains from search are thus smaller when costs are correlated and as a result consumers prefer not to search when price increases are only small. In case of a small cost decrease prices remain sticky causing rockets and feathers.

Though these models differ in their setups the underlying intuition is similar: consumers'

[1]While Lewis [2011] uses a behavioral model to explain why search increases following a price increase, Cabral and Gilbukh [2017] assume rational buyers that hold correct beliefs regarding seller prices.

current suppliers are in a more competitive environment when more consumers search for cheaper alternatives. Or as Tappata [2009] puts it, "Consumers' search decisions affect the firm's elasticity of the demand and therefore their cost pass-through". An empirically estimated asymmetric cost pass-through rate then may be explained by the interaction of price adjustments and adjustments of consumer search efforts. If this is the case then Peltzman's claimed gap in economic theory would be nothing else than a violation of the complete information assumption: for the *law of one price* – as known from the standard homogeneous good Bertrand model – to be valid, consumers must be aware of all offered prices for the product [Stigler, 1961].

In this context I empirically investigate the potential link between cost changes, price adjustments and consumers' search efforts utilizing a rich and unique panel data set on local prices, costs and consumer search intensity in the German residential electricity market. To my knowledge this is the first empirical paper that directly relates cost pass-through to consumer search patterns. Along with Gugler et al. [2018] it is also the first paper using a direct measure of consumer search intensity in a panel data context.

The analysis is conducted in three steps. First, I examine how consumers adjust their search efforts with respect to price changes. I consider the likely endogeneity between consumer search and pricing using regional variation in exogenous cost components (such as grid charges) to instrument for price.

Second, I analyze whether positive and negative cost changes are passed-through asymmetrically in the residential electricity market. To examine this, I apply the conventional approach by splitting cost changes into cost increases and decreases and regressing price changes on these two cost variables [e.g. Borenstein et al., 1997].

Of most relevance is the third step, where I allow cost pass-through rates to depend on consumer search intensity by including interactions of positive and negative cost changes with changes in consumer search intensity into the model. To get causal inference I instrument for search. I apply two instruments: The share of households in a zip code for which broadband internet would be technically available and the share of young households in a zip code. The identifying assumption is that both instruments reduce search costs but conditioning on the covariates (e.g. income) do not directly affect pricing.

To preview results, I find that consumers only search slightly more for better tariffs when prices go up but substantially decrease their search efforts when prices decrease. Moreover, there is a substantial asymmetry as consumers only slightly increase search efforts when prices rise but decrease search efforts rigorously when prices fall. I also find that costs are passed through asymmetrically in a rockets and feathers manner. Finally, I show that pass-through rates heavily depend on consumers' search intensity. When costs increase the pass-through rate is higher the less consumers search. However, the opposite is true if costs decrease. In this case more search intensity leads to a higher pass-through rate. In other words, cost increases are passed-through less to the consumer when search intensity is high while cost decreases are passed-through more when search intensity is high.

I will next describe the characteristics of the German residential electricity market in Section 1 and the data and variables in Section 2. Subsequentely, I examine the effect of price adjustments on consumers' search efforts in Section 3. In Section 4 I analyze the cost pass-through and how it is affected by consumer search. Section 5 concludes.

1 Market characteristics

The German residential electricity market has excellent properties for this analysis for a number of reasons. First, electricity is a classic example for a homogeneous good.[2] Hence, price differences should not result out of differences in product characteristics and quality.

Second, the market liberalization in 1999 (when the EU Directive 96/92/EC came into force) ended the period of local monopolies by allowing entry. Prices were not regulated anymore and customers can freely choose their electricity supplier since then. For instance, in 2014 a household could choose between 73 and 198 electricity retailers (155 on average), depending on its location. This makes collusion unlikely.

Third, there are many clearly demarcated local markets and prices and costs vary spatially and over time. More precisely, there are 777 local incumbency areas in Germany, each served by a different local incumbent. At each adress there is always only a single local incumbent and a large number of entrants.[3] However, costs and prices may differ even within the same supply area. This provides substantial regional variation in costs and prices.

[2]There may be some form of product differentiation, such as certification of a tariff with a "green" label etc. Thus, in the present application I exclude all search queries that exclusively consider eco-label tariffs (4% of all search queries) in order to eliminate price effects related to product differentiation. However, the results remain fully robust when these searches are also included.

[3]By law, the incumbent is the local electricity retailer with the largest customer base. Theoretically, an entrant may become the new incumbent because of that. However, this did not translate into practice due to low switching rates and the original incumbents retained their positions. The only exceptions where the incumbent changed were due to a few mergers of municipal utilities in the past two decades.

Fourth, there are apparently significant search frictions in the market due to a substantial asymmetry between incumbents an entrants: All households are automatically supplied with electricity by their local incumbent at the incumbent's default tariff. Hence, switching to an entrant requires search efforts.[4] However, even though a standard two-person household with 3,500 kWh yearly electricity consumption would have saved on average 196 Euro or 20% of the electricity bill[5] by switching from the incumbents' default tariff to the cheapest local electricity retailer in 2014, 78% of all German households were still served by the incumbent in that year, 33% even still paid the incumbent's default tariff.[6] A candidate explanation for the violation of the *law of one price* is the existence of search costs as theory [e.g. Stigler, 1961; Varian, 1980; Stahl, 1989; Janssen and Moraga-González, 2004; Chandra and Tappata, 2011] and empirical studies [e.g. Sorensen, 2000; Baye et al., 2004; Chandra and Tappata, 2011; Giulietti et al., 2014; Hortacsu et al., 2017; Pennersdorfer et al., 2015; Gugler et al., 2018] suggest. Neverthless, with regard to the market for residential electricity this explanation initially appears rather unlikely as the come up of price comparison websites has drastically decreased search costs by transforming the search process from sequential search to a *clearinghouse* environment. Thus, a consumer gets access to all prices ranked from lowest to highest by visiting just a single website. Hence, one would assume that search costs have become neglectable. However, a consumer only sees the ranking of prices after entering its expected consumption. This may cause search frictions it requires building expectations on future demand which is a function of future temperature and other things. As electricity tariffs are non-linear this induces uncertainty on the optimal tariff choice. Also, a consumer can choose between several options like price guarantee, contract duration, cancellation period or whether the ranking should include a "new customer bonus" or not, which also affects the ranking and introduces further uncertainty on the cheapest price. These contractual options are used by retailers to generate obfuscation on best tariffs which in turn increases search costs.[7]

Other factors such as switching costs or brand effects are less reasonable explanations for the observed consumer inertia and the price dispersion caused by it. Switching costs are very low as the switching process is conducted by the new supplier and not by the consumer. Also, there

[4]Moreover, a household that moves to another zip code is also automatically supplied by the local incumbent at its default tariff again.

[5]To appreciate the magnitude of this amount: the wholesale electricity price for 3,500 kWh only accounted for on average 16% of the incumbents' default tariffs in that year.

[6]Bundesnetzagentur [2015].

[7]Ellison and Ellison [2009].

are no “locked in effects” for consumers as the cancellation period for the incumbent’s default tariff is only two weeks by law. Brand effects are also not likely to play a substantial role in the market. There is no reason to assume that the incumbent supplier provides a higher security of supply as the incumbent has the legal obligation to guarantee a continuous provision of electricity to the consumers.[8] Thus, if an entrant goes bankrupt the bankrupt firm’s customers experience an automatic and seamless transition to the local incumbent’s default tariff without an interruption of electricity supply.[9] Nevertheless, it is still possible that consumers attach a loyalty premium to incumbents for whatever reason. But as the incumbents also offer cheaper tariffs this type of consumers would still switch in the absence of search costs.

To sum up, the above market characteristics suggest that if costs are passed-through asymmetrically then collusion may not be a very reasonable explanation though search costs may be.

2 Data

I construct a panel data set for the period 2011 to 2014 at the German zip code level. A key asset of the data is the detailed information about local online search queries at major price comparison portals, which enables me to construct a direct measure of consumer search intensity. Another particular advantage is that I do not have to make assumptions about market delineation, as consumers in the electricity retail markets can only choose among electricity suppliers that sell to their local address.[10]

The data stem from four sources. From *ene’t*, a German software and data provider for the electricity industry, I received detailed data on individual consumer searches at several online price comparison sites as well as retail electricity tariffs and cost components. The database marketing company *Acxiom* provided data on structural household characteristics in Germany. I also use data from the *European Energy Exchange* (EEX) to obtain a proxy for a retailer’s purchase costs of wholesale electricity. Moreover, I use data on the technical availability of broadband internet from *BreitbandAtlas Deutschland*. As consumers typically have yearly

[8]In this regard, Hortacsu et al. [2017]) estimate that there is a perceived brand effect consumers attach to the incumbent. However, the effect diminishes rapidly in the first years of retail choice and is already very small at the end of their observation in 2006. Hence, in my observation period (2011 to 2014) the majority of the consumers should be aware of the statutory safety net provided by the incumbents.

[9]Indeed, two of the bigger alternative providers went bankrupt in 2011 (Teldafax) and 2013 (Flexstrom), respectively.

[10]This is a major advantage compared to other industry studies such as competition between gas stations or supermarkets.

contracts I aggregate all data at the yearly level. As prices, costs and search intensity vary locally, the spatial data resolution is on the zip code level.

Consumer search

I construct a measure for consumer search intensity based on the *ene't* data. The data cover all search queries conducted on several of the major price comparison platforms including *Toptarif.de* (top tariff), *Stromtipp.de* (power tip), *Energieverbraucherportal.de* (energy consumption portal) and *mut-zum-wechseln.de* (courage-to-change). For each search query I observe the timestamp of the query, the zip code in which the price comparison of the electricity tariffs was requested, the (expected) yearly consumption entered on the interface, the consumer type (household or industrial customer), the search criteria, e.g. indicating whether the consumer is only interested in electricity tariffs with an eco-label as well as a search session ID indicating the order of different queries by the same searching consumer. Exemplary, a screenshot of the search interface of Toptarif.de is shown in Figure A1 in the Appendix. In sum I have information on 35,855,071 search queries and 17,302,530 search sessions from which 16,778,214 are conducted by households and the remaining 524,316 by industrial customers. I will focus on households and therefore exclude the search queries from industrial consumers. From the data I construct a measure for consumer information as follows: Because many searchers conduct several search queries within a search session (e.g. comparing prices for different levels of consumption and different tariff options) I only consider the number of search sessions and refer to a consumer conducting a search session as being fully informed regardless of the depth of the search activity. I then aggregate the search sessions within a zip code area on yearly basis and divide this value by the number of households living in the same zip code in that year.[11] Thus, my measure for the consumer search intenisty is

$$\mu_{it} = \frac{N_{it}^{SS}}{N_{it}^{HH}}$$

with μ describing search intensity, N^{SS} the number of search sessions, N^{HH} the number of households and subscripts i and t denote zip codes and years. Searches on online price comparison sites should serve as an excellent proxy for general consumer search intensity as the vast majority of consumers uses online price comparison site to search for electricity tariffs.[12]

[11]Because I observe some extreme outliers in some zip code areas apparently resulting due to web scraping bots I drop the 2% of the observations with the highest values.

[12]According to a survey 80% of the switchers searched online in 2011 (Kearney [2012].

Prices

Electricity retail prices vary substantially across Germany. There are 777 incumbents in Germany serving their local supply areas (mostly municipal utilities, so called Stadtwerke), however, their prices also vary within the same supply area due to finer cost variation. I therefore go down to the zip code level. In 2014, the electricity bill of a 2 person household with 3,500 kWh yearly electricity consumption for the incumbent's default tariff was on average 1,004 euro, varying between 761 and 1,204 Euro, depending on the zip code.[13] Figures A2 and A5 in the Appendix provide an overview of the spatial distrubution of the incumbent's default prices and the range of prices as measured as the difference between the local incumbents default tariff and the overall cheapest tariff listed on a price comparison site for a certain zip-code-year combination.

In the main application I will focus on a standard two-person household with on average 3,500 kWh yearly consumption. However, all results are fully robust to alternative household sizes such as one-person households with 2,000 kWh consumption or four-person households with an average consumption of 5,000 kWh/year.

Costs

Costs differ substantially over zip codes due to several locally varying cost components, particularly the grid charges and the concession fee. Grid charges are paid by the electricity provider to the respective system operator and thus vary over the 873 German distribution grids.[14] The concession fee is paid by the system operator to the municipality for the right to install and operate electric cables and varies at the municipality level (12,308 municipalities). The between-variation of the locally varying costs across zip codes ranges from 173 to 348 Euro and is on average 30 Euro. These costs also vary over time with a within-zip-code variation between 189 and 324 Euro and a within-zip code standard deviation of 15 Euro.

In addition there are cost components with time variation that do not vary locally. These are in particular the wholesale electricity price and the EEG cost apportionment – a fee consumers have to pay per MW in order to subsidize renewable energies according to the renewable energy act (Erneuerbare Energien Gesetz, EEG). For the wholesale price I use the *Phelix Base one year ahead futures* at the EEX (European Energy Exchange).[15] The costs for 3,500 kWh at the

[13]Prices in each zip code are observed on a due date each month and transformed into year averages.

[14]These are basically the former incumbents' supply areas, however, some former incumbents had to sell their grids in due course of the unbundling legislations.

[15]This choice was affected by talks with electricity retailers saying that they purchase *Phelix Base one year ahead future* to procure wholesale electricity.

wholesale markets where approximately 156 Euro in the period under observation and thus accounted for less than 16% of the incumbents' average prices. I also consider value added taxes, electricity taxes, measuring fees and CHP surcharges. From these cost data I compute a) the regionally varying costs and b) the total costs per zip code and year.

Figures A2 to A4 in the Appendix provide an overview on the spatial distribution of prices, costs and search intensity. Figure A6 illustrates the distribution of cost changes for each year.

Structural characteristics

Several household characteristics may also have an impact on a household's likelihood to engage in search. Data on household characteristics (zip code level) are gathered from *Acxiom* and include the share of households with the head of the household younger than 40, the number of persons living in a household as well as the share of households with low financial resources. These factors potentially affect consumers' search efforts: financially constrained households may be more likely to search for a cheaper electricity tariff. Also, younger people may be more familiar with the internet in general and with online shopping in particular and hence, they may have lower search costs. Finally, I obtained data on the share of households in a zip code for which broadband internet (minimum speed of 16 Mbit/s) would be technically available from *Breitbandatlas Deutschland*, an annual survey on broadband internet availability conducted by the German Ministry of Economics and Technology since the year 2005. The idea is that faster internet makes online shopping more convenient which reduces search costs. Table I provides the summary statistics of the variables.

Table I: *Summary statistics*

Variable	Mean	SD	Min	Max	Obs	Unit, Source
Search intensity	9.28	6.3	0.00	34.7	26,723	%, *ene't*
ΔSearch intensity	0.66	9.3	-27.6	33.9	17,346	%, *ene't*
Price	1,006	78.0	792	1,204	26,723	€/a, *ene't*
ΔPrice	51.7	47.4	-73.7	186	17,346	€/a, *ene't*
Total costs	843	52.0	698	999	26,723	€/a, *ene't*
ΔTotal costs	29.1	34.6	-88.4	144	17,346	€/a, *ene't*
Locally varying costs	255	31.7	159	369	26,723	€/a, *ene't*
ΔLocally varying costs	8.51	15.14	-96.8	84.8	17,346	€/a, *ene't*
Broadband internet availability	64.0	32.2	0.00	100	26,723	%, *breitbandatlas*
Young HH	24.7	5.2	8.38	55.1	26,723	%, *Acxiom*
HH with low income	74.5	22.0	0.00	100	26,723	%, *Acxiom*
Average HH size	2.11	0.2	1.52	2.55	26,723	%, *Acxiom*
No. of local retailers	132	24.9	54.67	192	26,723	#, *ene't*

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

3 Consumer search

That consumer search reacts to price adjustments can be already shown descriptively as Figure I illustrates. The left panel shows the aggregate weekly search sessions on the online price comparison sites I observe and the right panel represents Google Trends data based on Google searches for the word “Stromwechsel” (change of electricty supplier). Most electricity retailers adjust their prices in January each year because several cost changes get effective then (e.g EEG cost apportionment, CHP cost apportionment, concession fees etc.). As retailers are by law obliged to announce cost changes to their customers six weeks prior to the price change most consumers receive post in the days before November 20. The vertical solid lines indicate the yearly announcement of the next year’s price adjustments. It is evident that consumers search more when they get informed about price changes in November. Thus, Figure I provides a first descriptive indication on a relation between price changes and consumers’ search adjustments.

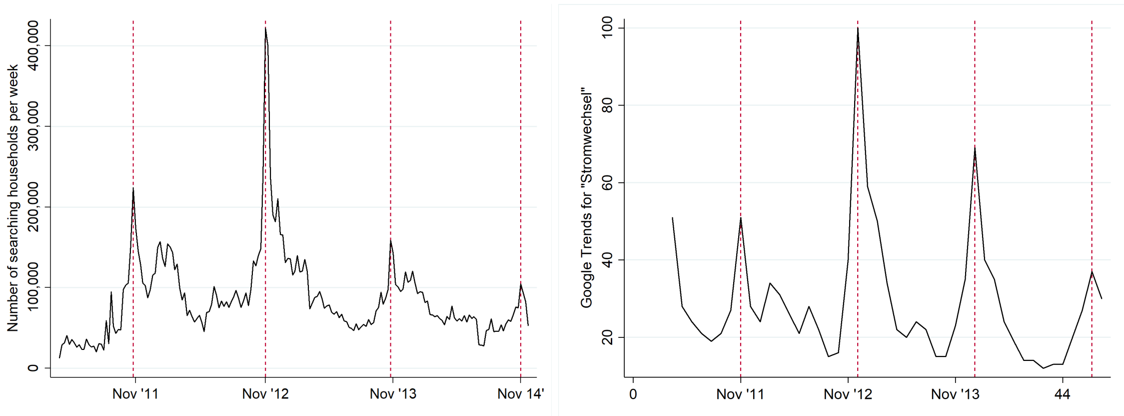

Figure I: *Development of the search queries*

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

I now examine this econometrically by estimating the following baseline model and some variations of it:

$$\Delta\mu_{it} = \tau_1(\Delta P_{it} \times \zeta_{it}) + \rho_1(\Delta P_{it} \times (1 - \zeta_{it})) + \Delta X_{it}\theta_1 + \gamma_{t1} + \vartheta_{i1} + \varepsilon_{1,it}, \quad (1)$$

where subscripts i and t index zip codes and years. μ denotes consumer search intensity and $\Delta\mu$ the change in consumer search intensity in zip code i from t-1 to t. P is the electricity price and ΔP its first difference. ΔX is a vector of control variables that may also effect search activity including the *availability of broadband internet*, the *average household size* (persons per household), the *share of households with a household head younger than 40* as well as the *share of households with financial constraints*. ζ is a sign operator which is equal to one if the price has increased compared to the last period and zero otherwise. Thus, $\Delta P \times \zeta$ represents the change in the electricity bill when it has increased and $\Delta P \times (1-\zeta)$ when it has decreased.

To consider a potential reverse causality between search intensity and pricing I apply instrumental variables (IV) and instrument for $\Delta P \times \zeta$ and $\Delta P \times (1-\zeta)$. The instruments are $\Delta C^v \times \eta$ and $\Delta C^v \times (1-\eta)$ where C^v reflects regionally varying costs.[16] η is the sign operator for cost changes and takes the value one for positive cost changes and zero otherwise.

The two endogenous variables $\Delta P \times \zeta$ and $\Delta P \times (1-\zeta)$ are identified by the instruments in all specifications as shown by the Kleibergen-Paap statistic, which always exceeds the critical values by Stock and Yogo.[17] The two first stages are estimated as follows:

$$\Delta P_{it} \times \zeta_{it} = \alpha_1(\Delta C^v_{it} \times \eta_{it}) + \beta_1(\Delta C^v_{it} \times (1-\eta_{it})) + X_{it}\theta_2 + \gamma_{t2} + \vartheta_{i2} + \varepsilon_{2,it} \qquad (2)$$

and

$$\Delta P_{it} \times (1-\zeta_{it}) = \alpha_2(\Delta C^v_{it} \times \eta_{it}) + \beta_2(\Delta C^v_{it} \times (1-\eta_{it})) + X_{it}\theta_3 + \gamma_{t3} + \vartheta_{i3} + \varepsilon_{3,it} \qquad (3)$$

The IV estimation of equation 1 is reported in Column (4) of Table II. However, before interpreting this results in more detail we start first with a baseline regression of search intensity on (instrumented) prices to get a benchmark. As shown in Column (1) price has a significantlly positve effect on search intensity. If prices increase by 10 Euro/kWh search intensity will increase by 0.8 percentage points. Hence, consumers search more when prices rise. Further, the point estimates also suggest that younger households search more and that the availability of broadband internet has a positive effect on a households' likelihood to search. In Column (2) the dependent variable is the change in consumer search and the variable of interest is the change in prices. The results are as expected very similar to those from Column (1).

In Column (3) I examine the effect of falling and rising prices on adjustments of search intensity. The estimates suggest that rising prices induce significant increases in consumer

[16]I use the change in regionally varying costs ΔC^v as instrument instead of the change in total costs ΔC because certain national cost components are probably known to the consumers and may also affect their search efforts. For instance, the yearly adjustment of the EEG cost apportionment attracts considerable media attention. This may affect consumers' search decisions and thus ΔC may not be a valid instrument as it may also affects search intensity directly. By contrast, consumers are not aware of the regionally varying costs, i.e. grid charges and concession fee. The variation in regionally varying costs thus should only affect consumer search efforts through their impact on price.

[17]In case of a single endogenous variable the Kleibergen-Paap F statistic is equivalent to the first stage F statistic.

search intensity and falling prices cause significant reductions in search efforts. However, the impact of price decreases on the adjustment of consumer search efforts is substantially higher: consumers reduce their search efforts much more when prices fall (coefficient 0.99) than they increase search efforts when prices rise (coefficient 0.063). If the electricity bill has increased by 10 Euro from the last period search intensity increases by approximately 0.6 percentage points. However, when price has decreased by 10 Euro then search intensity is reduced by almost 10 percentage points. Not surprisingly, this huge difference is statistically significant as a t-test rejects the null hypothesis of equality of τ and ρ which confirms an asymmetric adjustment of consumer search efforts to positive and negative price shocks. Column (4) I shows that the results remain robust if the lagged price is additionally included. The positive sign of the lagged price suggests that consumers are also more likely to adjust their search efforts when prices were already on a high level before.

Summed up, this suggests that consumers slightly increase search efforts when prices increase but rigorously decrease search efforts when prices fall.[18] With respect to the theory models discussed earlier the findings suggest that the predictions by Lewis [2011], and Cabral and Gilbukh [2017] (high prices and price increases trigger search) reflect the reality at least in this market better than Yang and Ye [2008], Tappata [2009] (more search when prices are low) or the rocking-the-boat theory in Cabral and Fishman [2012] (price changes generally increase search if large enough). A potential further interpretation is that the asymmetric adjustment of search efforts to rising and falling prices may arise due to loss aversion in the spirit of Kahneman and Tversky [1979]. Households may consider their current electricity bill as a reference point. If prices increase consumers are worse off than before and search more for better tariffs aiming to minimize losses. Analogously, they search less when prices decrease because this already improves their financial status quo.[19]

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[18]Related results were observed in gasoline markets. Lewis and Marvel [2011] and Byrne and De Roos [2017] show in time series regressions that a price comparison site for gasoline prices experiences higher traffic when gasoline prices increase on average.

[19]Empirical evidence for a related observation is in Genakos et al. [2018] who analyze switching incentives in mobile telephony. In their analysis all consumers pay a fixed monthly price which includes several allowances (for call minutes, data usage, etc.) which is interpreted as a consumer's reference price. If consumption exceed these allowances consumers have to pay an extra fee for the additional consumption, called overage. If their consumption falls below the included allowances they do not receive repayments. Consumers that consume less than the included allowances could save money by switching to a cheaper tariff with fewer included allowences. Similarly, consumers whose consumption exceeds the included allowances could save by switching to a more inclusive tariff. A firm informs the consumers about their potential savings. Genakos et al. [2018] find that consumers that pay an overage fee are four times more likely to switch than the consumers that could save the same amount by switching to a lower tariff. Hence, reducing the overage payment has a higher value for consumers than reducing the reference price, even if the potential savings are the same.

Table II: *IV estimation of consumer search*

	(1) μ	(2) $\Delta\mu$	(3) $\Delta\mu$	(4) $\Delta\mu$
Price	0.075***			
	(0.005)			
ΔPrice		0.081***		
		(0.006)		
ΔPrice × ζ			0.063***	0.101***
			(0.007)	(0.012)
ΔPrice × $(1-\zeta)$			0.990***	1.040***
			(0.315)	(0.324)
Lagged Price				0.064***
				(0.011)
Broadband internet availability	0.004**			
	(0.002)			
Young HH	0.077***			
	(0.029)			
HH with low income	0.002			
	(0.002)			
Average HH size	1.780			
	(1.103)			
ΔBroadband internet		0.016***	0.015***	0.014***
		(0.004)	(0.004)	(0.004)
ΔYoung HH		0.034	-0.032	-0.066
		(0.058)	(0.066)	(0.070)
ΔHH with low income		0.018***	0.019***	0.019***
		(0.004)	(0.004)	(0.004)
ΔAverage HH size		4.810***	1.836	-0.182
		(1.805)	(2.309)	(2.496)
Zip code FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Stock-Yogo weak ID critical values (10%)	16.38	16.38	7.02	7.02
Kleibergen-Paap *F* stat.	913	1497	13.38	13.21
Durbin-Wu-Hausman test (p-val.)	0.00	0.00	0.00	0.00
Observations	26,723	17,346	17,344	17,344

*Standard errors clustered at the zip code level in parentheses. Estimation is by GMM. Instrumented for $Price$, $\Delta Price$, $\Delta Price \times \zeta$ and $\Delta Price \times (1-\zeta)$. Instruments are the C^v_{it}, ΔC^v_{it}, $\Delta C^v_{it} \times \eta_{it}$, $\Delta C^v_{it} \times (1-\eta_{it})$. Significant at *p<0.1, **p<0.05, ***p<0.01.*

4 Cost pass-through

In the next step I first investigate whether the common approach in examining asymmetric cost pass-through actually generates asymmetric results for my data by estimating the following model:

$$\Delta P_{it} = \tau_2(\Delta C_{it} \times \eta) + \rho_2(\Delta C_{it} \times (1-\eta)) \tag{4}$$
$$+ X_{2,it}\theta_4 + \gamma_{t4} + \vartheta_{i4} + \varepsilon_{4,it}$$

The notation is as before. ΔP_{it} denotes the adjustments of the incumbents' prices in zip code i from year t-1 to year t, and ΔC_{it} the corresponding cost changes. $X_{2,it}$ is a vector of control variables including income, population density and the number of competitors in the same zip code. The number of competitors is lagged by one period due to potential endogeneity with price. $\tau > \rho$ would indicate that costs are passed-through asymmetrically and this is also what the estimates in Column (1) of Table III suggest. τ_2 is 0.847 and ρ_2 is 0.440 – a cost increase of 1 Euro causes an average price increase of 0.847 Euro while a cost decrease of 1 Euro only causes a 0.440 Euro price reduction. The difference is statistically significant as suggested by a t-test. Interestingly, the estimated pass-through rate is pretty much in line with Peltzman [2000] who finds that on average, the immediate response to a positive price shock is approximately twice as high as the response to a negative cost shock. The asymmetry also remains after including the lagged search intensity as shown in Column (2).

Next, I additionally allow the cost pass-through to depend on adjustments of the search intensity by interacting search adjustments with positive and negative cost changes. The model to be estimated can be written as:

$$\begin{aligned}\Delta P_{it} &= \tau_3(\Delta C_{it} \times \eta) + \rho_3(\Delta C_{it} \times (1-\eta)) \\ &\quad + \psi(\Delta\mu_{it} \times (\Delta C_{it} \times \eta)) + \phi(\Delta\mu_{it} \times (\Delta C_{it} \times (1-\eta))) + \varphi_2 \Delta\mu_{it} \\ &\quad + X_{2,it}\theta_5 + \gamma_{t5} + \vartheta_{i5} + \varepsilon_{5,it}\end{aligned} \tag{5}$$

As search activity is likely endogenous to price due to reverse causality, I instrument for all variables involving μ, i.e. $\Delta\mu_{it} \times (\Delta C_{it} \times \eta)$, $\Delta\mu_{it} \times (\Delta C_{it} \times (1-\eta))$ and $\Delta\mu$ itself. To instrument for $\Delta\mu$ I use the variation in the *availability of broadband internet* and in the *shares of households with a household head younger than 40*. The share of young households is probably correlated with income and as income may affect prices, for instance because it increases non-payment risks, I include $income$ as a control variable in vector $X_{2,it}$. As instruments for the interactions of $\Delta\mu$ I employ interactions of the instruments for $\Delta\mu$ – the changes in the share of young households and broadband internet availability – with the cost increase and cost decrease variables. The variation in the instruments is sufficiently strong to identify the potentially endogenous variables as the Kleibergen-Paap F statistic exceeds the critical values.

Turning to the results in Column (3), the pass-through asymmetry for positive and negative cost shocks is still evident suggesting that firms pass-through cost increases more than decreases if consumers do not adjust their search efforts following a price change. This is in line with expectations as firms are interested in passing on cost increases as much as possible but retaining profits from cost decreases instead of passing them on to their customers. However, the estimates also show that pass-through rates depend on the consumers' search efforts. ψ is significantly negative meaning that cost increases are passed through less when search intensity increases. The incumbent is thus willing to accept a lower markup the larger the share of its customers that is likely to search in case of price increase. On the other hand, ϕ is significantly positive which in turn means that increased search efforts lead to a higher pass-through rate of a negative cost shock. In other words, cost increases are passed through less while cost decreases are passed through more when search increases. Figure II shows the marginal effects of search adjustments on the pass-through rate to illustrate this. Since we already know that consumers search more when prices increase but substantially decrease search efforts when prices decrease, this provides evidence for a search related explanation for asymmetric cost pass-through.

Table III: *Estimation of cost pass-through*

Dependent variable is ΔPrice	(1) OLS	(2) OLS	(3) IV	(4) IV
ΔCosts $\times\ \eta$	0.847***	0.588***	0.774***	0.533***
	(0.021)	(0.019)	(0.033)	(0.030)
ΔCosts $\times\ (1-\eta)$	0.440***	0.198***	0.343***	0.131***
	(0.029)	(0.024)	(0.052)	(0.041)
$\Delta\mu \times (\Delta$Costs $\times\ \eta)$			-0.040***	-0.028***
			(0.007)	(0.006)
$\Delta\mu \times (\Delta$Costs $\times\ (1-\eta))$			0.050***	0.036***
			(0.014)	(0.013)
$\Delta\mu$			0.488*	0.282
			(0.292)	(0.261)
Lagged Price		-0.643***		-0.620***
		(0.012)		(0.021)
Lagged No. retailers	-0.312***	-0.046	-0.476***	-0.222***
	(0.048)	(0.039)	(0.062)	(0.056)
Population Density	0.000***	0.000***	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
HH with low income	0.031***	0.064***	0.052***	0.079***
	(0.009)	(0.008)	(0.010)	(0.009)
Zip code FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Stock-Yogo weak ID critical values (10%)	–	–	10.01	10.01
Kleibergen-Paap *F* stat.	–	–	12.50	12.50
Durbin-Wu-Hausman test (p-val.)	–	–	0.00	0.00
Observations	17,344	17,344	17,344	17,344

*Standard errors clustered at the zip code level in parentheses. Estimation is by GMM. Instrumented for $\Delta\mu$ and interactions involving $\Delta\mu$. Instruments are the share of HH with a household head younger than 40 and the availability of broadband internet and their first differences as well as interactions of these variables with cost increases ($\Delta C \times \eta$) and decreases ($\Delta C \times$ (1-η)). Significant at *p<0.1, **p<0.05, ***p<0.01.*

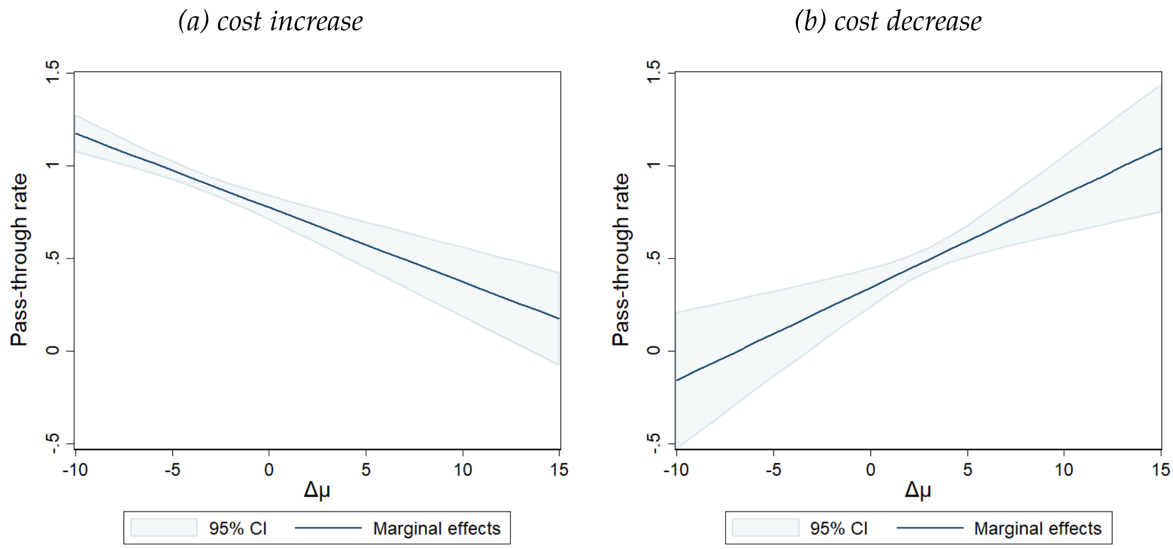

Figure II: *Marginal effects of Δμ on the cost pass-through rate (10%-90% of the observed range of Δμ)*

Robustness

Electricity tariffs are non-linear in consumption in that they are two part tariffs consisting of a fixed component and a per-unit of consumption component. While the main application is for a standard two person household with a yearly electricty consumption of 3,500 MWh the results remain fully robust for a standard five person household with 5,000 MWh electricity consumption as shown in Table B1 in the Appendix.

Also, 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 (so called Stadtwerke). However, larger incumbents often have several zip codes in their incumbency area. Though they also charge different prices for different areas in their incumbency areas, they do not necessarily price at the zip code level. Thus, as a second robustness check I also estimate equations 2 and 3 with incumbent fixed effects instead of zip code fixed effects and cluster standard errors at that level. The results are robust to this specification and are reported in Table C1 in the Appendix.

As a third robustness check I apply the instrumental variable approach recently suggested by Lewbel [2012] as an alternative to the conventional IV. Lewbel [2012] provides an estimator for linear regression models containing an endogenous regressor, which does not rely on outside instruments. In a nutshell, the method works by exploiting the model heteroskedasticity to construct instruments using the available regressors. The results of the Lewbel IV estimations confirm the earlier findings and are reported in Table D1.[20]

5 Conclusion

Asymmetric price adjustment to positive and negative cost changes is an empirical phenomenon that is still not fully understood. Though often assigned to collusion it is also omnipresent in atomistic markets [Peltzman, 2000]. To find explanations recent economic theory aims to explain asymmetric cost pass-through by different reactions of consumers' search efforts to positive and negative price adjustments. I empirically investigate this for the German residential electricity market using a unique panel data set on local prices, costs and consumer search intensity at online price comparison sites for electricity tariffs.

The empirical results clearly support the existence of a link between consumers' search intensity and price adjustments. First, the estimates suggest that consumers search intensity increases when prices are high or increase. Moreover, the effect is asymmetric in the sense that consumers search only slightly more when prices increase but decrease their search efforts substantially when prices fall. Second, consumer search intensity significantly affects cost pass-through. Cost increases are passed through less while cost decreases are passed through more when search increases.

Taken together this provides for the first time direct empirical evidence that the well-known rockets-and-feathers phenomenon may be explained by the interaction of price adjustments and adjustments of consumer' search efforts. Hence, asymmetric cost pass-through does not necessarily point towards a "gap in an essential part of economic theory" as claimed by Peltzman [2000] as it may simply reflect a violation of the complete information assumption.

[20] A technical description of the required assumptions for the Lewbel [2012] IV estimation and a brief description on the procedure itself are provided in Section D in the Appendix.

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Appendix

A Additional figures

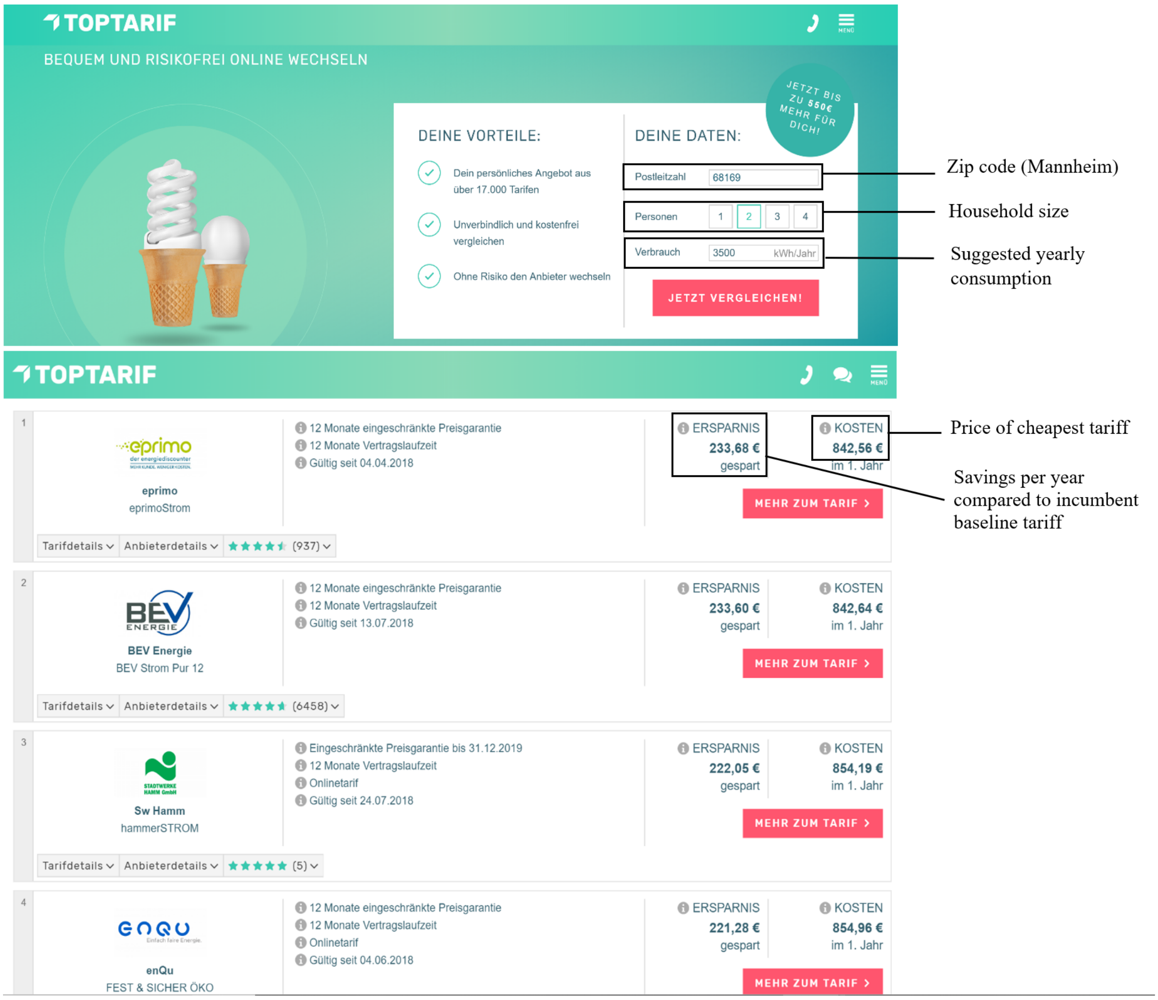

Figure A1: *Screenshot of a price comparison website (Toptarif.de)*

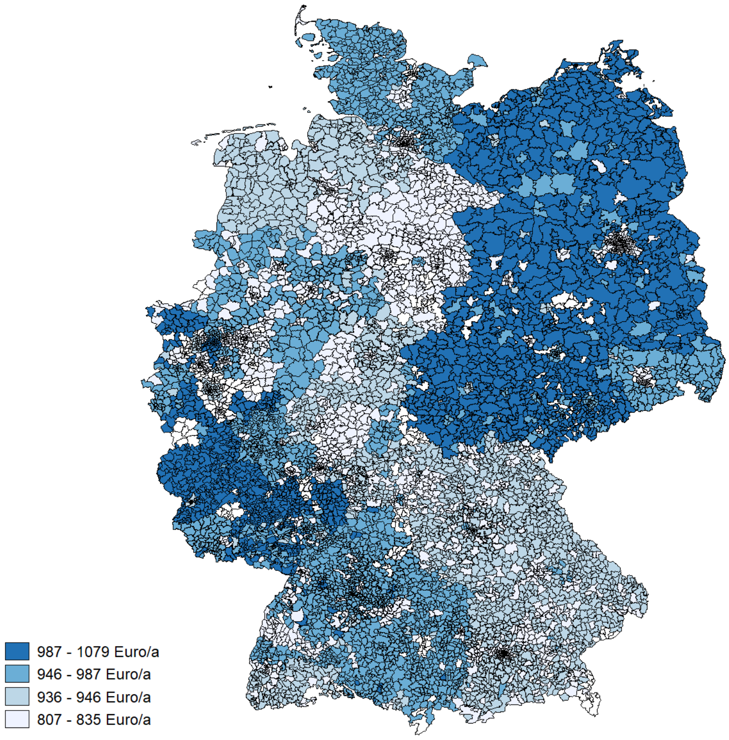

Figure A2: *Incumbent default tariffs (2012)*

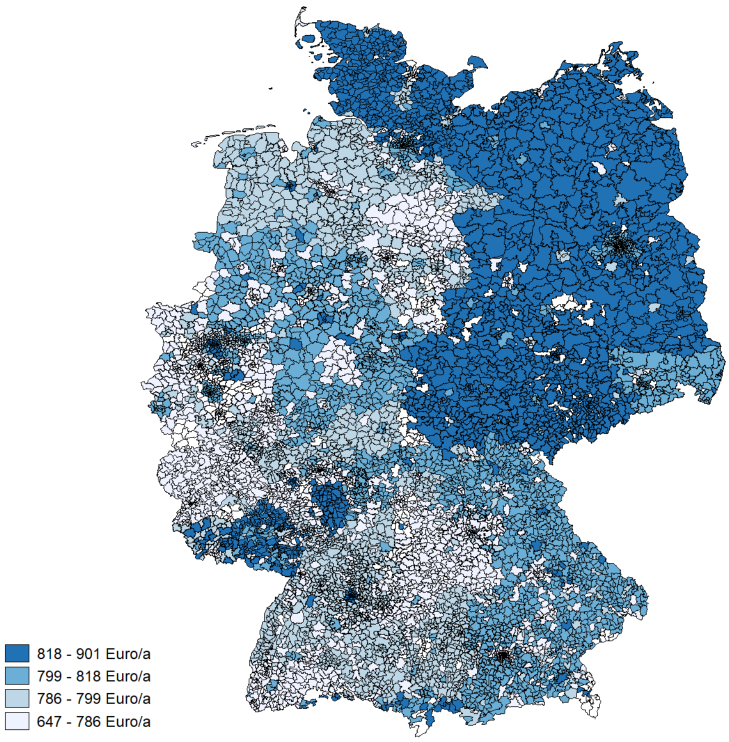

Figure A3: *Total costs (2012)*

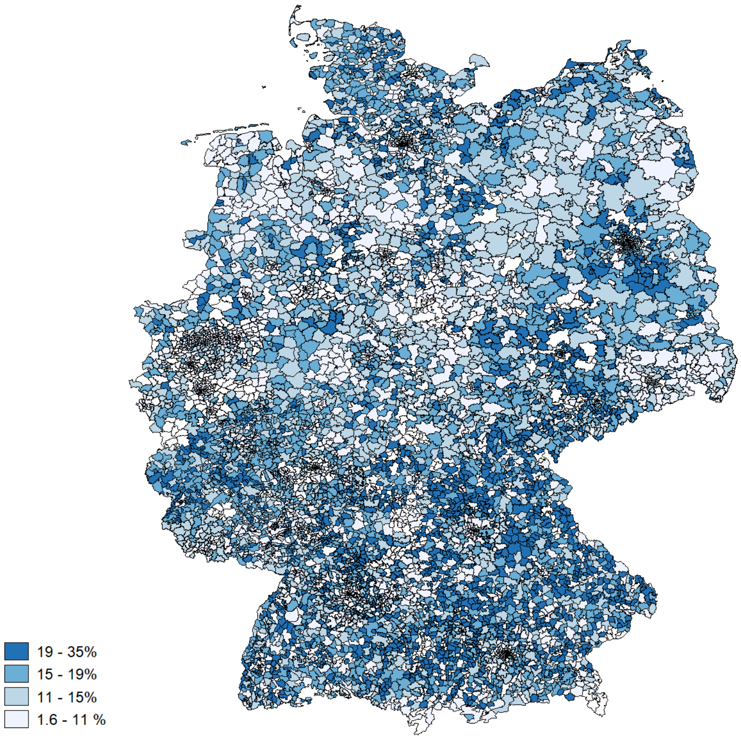

Figure A4: *Search intensity (2012)*

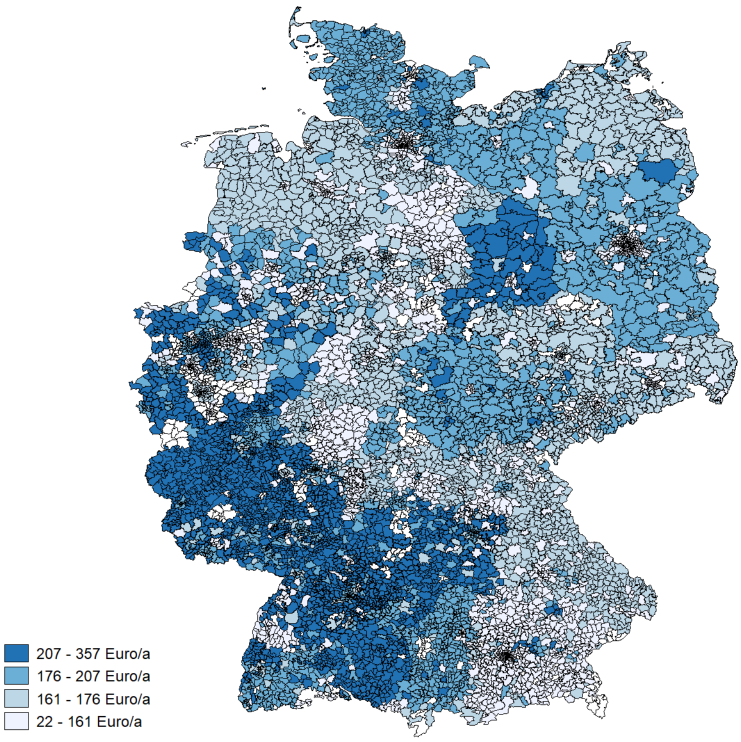

Figure A5: *Range of prices (2012)*

(a) Changes of total costs *(b) Changes of locally varying costs*

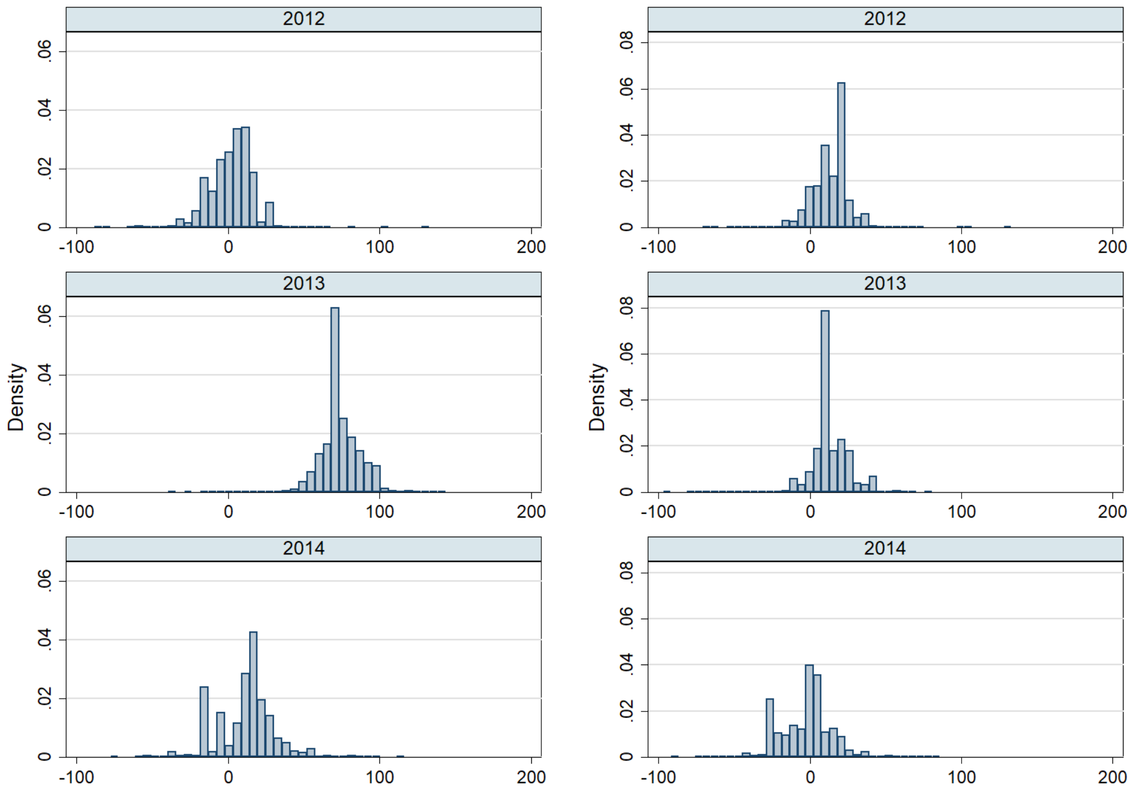

Figure A6: *Distribution of cost changes by year*

B Alternative consumption level

Table B1: *Estimation of cost pass-through for a standard 5 person household (5,000 MWh/a)*

Dependent variable is ΔPrice	(1) OLS	(2) OLS	(3) IV	(4) IV
Δ Costs $\times\ \eta$	0.847***	0.583***	0.799***	0.547***
	(0.022)	(0.019)	(0.033)	(0.030)
Δ Costs $\times\ (1-\eta)$	0.413***	0.222***	0.321***	0.172***
	(0.027)	(0.022)	(0.042)	(0.034)
$\Delta\mu \times (\Delta$ Costs $\times\ \eta)$			-0.033***	-0.024***
			(0.007)	(0.006)
$\Delta\mu \times (\Delta$ Costs $\times\ (1-\eta))$			0.060***	0.038***
			(0.013)	(0.012)
$\Delta\mu$			0.401	0.233
			(0.412)	(0.376)
Lagged Price		-0.647***		-0.619***
		(0.012)		(0.021)
Lagged No. of retailers	-0.429***	-0.107*	-0.737***	-0.385***
	(0.068)	(0.056)	(0.085)	(0.079)
Population Density	0.000***	0.000***	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
HH with low income	0.045***	0.093***	0.067***	0.109***
	(0.013)	(0.012)	(0.014)	(0.013)
Zip code FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Stock-Yogo weak ID critical values (10%)	–	–	10.01	10.01
Kleibergen-Paap *F* stat.	–	–	11.96	11.66
Durbin-Wu-Hausman test (p-val.)	–	–	0.00	0.00
Observations	17,344	17,344	17,344	17,344

*Standard errors clustered at the zip code level in parentheses. Estimation is by GMM. Instrumented for $\Delta\mu$ and interactions involving $\Delta\mu$. Instruments are the share of HH with a household head younger than 40 and the availability of broadband internet and their first differences as well as interactions of these variables with cost increases ($\Delta C \times \eta$) and decreases ($\Delta C \times$ (1-η)). Significant at *p<0.1, **p<0.05, ***p<0.01.*

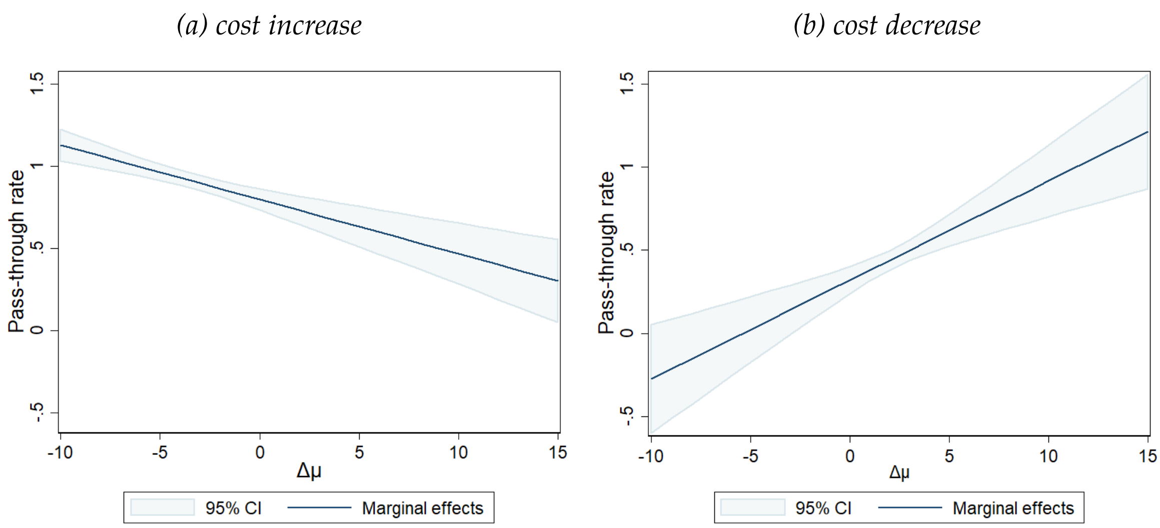

Figure B1: *Marginal effects of $\Delta\mu$ on the cost pass-through rate for a 5 person household (5,000 MWh/a)*

C Alternative fixed effects

Table C1: *Estimation of cost pass-through with incumbent FE*

Dependent variable is ΔPrice	(1) OLS	(2) OLS	(3(IV	(4) IV
ΔCosts $\times\ \eta$	0.822***	0.684***	0.969***	0.540***
	(0.140)	(0.098)	(0.105)	(0.095)
ΔCosts $\times\ (1-\eta)$	0.399***	0.191**	0.517***	0.037
	(0.136)	(0.097)	(0.133)	(0.121)
$\Delta\mu \times (\Delta$Costs $\times\ \eta)$			-0.021*	-0.045***
			(0.011)	(0.013)
$\Delta\mu \times (\Delta$Costs $\times\ (1-\eta))$			0.052***	0.009
			(0.018)	(0.017)
$\Delta\mu$			-0.227	1.398*
			(0.740)	(0.795)
Lagged Price		-0.373***		-0.515***
		(0.111)		(0.072)
Lagged No. of retailers	0.330***	0.225***	0.163*	0.095
	(0.113)	(0.081)	(0.089)	(0.080)
Population Density	0.000*	0.000***	0.000	0.000**
	(0.000)	(0.000)	(0.000)	(0.000)
HH with low income	0.006	0.029**	0.015	0.040***
	(0.013)	(0.012)	(0.010)	(0.008)
Incumbent FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Stock-Yogo weak ID critical values (10%)	–	–	10.01	10.01
Kleibergen-Paap F stat.	–	–	8.28	9.33
Durbin-Wu-Hausman test (p-val.)	–	–	0.00	0.00
Observations	18,436	18,436	18,436	18,436

*Standard errors clustered at the incumbency area level in parentheses. Estimation is by GMM. Instrumented for $\Delta\mu$ and interactions involving $\Delta\mu$. Instruments are the share of HH with a household head younger than 40 and the availability of broadband internet and their first differences as well as interactions of these variables with cost increases ($\Delta C \times \eta$) and decreases ($\Delta C \times$ (1-η)). Significant at *p<0.1, **p<0.05, ***p<0.01.*

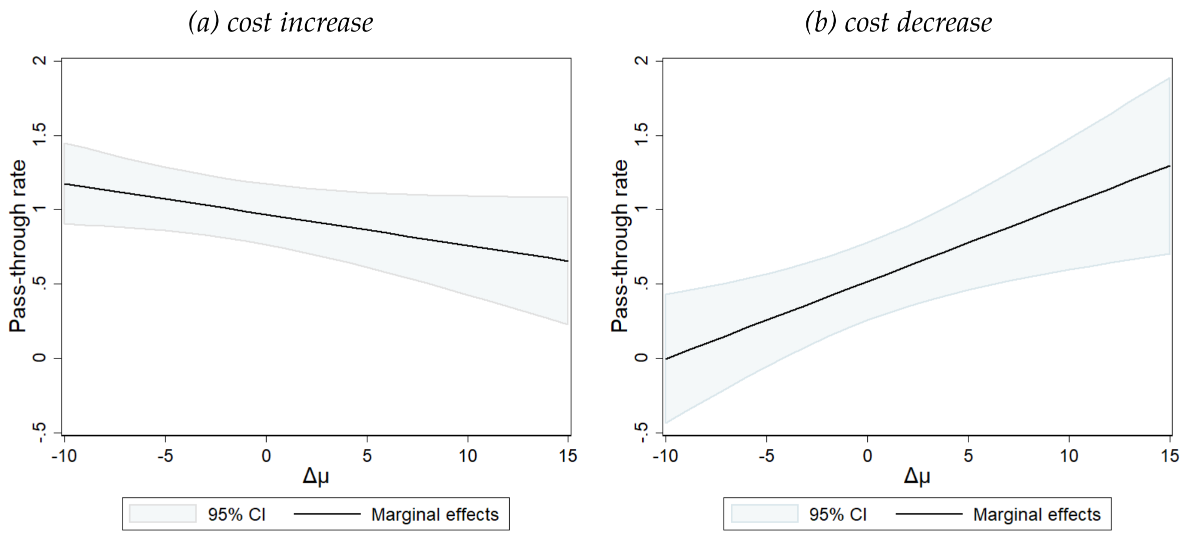

Figure C1: *Marginal effects of $\Delta\mu$ on the cost pass-through rate based on estimations with incumbent FE*

D Technical description of Lewbel's (2012) IV method and results

D.1 Technical description

Consider the linear relationship $Y = X\beta + Z\gamma + \varepsilon_1$, where Z is potentially endogenous (the interactions of $\Delta\mu$ and the two cost change variables here) and γ is the parameter we wish to estimate. The equation that determines Z is $Z = X\alpha + \varepsilon_2$, where ε_1 and ε_2 may be correlated and no element of X can be used as an instrument, i.e. there is no outside instrument available. As usual, the requirement is that $E(X\varepsilon_1) = 0$, $E(X_i\varepsilon_2) = 0$, and that $E(XX')$ is nonsingular. The additional assumptions for the identification in the absence of an outside instrument are that $Cov(X, \varepsilon_1\varepsilon_2) = 0$ and that there is some heteroskedasticity in the error of the first-stage, $Cov\left(X, \varepsilon_2^2\right) \neq 0$. If these assumptions hold the variation in ε_2 can be used to identify the model parameters. γ (and β) can then be estimated consistently by using interactions of the mean-centered control variables and the residuals ($\left(X - \bar{X}\right)\hat{\varepsilon}_2$) to instrument for Z.

The estimation procedure is then as follows:

1. Estimate $\hat{\alpha}$ by an OLS regression of Z on X to obtain $\hat{\varepsilon}_2 = Z - X\hat{\alpha}$.

2. Use the interactions of the residuals $\hat{\varepsilon}_2$ and the mean-centered covariates $(X - \bar{X})$ as instruments for Z and estimate $Z = X\alpha + \gamma\left(X - \bar{X}\right)\hat{\varepsilon}_2 + \varepsilon_3$.

3. Obtain $\hat{\beta}$ and $\hat{\gamma}$ by estimating $Y = X\beta + \hat{Z}\gamma + \varepsilon_4$.

D.2 Results

As Lewbel [2012] shows, the model is identified if the errors from a regression of the endogenous variable on covariates from the main model are heteroskedastic and the variance of these errors is correlated with at least some of the covariates but not with the covariances of these errors and the second stage errors. I test the heteroskedasticity requirement based on the residuals of the first stage regression, using a modified Wald statistic for groupwise heteroskedasticity. The test rejects the null hypotheses of a constant variance as can be seen in Table D1.

The Kleibergen-Paap F-statistic suggests that the generated instruments are sufficiently strong to identify the endogenous variables in all estimations as the Stock and Yogo critical values are exceeded. Again, the results remain robust to this alternative IV.

Table D1: *Lewbel [2012] IV estimation of cost pass-through*

Dependent variable is ΔPrice	(1) IV	(2) IV
ΔCosts $\times\ \eta$	0.855***	0.592***
	(0.019)	(0.018)
ΔCosts $\times\ (1-\eta)$	0.318***	0.179***
	(0.025)	(0.022)
$\Delta\mu \times (\Delta$Costs $\times\ \eta)$	-0.006***	-0.005***
	(0.001)	(0.001)
$\Delta\mu \times (\Delta$Costs $\times\ (1-\eta))$	0.047***	0.022***
	(0.004)	(0.003)
$\Delta\mu$	0.082*	-0.031
	(0.046)	(0.042)
Lagged Price		-0.600***
		(0.012)
Lagged No. of retailers	-0.320***	-0.042
	(0.043)	(0.037)
Population Density	0.000**	0.000**
	(0.000)	(0.000)
HH with low income	0.031***	0.066***
	(0.009)	(0.008)
Zip code FE	Yes	Yes
Year FE	Yes	Yes
First-stage Wald test for group heteroskedasticity (p-val.)	0.00	0.00
Stock-Yogo weak ID critical values (10%)	10.63	10.70
Kleibergen-Paap F stat.	146.36	123.90
Durbin-Wu-Hausman test (p-val.)	0.00	0.00
Observations	17,344	17,344

*Standard errors clustered at the zip code level in parentheses. Estimation is by GMM. Instrumented for $\Delta\mu$ and interactions involving $\Delta\mu$ using Lewbel [2012] heteroskedasticity based instruments. Significant at *p<0.1, **p<0.05, ***p<0.01.*

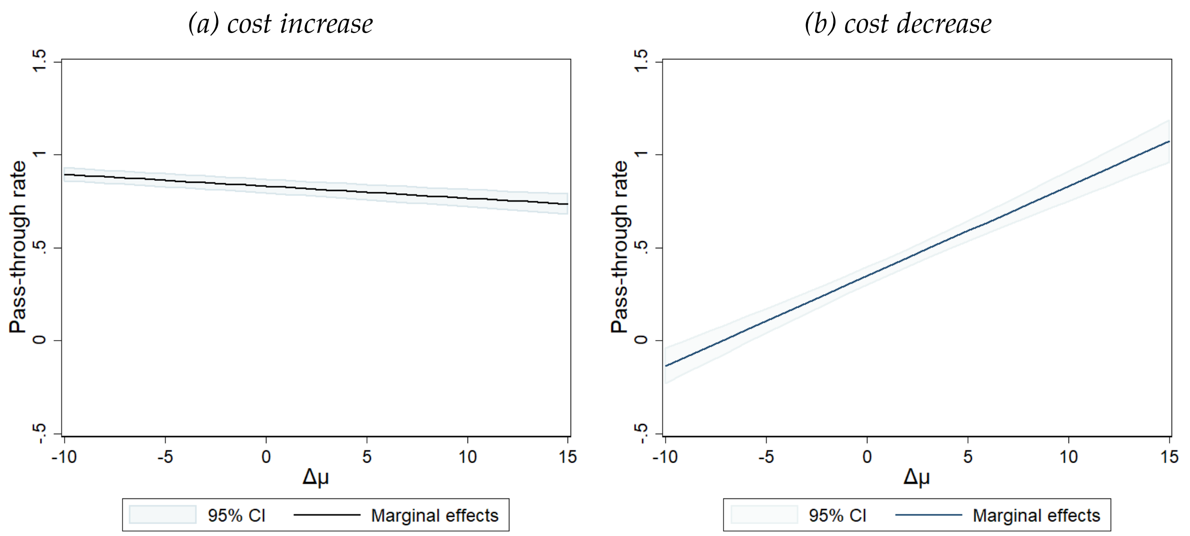

Figure D1: *Marginal effects of $\Delta\mu$ on the cost pass-through rate based on Lewbel [2012] IV estimations*