

Testing the Regulatory Threat Hypothesis: Evidence from Sweden

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Abstract

This study examines whether threat of stricter regulation influences the pricing behavior of firms. Using data on unregulated Swedish local district heating monopolists, we measure the threat level by the number of customer price complaints received by a national board. Exploiting a natural experiment, we find that firms reduce prices when customer complaints increase.

Keywords: regulatory threat, monopoly, price setting, spatial interaction, natural experiment.

JEL Codes: L12; L43.

1 Introduction

We study the effect of regulatory threat on the pricing behaviour of Swedish district heating (DH) monopolists. The Swedish DH industry consists of many local natural monopolies and the price is unregulated. This is a unique setup that allows to study pricing behavior of monopolists. As a measure of threat, we use the number of customer complaints submitted to the Swedish District Heating Board. The sole function of this body is to make DH prices and customer complaints publicly and politically visible.

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Abundant anecdotal evidence suggests that complaints to the DH Board are related to a higher risk of stricter regulation.

To evaluate the pricing behaviour, we use a novel data set on prices and complaints. The main empirical challenge is that customer complaints and prices are potentially in a reverse causality relationship, which leads to endogeneity concerns. To deal with this concern, we use a natural experiment that exploits variation in unforeseen technological failures in the distribution of heat as an instrument for customer complaints.

Our results indicate that monopolists lower prices when facing higher risk of stricter regulation. One additional complaint reduces the DH price on average by 0.69%. This finding is in line with the so-called Regulatory Threat Hypothesis (RTH). The RTH has been theoretically derived by [Glazer and McMillan \(1992\)](#) and empirically evaluated by [Erfle et al. \(1989\)](#), [Erfle and McMillan \(1990\)](#), [Wolfram \(1999\)](#), [Boyer \(2000\)](#), [Acutt et al. \(2001\)](#), [Stango \(2003\)](#), [Antweiler \(2003\)](#) and [Ellison and Wolfram \(2006\)](#). To the best of our knowledge, our paper is the first to use a natural experiment to deal with the endogeneity of threat. Other papers have relied on simple OLS ([Boyer \(2000\)](#)), on strong parametric assumptions on the error term ([Ellison and Wolfram \(2006\)](#)), or on non-experimental instrumental variables (IV) ([Erfle and McMillan \(1990\)](#) and [Antweiler \(2003\)](#)). In addition, our measure of threat (complaints) can be more clearly related to threat than other measures used in the literature. In particular, the usual strategy consists of measuring media coverage of policy debates and public discussions on the issues at stake. This is, however, insufficient to identify firms' behavior as these variables do not usually vary across firms. In order to obtain firm-level variation, researchers have interacted these generic variables with firm characteristics that influence either the probability of regulation through political and public visibility (e.g. firm size, [Stango \(2003\)](#), [Erfle and McMillan \(1990\)](#)), or the expected financial loss of the firm in the case of regulation (such as the residual duration of patents on drugs in the study of the pharmaceutical industry conducted by [Ellison and Wolfram \(2006\)](#)). These strategies

provide an indirect measure of firm-specific threat levels at best, and the data patterns are compatible with alternative mechanisms, such as reputation effects and entry deterrence. Customer complaints are more directly related to threat of regulation as the DH Board is established precisely as a result of a debate about a stricter regulation of DH prices.

The paper is structured as follows. In the next section, we describe the Swedish DH market and the data. In section 3, we present the identification strategy and in section 4 the empirical results. Section 5 concludes.

2 Institutional setup and data

2.1 Institutional setup

Currently, there is one DH firm in the main locality in 262 of the 290 Swedish municipalities. All DH utilities are vertically integrated, i.e. production and distribution are owned by the same firm. With the exception of two large firms (E.ON and Fortum) and a few smaller collaborators that own networks in several municipalities, each firm/market is economically and legally independent from all other firms/markets.¹ The high fixed distribution costs and the fact that customers can only purchase DH from the firm in the municipality where they resides imply that each utility is a local natural monopoly.

Furthermore, DH technology is only viable in densely populated urban areas. Customers in cities typically have two possible sources of heat: DH and electricity-based technologies, primarily in the form of heat pumps.² For customers connected to the DH network, DH is the cheapest source of heat compared to electricity with a ratio of variable costs around 0.5, [EMI \(2012\)](#). Due to the geographical restriction of DH and the high switching cost³, these customers are locked in to their providers. This lock-in

¹ Firms that are active in several municipalities are excluded from the empirical analysis.

² Natural gas plays a negligible role in Sweden, and oil was phased out during the 1980s and 1990s.

³ A one-time connection fee is paid at the time when the residence connects to the network. This fee is high and can amount to ten times the total annual consumption cost.

effect and the fact that heating is a basic need in Sweden lead to a demand elasticity close to zero, see [Brännlund et al. \(2007\)](#). In contrast, the change in demand that results from attracting new customers is elastic and sizable, [Biggar et al. \(2018\)](#).

The DH market opened for private investors in 1996. The DH prices are set independently by each firm, and since 1996, prices are not subject to any periodic sector-specific review by a regulatory agency. This is in stark contrast to how electricity prices are set: the retail price is determined on a competitive market and the transportation prices (transmission and local distribution) are regulated by the Swedish Energy Markets Inspectorate through ex ante revenue caps.

At the end of 2005, a national debate started with calls for regulation of DH prices (SOU 2005a, b). The regulatory debate culminated in the adoption of the District Heating Act (2008:263) in 2008. The most important provision in this law was the establishment of the Swedish District Heating Board. Since July 2008, a consumer who is dissatisfied about his/her DH price can file a complaint to the DH board. The cost of filing one complaint is 500 SEK (roughly 50 Euro). Filing a complaint requires customers to explain why they think the price is too high. There are no requirements about page numbers or number of words that the explanation needs to meet. Thus, the explanation can be short and written by a nonprofessional. Notably, a customer can only complain to the DH board because of dissatisfaction with the price. Furthermore, dealing with the complaints about prices is the only function of the DH board. If the complaint is considered well-grounded, the committee launches a negotiation process with the consumer and the utility, and it provides expert opinions about how the DH price should be determined. The DH firm can accept or reject the board's suggestion without any direct consequences. Therefore, the District Heating Act provides consumers with no real additional rights, but it exposes consumer dissatisfaction to the public. While the information that a complaint has been filed is publicly available on the webpage of the DH board, there is no public information on the subsequent negotiation

process (and there is no information about whether there has been such a process). For further information about the Swedish District Heating sector, see [Biggar et al. \(2018\)](#).

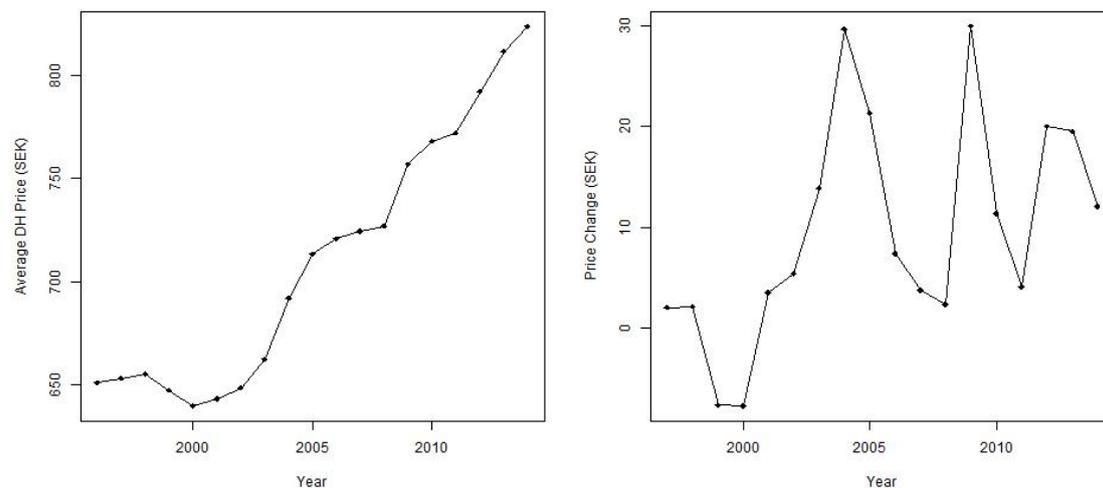
2.2 Data and descriptive statistics

Our dataset contains annual information on each local DH market. Information about prices was gathered from the Nils Holgersson annual price survey (NHS), which reports municipal specific list prices for a representative customer.⁴ Between September and November each year, the firms announce the price that will be charged in the next year from the 1st of January. Figure 1a shows the average annual price for DH between

Figure 1: Average prices and price changes.

(a) Average prices, 1996-2014

(b) Changes in average prices



1996 and 2014, and 1b shows the changes in price over the same time period. After 2000, prices increased steadily. By 2005, when the debate about regulation started (the

⁴ This annual survey is run by several of the largest organizations with interest in the Swedish property markets, specifically the Swedish Union of Tenants, HSB Riksfoerbund (Sweden's largest housing cooperation), Riksbyggen (an organization owned by the building unions, local housing associations and by other national co-operative associations), SABO (the Swedish Association of Public Housing) and the Swedish Property Federation.

beginning of the threat period), prices had increased by a total of 11%. By the peak of the debate at the end of 2008, prices were almost 20% higher than in 2000. It is interesting to note that after 2005, prices increased at a slower pace. After 2009, price changes follow no clear pattern.

Information on customer price complaints was collected directly from the DH board. Additional demand and supply characteristics were added from other sources. On the supply side, we have information on the different fuel types and quantities used to produce heat by each firm. The types and amounts of fuel used affect firms' cost levels. This information was collected from the Energy Markets Inspectorate and directly from the DH firms. We also observe labor cost for the period 2008-2014. On the demand side, our dataset contains municipal-specific information on the average income, the share of the population above the age of 65, the total number of inhabitants, and the share of detached dwellings (i.e. single family houses). These variables are collected from Statistics Sweden and the municipalities directly. Additional covariates such as the electricity tax (a measure of the price of the substitute) and weather (number of heating degree days and amount of precipitation) were also gathered. Since they have no (electricity tax) or only very limited (weather) cross-sectional variation, including them into the analysis made no difference. Table 1 contains descriptive statistics on

Table 1: Summary statistics of the sample used to test the RTH (2010-2013)

Variable	Min	1st Quar	Median	Mean	3rd Quar	Max
Price	444.47	763.76	808.74	805.75	855.87	1163.23
Population	965	4747	8463	75 954	21 725	1469131
Labor cost	22 892	25 009	25 689	25 779	26 452	30 744
Age > 65	0.12	0.20	0.23	0.22	0.25	0.32
Complaints	0	0	0	0.19	0	81
Unanticipated disruptions	0	0	0	2.57	1	197

Note: summary based on 927 observations. Period of observation: 2010 - 2013.

the subsample used to test the RTH. Due to availability of the data on the instrument, we only use the periods 2010-2013 (see section 3 for details). The price is measured in SEK per MWh. The labor cost variable depicts the monthly labor cost per worker (in SEK, averaged over the year and across workers). The last variable in this table, “Unanticipated disruptions”, is explained in section 3. Finally, the table reveals that complaints are in general rare events, with a mean number of complaints per year and per market equal to 0.19. Our panel dataset contains 50 nonzero firm-year complaints observations, exhibited in 28 firms (that is, in roughly 12 % of all 238 firms in our sample). 12 Firms exhibited complaints in one year, 11 firms in 2 different years, 4 firms in 3 different years and 1 firm exhibited complaints in all 4 years of observation.

Remark: the substitute. The only substitute of district heating is electricity-based heating. The electricity price paid by end-consumers consists of three parts - an electricity tax the retail price and the local distribution price - where only the first component is observable. The increase in electricity tax in the period 2010-2013 has practically no cross-sectional variation.⁵ The retail price is determined on a highly competitive international market (the so called Nord Pool electricity retail market) and has generally no local variation, see [Botterud et al. \(2010\)](#) for a detailed description of the Nord Pool market. The Swedish Energy Markets Inspectorate records prices for every regulated local distribution firm. According to these records, the distribution price has been almost constant during the relevant sample period. As a result, it is plausible to model the price of the substitute as an individual time-constant fixed effect.

2.3 Complaints as threat of regulation

Customer complaints are used in many industries to discipline the behavior of firms. The Consumer Financial Protection Bureau in the US, for instance, maintains a database of customer complaints that are visible to firms, customers and politicians. The classical

⁵ Descriptive statistics is available upon request.

example of the self-regulatory power of customer complaints is discussed in [Olmstead and Rhode \(1985\)](#) in the context of the oil and gas industry. Two more recent examples include: (i) proposed price increases by domestic waste firms in Ireland resulted in intense customer complaints and informal talks between the Government and the firms where the firms voluntarily agreed on a temporary price cap (Irish Independent, 19th June 2016), and (ii) following complaints about excessively high electricity prices in the UK and the opening of an investigation by the UK Competition Authority, several of the energy firms reduced their prices shortly ahead of the Authority’s release of its provisional conclusions (The Guardian, 23 Jan 2016).

In this section we discuss how customer complaints increase the threat of stricter regulation in the Swedish DH sector. The major difficulty is that threat of regulation, defined as the likelihood of introducing some stricter form of regulatory policy, is not directly measurable. Instead, we rely on several indirect arguments.

First, the DHB owes its very existence to the public debate over the relevance of regulation. When it was introduced, the hope was that it would provide enough pressure on prices to avoid a full-blown regulatory procedure.

As a second and related argument, each year, the DHB submits a report with a summary of the complaints and their reasons to the Swedish Parliament. Thus, complaints (and thus pricing behavior of the firms) is politically visible.

Third, customer complaints are visible in the media. We retrieved information on newspaper articles from Retriever, which is a database that contains all articles from regional and national newspapers in Sweden, and matched them with specific complaints made by customers.⁶ Our results imply that roughly 44% of all complaints are also discussed in a newspaper article, on the radio or on the TV. In many of the media

⁶ The webpage of Retriever is www.retriever-info.com. At the time of the search (15 Aug 2019), it contained 924 Swedish news providers, including all newspapers with regional and national coverage. The Swedish translation of “Swedish District Heating Board” was used as the single keyword and the search was restricted to the period 1 Jan 2008 to 31 Dec 2014. This time span was chosen to match the time span of our empirical evaluation in the next section.

exposures, a complaint is used to demand a stricter regulation from the politics. An example is the following statement made by Per Forsling, energy expert at the Property Federation: “The new District Heating Act is toothless and it is necessary to review the rules in the district heating market” (Swedish Radio Stockholm, 25 April 2009).

Finally, although the reports of the DHB, as well as the negotiating process with the firms, are not public, there is occasional anecdotal evidence in newspaper articles that firms do respond to complaints. As an example, the DH firm Telge Nät responded to a complaint by suggesting it would be willing to reconsider its pricing decision, as reported by the newspaper *Länstidningen Södertälje* on November 10 2010. Other firms have promised to give more information to customers on price increases, or, alternatively, to give more time to customers to adapt to price changes.

3 Identification strategy

The most straightforward way to formulate the RTH is to assume the following relationship:

$$p_{it} = \phi(C_{it}, V_{it}) \tag{1}$$

where p_{it} is the price charged by the local monopolist in market i at time t , C_{it} , the number of complaints filed by consumers in market i , and V_{it} , a vector of other factors that influence the price. ϕ is a function that relates these variables. The RTH then requires that:

$$\frac{\partial \phi}{\partial C_{it}} < 0 \tag{2}$$

Testing (1) in a regression context with C_{it} as an independent variable is potentially hampered by the endogeneity of C_{it} . In particular, C_{it} may be endogenous because of reverse causality between prices and complaints. Increases in threat levels lead firms to reduce prices, but price changes also influence regulators’ propensity to regulate.

Another source of endogeneity is the possible correlation between C_{it} and unobserved factors that are influencing prices.

To instrument for C_{it} , we use a natural experiment induced by unforeseen service failures. DH services occasionally exhibit temporary disruptions during which no heat is provided to customers. Firms are obliged to report these disruptions to the Swedish Energy Markets Inspectorate (the regulator). A unique feature of the Swedish DH regulation is that DH firms need to distinguish between “anticipated” and “unanticipated” disruptions. Anticipated disruptions are either known with certainty in advance or can be predicted with a certain probability based on experience. An example of known disruptions would be planned shutdowns of operation for purposes of maintenance. Events that can be predicted are repetitive disruptions due to materials and components wearing over time.

In contrast, unanticipated disruptions result from unpredictable technological breakdowns. An example would be a leak in the distribution network. Their frequency, duration and occurrence are not known in advance by the firms. They are only reported once they occur whereas anticipated disruptions are announced in advance. They are qualified by the firm as unanticipated to signal that their occurrence conveys no information on the likelihood and nature of future unanticipated disruptions. Let D_{it} denote the number of unanticipated service disruptions. Statistically, D_{it} in each period can be viewed as a noise in the total amount of service disruptions, and the process $(D_{it})_{t=1996,1997,\dots}$ can be viewed as the increments of a random walk stochastic process.

We use the number of unanticipated service disruptions D_{it} as an instrument for C_{it} . We observe D_{it} for the period 2011-2013, see Table 1 in section 2.2 for a summary of its empirical distribution. Its mean is equal to 2.57 and its third quartile only equal to 1. This implies that - similarly to complaints - unanticipated disruptions are rare events. Due to the importance of heating in a cold country like Sweden, however, they can create substantial disutility among customers. It is plausible that a customer that

has experienced an unanticipated disruption is more likely to complain.

We now explain why D_{it} qualifies as a natural experiment. This discussion revolves around the two possible channels of invalidation of an instrument: a direct effect on the price (violation of the exclusion restriction), and endogeneity through unobserved confounding factors.

The validity of the exclusion restriction. Consider first the demand side. A violation of the exclusion restriction could occur if D_{it} had a direct impact on the price through a demand shift. This is unlikely for reasons that differ between already connected (i.e. actual) customers and potential customers. For connected, locked-in customers, the demand for DH is inelastic with respect to technical disruptions for the same reasons as those described in section 2.1 for justifying price inelasticity. Furthermore, they could disconnect and shift to electric heating if unanticipated disruptions were very frequent, but they are extremely rare events.

For potential customers, unanticipated disruptions are unlikely to influence a decision to adopt DH because these customers do not experience (unanticipated) disruptions before connection. Even if they make efforts to collect information on websites, as revealed, unanticipated service disruptions rarely occur. Disruptions in the electricity service, on the contrary, are much more common because the electricity grid is more sensitive to severe weather occurrences (wind and wet snow that break overhead lines).

On the supply side, the exclusion restriction would be violated if unanticipated service disruptions directly shifted the supply curve, i.e. the amount of DH the firm was willing to supply at a given price. Such a direct effect can be safely precluded for two reasons. First, firms choose and announce the price that will be charged during the year t at the end of year $t - 1$ (usually in October). Unanticipated service disruptions in one period, however, have no power to predict unanticipated service disruptions in the next period. Thus, when choosing p_{it} , the firm has no reason to use the cost resulting from an event observed in year $t - 1$ to build an expectation for the cost in year t (and hence, to adjust

the price). Second, D_{it} have a negligible impact on the total cost of DH.

Confounding factors. Since D_{it} result from random technical failures on the supply side, they are not related to unobserved factors of demand. We therefore focus on possible confounding factors on the supply side. In principle, it cannot be excluded that D_{it} are related to technology type and management of the facility. In the short period of observation (3 years) however, those factors can be assumed fixed for each firm. In our main results below, we account for firm- and time-specific variation by including firm fixed effects and year dummies.

Table 2: Regression of unanticipated service disruptions on observed factors of demand and supply

$Y = D_{it}$	Coef.	Std. Err.	t	p-value	[95% Conf. Int]	
$\hat{\beta}_0$	25.40	16.61	1.53	0.127	-7.31	58.11
HDD	-0.00006	0.0002	-0.29	0.77	-0.0005	0.0004
# Households	0.0006	0.001	0.67	0.51	-0.001	0.003
Population % > 65	60.13	66.13	0.91	0.36	-70.09	190.36
Av. Income	-0.14	0.09	-1.54	0.125	-0.309	0.038
Fixed effects	Yes					
Num of obs:	777					
Prob> F:	0.17					

In addition, we back up our analysis with a regression of D_{it} on observed covariates. The estimated coefficients have no causal interpretation, but they do provide indirect evidence of whether D_{it} is related to unobserved confounding factors. The results are shown in Table 2. None of the estimates is significant, which provides evidence that D_{it} is not related to unobserved confounding factors.

4 Empirical results

4.1 Main results

We translate the equation (1) into the following estimable model:

$$p_{it+1} = \beta_0 + \gamma C_{it} + X_{it}\beta + \sum_{l=1}^{T-1} \delta_l T_l + \theta_i + \varepsilon_{it}, \quad (3)$$

where X_{it} is a $1 \times k$ -dimensional random vector of observed covariates, T_l are time dummies with $T_l = 1$ if $l = t$ and 0 otherwise, θ_i are municipality fixed effects, γ , β_0 , $\beta = (\beta_1, \dots, \beta_k)'$ and $\delta_1, \dots, \delta_{T-1}$ are unknown coefficients, and ε_{it} is the time-varying idiosyncratic error of the regression model. The main parameter of interest is γ . It can be interpreted as the threat effect that complaints in market i induce on the DH price in that same market. The RTH predicts a negative γ (in line with (2)). Note that prices for period $t + 1$ are set by the firms at the end of period t , which explains the lagged index on the r.h.s of (3).

The results are shown in Table 3. Each of the specifications (1)-(4) corresponds to a different set of underlying assumptions. Specification (1) assumes exogeneity of C_{it} , and the estimates are obtained with an OLS fixed effects (FE) estimator. The estimate $\hat{\gamma}_{OLS}$ is negative but insignificant. This coefficient is also of very small magnitude. According to this result, 1 additional complaint would lead to a 0.02 SEK decrease of the price per unit of DH, which is approximately 0.0025% of the average price in 2010. Given how rare complaints are - the third quartile of their empirical distribution is equal to 0 - the economic interpretation of the estimate is that complaints create no real pressure on firms to reduce prices.

Estimates in specifications (2)-(4) are obtained with a TSLS FE estimator and with D_{it} as an instrument for C_{it} . Specification (2) assumes homoskedastic i.i.d. disturbances, whereas (3) and (4) produce standard errors that are robust to heteroskedasticity and

Table 3: Empirical results, testing the RTH.

	OLS FE		IV FE	
	(1)	(2)	(3)	(4)
Complaints	-0.015 (0.18)	-5.57** (3.29)	-5.55** (3.32)	-5.88** (3.44)
Population	-1.82 (1.78)			-1.58 (2.97)
Age > 65	295.24 (445.2)			411.3 (763.2)
Labour Cost	0.009*** (0.003)			0.01** (0.006)
Year dummies	Yes	Yes	Yes	Yes
Fixed effects	Yes	Yes	Yes	Yes
Num of obs.	927	927	927	927

Note: Specification (1) estimated using OLS. Specifications (2)-(4) estimated using IV. Specification (2) estimated under the assumption of i.i.d homoskedastic errors, and specifications (3) and (4) under HAC-robust errors. * denotes $p < 0.1$, ** denotes $p < 0.05$, *** denotes $p < 0.01$. One-sided test for the coefficient of complaints. Standard errors in parenthesis.

autocorrelation (HAC). Furthermore, while specifications (2) and (3) include only C_{it} as a covariate, specification (4) includes observed covariates.⁷

All three IV specifications produce very similar estimates for γ and they are all negative and statistically significant at the 5% level. As an example, the estimate in (2) is equal to -5.57 , which implies that 1 additional complaint would lead to a price decrease of 5.6 SEK, or a 0.69% reduction of the average price in 2010. Hence IV estimates are approximately 350 times higher in magnitude than the corresponding OLS estimate. A Durbin-Wu-Hausman test rejects the exogeneity of C_{it} (p-value = 0.0051).⁸ The positive bias is in line with economic intuition. In particular, reverse causality implies that factors that shift prices up also increase complaints (through the increase in prices).

⁷ Thus, while one advantage of specification (4) is to give a more detailed picture, the advantage of specifications (2) and (3) is that they are not prone to omitted variable bias via additional covariates.

⁸ We implement the version of the test that is robust to HAC errors, see e.g. Hayashi (2000), p. 233-234.

Table 4: First stage results for the corresponding IV results in Table 3.

	(1)	(2)	(3)
D_{it}	0.049** (0.02)	0.052** (0.02)	0.052** (0.02)
Population			0.04 (0.35)
Age > 65			13.79 (99.46)
Labour Cost			0.0003 (0.0008)
Year dummies	Yes	Yes	Yes
Fixed effects	Yes	Yes	Yes
Num of obs.	927	927	927
F-stat.	4.79	4.74	4.62

Note: Specifications (1)-(3) display the first stage estimates corresponding to specifications (2)-(4) from Table 3 in section 4 in the main paper, respectively. * denotes $p < 0.1$, ** denotes $p < 0.05$, *** denotes $p < 0.01$. Standard errors in parenthesis.

The estimates in (4) indicate that out of all additional observed covariates, only labor has a significant effect but with a very small magnitude. This result is not surprising since both the number of households and the share of population above 65 are variables that are rather stable over time. This leaves little variation to estimate the impact of these variables on prices.

The first-stage results of the three IV specifications are displayed in Table 4. The estimated coefficients of D_{it} are positive and significant in all three specifications. This is in line with the intuition that more service disruptions lead to more complaints through decreased tolerance. The instrument, however, appears to be rather weak, with F-statistic well below the rule-of-thumb value 10. We address this problem in the next section.

Table 5: Empirical results, testing the RTH.

	IV FE		
	(2)	(3)	(4)
Complaints	-5.04** (2.33)	-5.04** (2.41)	-5.29** (2.40)
Population			-1.75 (2.65)
Age > 65			671.3 (763.2)
Labor Cost			0.01** (0.005)
Year dummies	Yes	Yes	Yes
Fixed effects	Yes	Yes	Yes
Num of obs.	920	920	920
I-Stage F-stat.	8.592	7.66	8.437

Note: IV estimations with a restricted sample. Specifications (1)-(3) analogous to specifications (2)-(4) in table 3. * denotes $p < 0.1$, ** denotes $p < 0.05$, *** denotes $p < 0.01$. One-sided test for the coefficient of complaints. Standard errors in parenthesis.

4.2 Robustness checks

In this section, we address the two main problems of our regression analysis in the previous section: (i) complaints and unforeseen service disruptions are sparse; and (ii) the instrument is weak. As these two problems are closely related, our solutions to them will also be related.

The sparse data problem. Because complaints are rare events, the mean regression results are potentially sensitive to the presence of outliers. This problem can be addressed in two ways: through a sensitivity analysis and through a quantile regression approach. In our sensitivity analysis, we remove the outliers in the sample and estimate regressions analogous to those presented in the previous section. In particular, we remove all observations with number of complaints in a single year larger than 10 or with the number of disruptions larger than 100. This restriction reduces the sample by 7 observations. The results from three different regressions are presented in table 5. Analogously

to the IV regressions in table 3, the first column contains the results from a regression with no further covariates with standard errors produced under homoscedasticity assumption. In the second regression, we allow for heteroscedasticity and autocorrelation. In the third regression, we add further covariates. There are two important takeaways from the results in table 5. First, the estimated effects of complaints are very similar to those obtained with the full sample. Second, the strength of the instrument has almost doubled as indicated by the first-stage F statistic.

A second possibility to deal with the sparsity of the data is to estimate a quantile regression. The major advantage of running a quantile regression is that the estimates are robust w.r.t. outliers. A major disadvantage is that a simple IV within-estimation is not possible in the quantile regression context. The typical quantile IV panel estimator requires a long panel (i.e. large T) to estimate the fixed effects. This restriction is not satisfied in our case. We nevertheless implemented the FE quantile IV-estimator of [Harding and Lamarche \(2009\)](#) for the quantiles $r = 0.1, 0.25, 0.5, 0.75$ and 0.9 . The estimated coefficients (and the corresponding SE) are $1.71(154.3)$, $0.832(33.50)$, $-3.269(410.12)$, $-4.206(55.65)$, $-4.22(46.92)$. The sign of the estimates indicates that firms with prices that are high or moderately high in the price distribution tend to decrease their prices as a reaction to complaints, whereas the firms on the lower tail of the distribution even tend to increase their prices. These effects, however, are highly insignificant and we cannot use them as reliable evidence.

The weak instrument problem. We present several arguments that our results are in fact valid causal estimates. First, the estimates remain very similar with a stronger instrument in the restricted sample (table 5). If the results were produced by pure randomness, one would not expect this stability, since deviations produced due to the weakness of the instrument are in general very volatile, see e.g. [Angrist and Pischke \(2009\)](#). In addition, the F -stat with the restricted sample is much closer to the “safe level” of 10.

Table 6: Empirical results with LIML.

	IV FE		
	(2)	(3)	(4)
Complaints	-4.76*** (1.83)	-4.76*** (1.84)	-4.95 (5.27)
Population			-1.62 (2.06)
Age > 65			392.3 (470.15)
Labor Cost			0.01** (0.005)
Year dummies	Yes	Yes	Yes
Fixed effects	Yes	Yes	Yes
Num of obs.	920	920	920

Note: IV estimations with LIML. Specifications (1)-(3) analogous to specifications (2)-(4) in table 3. * denotes $p < 0.1$, ** denotes $p < 0.05$, *** denotes $p < 0.01$. One-sided test for the coefficient of complaints. Standard errors in parenthesis.

Second, as a robustness check, we estimate equation (3) with a Limited Information Maximum Likelihood (LIML) estimator and several instruments. These instruments are derived from the initial instrument through a functional transformation (polynomials). The rationale for this exercise is the well-established fact, that in the overidentified case (i.e. several instruments and one endogenous variable), LIML is *approximately* unbiased even if the instruments are weak, see [Rothenberg \(1983\)](#), [Sawa \(1972\)](#) or [Anderson et al. \(1982\)](#). We use the set of instruments (D, D^2, D^3, D^4, D^5) . Our LIML estimates are displayed in table 6. The estimates are very close to the estimates in table 3, although with slightly smaller absolute value. The only considerable difference is that now the estimate in column (4) is no longer significant (p-value for the one-sided test slightly above 0.1).

Third, we compare the reduced form results obtained from a regression of prices on the instrument with the product of the main coefficients in the first and the second stage in our TSLS estimation. This robustness check is commonly used by empiricists, see e.g.

[Angrist and Pischke \(2009\)](#). It can be motivated in the following way. Consider the (simplified) first and second stage

$$p = \gamma_0 + \gamma C + \varepsilon \tag{4}$$

$$C = \alpha_0 + \alpha_1 D + \epsilon. \tag{5}$$

Substituting the first stage in the second stage yields the reduced form

$$p = (\gamma_0 + \gamma\alpha_0) + \gamma\alpha_1 D + (\varepsilon + \gamma\epsilon). \tag{6}$$

Both the reduced form ($\gamma\alpha_1$) and the first stage (α_1) can be estimated with OLS since the instrument is exogenous. In addition, the OLS has the appealing property that it is unbiased even with a weak instrument. We can thus use the ratio of these estimates as a comparison to the TSLS estimate of γ . A small or no difference would provide evidence that the TSLS estimate is reliable. The estimated coefficient of D in the reduced form (that is, $\gamma\hat{\alpha}_1$) is -0.295 , and its standard error is 0.1088 (p-value = 0.00778). The product of $\hat{\gamma}$ and α_1 produced by TSLS estimation in the HAC case with no covariates is $-5.5 \times 0.052 = -0.286$. This is very close to the reduced-form estimate, with less than 4% difference.

Finally, we note that weak instruments are mainly a problem in the overidentified setup with many weak instruments. In the just-identified case, on the contrary, “2SLS (say, the simple Wald estimator) is approximately unbiased. [...] (In addition) even with weak instruments, just-identified 2SLS is approximately centered where it should be (we therefore say that just-identified 2SLS is median-unbiased)”, [Angrist and Pischke \(2009\)](#).

As a summary, all our specifications yield a very similar estimate for the coefficient of the complaint variable. In addition, the estimated coefficients for all other variables also remain robust under different specifications - in sign, magnitude and statistical signifi-

cance. Therefore, we tentatively conclude that the weak instrument has not invalidated the empirical evaluation of the RTH hypothesis.

5 Conclusion

Our results indicate that an increase in the number of complaints significantly reduces the price of DH. In particular, one additional complaint is shown to reduce the price by 0.69%. The disciplining effect of complaints on prices does not only support the RTH, but also provides an important insight into how to construct an institutionalized mechanism for threat of regulation. In the majority of the related papers, an increase in threat level is a temporary consequence of a current political debate (Acutt et al. (2001), Driffield and Ioannidis (2000), Elliott et al. (2016), Elliott and Wei (2010), Elliott et al. (2010), Ellison and Wolfram (2006), Stango (2003) and Wolfram (1999)). Our study shows that formal customer complaints have the potential to be a sustainable mechanism for maintaining threat over time.

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