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Lowering consumer search costs can lead to higher prices

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HIGHLIGHTS

- Price transparency regulation may increase prices even in markets where firms do not collude.
- A decrease in consumer search cost heterogeneity may lead to all firms setting the monopoly price.
- Across 366 retail gasoline markets, reducing the mean and standard deviation of search costs by 20% and 48%, respectively, leads to price increases in 32% of markets and an average price increase of 5.2 cents per gallon across all markets.

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ABSTRACT

We demonstrate that regulations that lower consumer search costs and make them less heterogeneous across consumers can lead to higher prices charged by firms. We estimate the distribution of consumer search costs for 366 isolated retail gasoline markets, and find that reducing the mean and standard deviation by 20% and 48%, respectively, leads to price increases in 32% of markets and an average price increase of 5.2 cents per gallon across all markets. Thus, price transparency regulation that results in higher prices may not stem from collusion, but from an equilibrium with less consumer search.

1. Introduction

Governments impose price transparency regulations with the intention of increasing consumer welfare. For instance, in retail gasoline markets, regulators have created online price aggregators,[1] or mandated how stations display prices for different payment methods (i.e., cash and credit card). Despite the well-intentioned goal of these types of regulations, in some instances, they have resulted in higher prices. While an increased ability to collude is a common explanation for the change in pricing behavior, in this article we offer an alternative possibility. Price transparency regulations make consumer search costs more similar, which, as we demonstrate, can result in competing firms setting higher prices.

Diamond (1971) proves that if all consumers have the same, positive cost of search then the unique, static equilibrium is for all firms to set the monopoly price. We show that decreasing – but not eliminating – search cost heterogeneity can lead to competing firms setting higher average prices. More generally, we examine how policy affecting the mean and variance of the consumer search cost distribution impacts pricing and search behavior in *competitive* markets. As such, we focus on equilibria where firms do not collude. In an empirical application using retail gasoline data, we estimate a structural model and use counter-factual experiments to show that price transparency frequently leads to price increases in non-collusive markets. Although collusion may explain some real-world instances of price increases resulting from transparency policy, our intention is to demonstrate an alternative explanation that is important to consider in practice.

In the United States, a number of websites report individual stations' retail gasoline prices in local markets. If a government policy created and promoted an additional price aggregation website then consumers that were already using such a service would have their search cost unchanged by the regulation. Consumers that

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[1] In 2008, South Korea required retail gas stations to report prices to a public website, Opinet. In 2011, the Austrian government enacted similar legislation.

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were not previously using an aggregator, perhaps because they were not aware of it, and started to use the government website, would have their search cost lowered.[2] By lowering search costs for only a subset of consumers, the regulation decreases both the mean and variance of the search cost distribution. We demonstrate through simulation and an empirical application that this type of policy can either increase or decrease the expected price paid by consumers, depending upon the relative decrease of the mean and variance.

To perform the analysis, we employ a variant of the Burdett and Judd (1983) search cost model extended to allow for vertical product differentiation by Wildenbeest (2011). We first demonstrate how changing (i) the mean (ii) standard deviation and (iii) both simultaneously affect the distribution of equilibrium prices and consumer search behavior. Using a panel data set of retail gasoline prices, we estimate the distribution of consumer search costs separately for 366 markets. With these estimates, we perform a counter-factual experiment that reduces both the mean and variance of search costs by 20% and 48%, respectively, in each market, and find that prices increase in 32% of markets. Prices increase by \$0.052 per gallon, on average across all markets.

Previous research uses tacit collusion to explain price increases following the introduction of price aggregation technology in airline (Borenstein, 1998) and retail gasoline markets (Luco, 2017). Albaek et al. (1997) find that transparency regulation led to softened competition and higher prices in Denmark's ready-mixed concrete industry. Byrne and de Roose (2017) analyze Australian retail gasoline data, where prices are characterized by Edgeworth cycles (Maskin and Tirole, 1988), and find that mandatory price disclosure facilitated tacit collusion along the cycle. Alternatively, Ater and Rigbi (2017) find that regulated price disclosure led to price declines in Israeli supermarkets. Similarly, Rossi and Chintagunta (2016) find that mandatory signage on Italian highways modestly decreased prices. In total, the effect of transparency regulation is ambiguous and market dependent. We offer a new explanation for price increases – competitive firms pricing to consumers with less heterogeneous search costs.

Local retail gasoline markets typically have a small number of firms, and in our data the median number is three, which may facilitate collusion. Although collusion has been identified in retail gasoline markets,[3] there are also a number of studies that find retail gasoline prices to be more consistent with models of costly consumer search.[4] It is therefore appropriate to also consider non-collusive equilibria as an outcome in the market.

2. Modeling consumer search

We analyze the fixed-sample search model developed by Burdett and Judd (1983) and extended by Wildenbeest (2011) to incorporate vertical production differentiation. For ease of exposition, we present the homogeneous product version of the model. The simulations and empirical model account for vertical product differentiation and differences in marginal cost.[5]

N firms sell a homogeneous product to a continuum of consumers with inelastic demand for one unit if price is less than $\bar{p}$, and otherwise do not purchase.[6] Each consumer has a cost of search $c \geq 0$, distributed i.i.d according to the CDF, F_c. Firms do not observe a consumer's search cost, but know F_c. Firms simultaneously choose price, which generates the equilibrium price CDF, $F_p(p)$; $\underline{p}$ and $\bar{p}$ are its lower and upper bound, respectively. Firms have constant and identical marginal costs, r. In equilibrium, firms either play a symmetric mixed strategy that generates price dispersion, or all set the monopoly price, $\bar{p}$.[7]

Consumers know $F_p(p)$, but engage in fixed-sample search to learn individual prices. Each consumer receives one free quote, chooses the number of additional prices to search at a per-quote cost, c, learns all prices in their sample, and finally purchases one unit from the lowest-priced firm in the sample. Consumers minimize total expected expenditure by choosing the number of firms to search, $l-1$, where,

$$l = \arg\min_{l\geq 1}\{c\cdot(l-1) + \int_{\underline{p}}^{\bar{p}} l\cdot p(1-F_p(p))^{l-1}f(p)dp\}.$$

The first term, $c(l-1)$, is the total cost of search and the second is the expected price paid. Searching $i+1$ firms yields expected marginal savings of $\Delta_i \equiv Ep_{1:i} - Ep_{1:i+1}$, where $p_{1:i}$ is the minimum price when i draws are taken from F_p. Accordingly, a consumer with search cost c samples i stores when $\Delta_{i-1} > c > \Delta_i$. The proportion of consumers with i price quotes, q_i, is therefore $q_1 \equiv 1 - F_c(\Delta_1)$ and $q_i \equiv F_c(\Delta_{i-1}) - F_c(\Delta_i)$ for $i \geq 2$.

Firms maximize profits by choosing a symmetric, mixed-strategy, $F_p(p)$, for all $p \in [\underline{p}, \bar{p}]$. Total profit is therefore $\Pi(p) = (p-r)[\sum_{i=1}^{N} q_i \cdot \frac{i}{N}(1-F_p(p))^{i-1}]$. Mixed strategies imply an equilibrium condition that each firm is indifferent between charging the monopoly price, $\bar{p}$, and any other price $p \in [\underline{p}, \bar{p}]$,

$$\frac{(\bar{p}-r)\tilde{q}_1}{N} = (p-r)[\sum_{i=1}^{N}\tilde{q}_i \cdot \frac{i}{N}(1-F_p(p))^{i-1}]. \quad (1)$$

Implicitly solving Eq. (1) for price yields the inverse pricing function,

$$p(z) = \frac{\tilde{q}_1(\bar{p}-r)}{\sum_{i=1}^{N} iq_i(1-z)^{i-1}} + r, \quad (2)$$

where $z = F_p(p)$.

3. Estimating the model

The data and estimation routine follows Nishida and Remer (2017), which extends Wildenbeest (2011) to allow for marginal cost changes over time. We provide a high-level summary of the estimation, and refer interested readers to those articles for further details. We estimate the model using 30 days (February 27th to March 28th, 2007) of daily, gas station-level data for stations located in California, Florida, New Jersey, and Texas. We estimate search cost distributions using data from 366 "isolated" markets: a set of stations all within 1.5 miles of each other, and all stations outside of the market are more than 1.5 miles from every station within the market. To control for marginal cost changes, we use the NYMEX spot price of gasoline delivered to NY Harbor, Gulf Coast, and Los Angeles for gas stations located in those respective

2 Similarly, requiring credit card prices to be publicly displayed reduces the search cost for consumers that prefer this payment instrument, but leaves unchanged the cost to cash buyers.

3 See, for example, (Clark and Houde, 2013).

4 See, for example, Lewis (2011), Remer (2015), Nishida and Remer (2017). Hosken et al. (2008) analyze gasoline prices in the Washington, DC metro area, and do not find dynamics consistent with collusion.

5 See (Nishida and Remer, 2017) for a more complete treatment of the model.

6 Estimates of short-run demand elasticity for gasoline in the United States in the early 2000's range from almost perfectly inelastic (Hughes et al., 2008, −0.034 to −0.077; Park and Zhao, 2010, −0.05 to −0.15) to inelastic (Levin et al., 2017, −0.30). We assume demand is perfectly inelastic up to $\bar{p}$, which we estimate, and perfectly elastic thereafter. While this is a simplification for empirical convenience, it is consistent with previous implementations of the model (e.g. Wildenbeest, 2011) and close to actual gasoline elasticity estimates.

7 See Burdett and Judd (1983) for a proof of this claim, and Nishida and Remer (2017) for evidence of mixed-strategy pricing in the data.