Topics

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Price Disclosure Rules and Consumer Price Comparison

Abstract: Search frictions are regarded as a major impediment to active competition in many markets. In some markets, such as financial and retail gasoline, governments and consumer protection agencies call for compulsory price reporting. Consumers could then more easily compare the firms' offers. We show that for a given level of price comparison, mandatory price reporting indeed generally benefits consumers. Such regulation, however, feeds back into firms' strategies, resulting in lower levels of price comparison in equilibrium. This effect may dominate so that the regulation leads to higher expected market prices.

1 Introduction

In the context of consumer protection policies, improved transparency on the consumer side of the market is typically viewed as beneficial for consumers. It is often loosely argued that if consumers can compare the offers of firms, the elasticity of demand increases, so that equilibrium prices tend to be low. In many industries, it is moreover documented that firms strategically limit price recognition by consumers. Firms take advantage of consumers' different information levels leading to price dispersion for almost identical products. See, for instance, Hortacsu and Syverson (2004) for evidence on financial markets and Ellison and Ellison (2009) for evidence on Internet retailers.

In the US retail gasoline markets, Chandra and Tappata (2011) identified an important role of imperfect consumer information in explaining the level and the variability of gasoline prices. Consumers could save as much as 5% by searching

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for low prices, although search costs often deter consumers from price-shopping. In the same vein, Pennerstorfer et al. (2014) empirically conclude a significant negative effect of the share of informed consumers on the price level in Austrian retail gasoline markets.

Governments and consumer protection agencies therefore act to enhance consumer incentives to acquire price information. In utility markets, especially retail gasoline, some governments legally mandate the price reporting of retail prices to a centralized database, mostly organized by the governments, which directly or indirectly discloses the data to the public via telephone and Internet services. Since 2001, "Fuel-Watch" commences daily monitoring of gasoline prices in Western Australia, and since 2011, there has been a similar service in Austria. The government of South Korea has been publishing daily prices of all gasoline stations on a publicly available web site since 2008. Consumers should then be able to compare prices via, for example, a mobile device.[1] As of September 2013, a statutory obligation to report price data came into effect in Germany. The obligation entails the mandatory reporting of price changes to a market transparency unit of the Federal Cartel Office (Bundeskartellamt), which then compiles a database of prices and makes it available to commercial service providers.

Also in the financial markets, member states of the European Union have launched several initiatives to promote bank fee transparency and the comparability of personal current accounts.[2] In France, recent initiatives from the "Comité Consultatif du Secteur Financier" and the "Conseil Français de Normalisation Bancaire" were launched regarding the disclosure of banking fees. The initiative is based on self-commitment by the industry. Similarly, in the UK, an initiative on self-regulation has been launched by personal current account providers under the pressure of the Office of Fair Trading. It aims at increasing transparency through commitments related to disclosing lists of fees. In other countries, an even stricter legislation obliges banks to provide price data to public authorities for insertion in a comparison tool. In Portugal, banks are legally obliged to provide updated lists of fees to Banco de Portugal which owns and operates a comparison tool for consumers.

The present article focuses on such mandatory price disclosure rules and compares equilibria with voluntary and obligatory price listing of firms.[3] In the

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1 See www.fuelwatch.com.au for Australia and www.spritpreisrechner.at for Austria.

2 For a survey on different instruments in the member states, see http://ec.europa.eu/consumers/rights/docs/1912012_market_study_en.pdf.

3 One may also interpret such regulation as a reduction in search costs. We do not focus on this effect but refer the reader to Moraga-González, Sandor, and Wildenbeest (2014) who find ambiguous effects of lowering search costs on market prices.

empirical literature, the effect of price comparison on market prices is still being debated. While some studies conclude that lower prices for commodity products emerge (Brynjolfsson and Smith 2000), others find no significant differences in price levels (see, e.g., Clay et al. 2002) for products listed on a price comparison web site and non-listed products. Some studies also find a high degree of price dispersion even for homogenous goods (see, e.g., Baye, Morgan, and Scholten 2004). In their empirical study, Baye and Morgan (2009) find that price dispersion is a persistent phenomenon which remains quite stable at 35–40%. Early seminal theoretical papers on consumer search and price dispersion are, for example, Reinganum (1979), MacMinn (1980), Braverman (1980) and Burdett and Judd (1983). Baye, Morgan, and Scholten (2006) provide a comprehensive overview of both empirical and theoretical search-theoretic papers and clearing-house models on price dispersion.

In our model, it turns out that predictions of the impact of a mandatory price reporting regulation cannot be made on a priori grounds. A regulation on the supply side leads to changes in consumer behavior on the demand side. We compare expected equilibrium prices and the equilibrium price comparison intensity in a regulated market where firms are obliged to report prices, with an unregulated market equilibrium in the style of Baye and Morgan (2001) where firms voluntarily choose to list their prices. It turns out that the equilibrium price comparison intensity in the regulated market is strictly lower than in the unregulated market. Moreover, in the regulated market there does not exist an equilibrium in which all consumers compare prices, which does exist in the unregulated setting of Baye and Morgan (2001), though. Hence, because the price comparison intensity is lower in the regulated regime, equilibrium prices may be higher.

The paper is also related to Janssen and Moraga-González (2004), who show that there are multiple equilibria, depending on how intensively consumers search, and how firms react by their pricing strategy. It is also related to Janssen and Non (2008), who analyze the interdependency between firms' advertising and consumers' search decisions and show that searching and advertising are strategic substitutes over a wide range of parameters. Jang (2014) empirically confirms that publishing of gasoline prices in South Korea changed not only how consumers search for lower prices but also how gasoline stations compete and set prices. He concludes that higher smartphone penetration rates, which are a proxy for the number of searchers, imply higher price dispersion and a higher average price level. When search costs are heterogenous, Moraga-González, Sandor, and Wildenbeest (2014) derive a counterintuitive result that higher search costs may result in lower prices. This is due to two countervailing effects. First, higher search costs result in less search intensity,

making demand more inelastic; but second, higher search costs also lower the participation of consumers who happen to search little, which makes demand more elastic. They show that either effect may dominate.

The article is organized as follows. Section 2 provides the basic model and Section 2.1 the firms' strategy sets and the consumers' price comparison decision in an unregulated market equilibrium. Section 2.2 considers the decisions in a regulated market. Section 2.3 compares the outcomes. Section 3 discusses and concludes.

2 The basic model

Two firms offer a homogenous product at zero marginal costs at a linear price p. A unit mass of consumers has unit demand up to v, which we normalize to 1. Consumers are initially uninformed about market prices and divide into two groups. A fraction $1 - \mu$ does not subscribe to a price comparison service and decides to search for the firms' offers. For each search action a consumer incurs a cost of $\varepsilon > 0$. We concentrate on the case where non-subscribers search for exactly one firm and provide the equilibrium condition for this case. This level of search corresponds to the "moderate search intensity equilibrium" of Janssen and Moraga-González (2004) and is in line with empirical evidence provided by, for example, Chandra and Tappata (2011) and the General German Automobile Association (ADAC),[4] which states that most consumers do not search beyond the first offer in gasoline markets.[5] The remaining fraction μ subscribes to a price comparison service at a fixed cost of c in the first stage and buys at the lowest observed price. We interpret the term *cost* on the consumer side as all frictions, not necessarily only monetary frictions, which hinder consumers in their effort to obtain price quotations.

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4 See http://www.adac.de/infotestrat/tanken-kraftstoffe-und-antrieb/kraftstoffpreise/medienb erichte/.
5 Importantly, consumers search non-sequentially, but decide upfront on the number of price quotations to obtain. Janssen and Moraga-González (2004) also consider "low search intensity" and "high search intensity" equilibria, where consumers consider obtaining between no or one and one or two price quotations. The moderate search intensity in our model seems to be supported by empirical data, e.g., in gasoline markets. Moreover, it serves as the mere rationale for regulatory intervention to encourage consumers to search with higher intensity. We make some comments on sequential search in the conclusion.

A firm decides on its price and whether or not to put its product on listing on a price comparison web site at a fixed cost of κ.[6] Firms simultaneously decide on their prices and listing on the price comparison web site. Firms list their prices truthfully.[7] With probability ϕ_i firm i decides to list and chooses a price from the distribution function $F_{1i}(p)$, where the subscript 1 denotes the listing. With probability $1 - \phi_i$ it decides not to list and extracts the rent from its share of non-subscribers by charging the monopoly price of 1. Equilibrium pricing will be in symmetric mixed-strategy equilibria (SMSE). A listing firm randomizes prices drawn from $F_1(p)$, where we drop the index i henceforth, and consumers visit the price comparison web site with probability μ.

The timing of the game is as follows. First, firms and consumers simultaneously decide on their subscription and on their listing. In the next stage, firms and consumers simultaneously decide on their pricing and purchasing. Consumers' shopping and purchasing decisions depend on whether they subscribe to the price comparison services, as well as on firms' listing and pricing decisions.

2.1 Unregulated market equilibrium

We provide an unregulated market framework in the style of Baye and Morgan (2001). Non-subscribers randomly choose to visit one of the firms with equal probability and subscribers buy at the lowest posted price. Each firm balances the well-known trade-off (Varian 1980) of charging the reservation value to extract the rent from non-subscribers (and from subscribers, if they find no price on the price comparison web site) or competing for subscribers and listing a lower price but incurring a listing fee of κ.[8] It is clear that no firm will set a

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6 As pointed out by Brynjolfsson, Dick, and Smith (2004), price comparison services have been changing over time. They have moved from a more objective presentation of price data to listing only products from companies that pay to be included. For instance, energy suppliers often actively report their prices to price comparison web sites and pay a royalty to the provider for every contract signed through the providers' web site, see, e.g., http://www.confused.com/about-us or http://www.verivox.de/branchendienste/energieversorger.aspx. In other industries, firms may still not actively list their prices on the price comparison web sites, but consumers report the prices to the web sites. As a result, some gasoline stations are listed and some are not. This would not alter our main results, because firms face the same trade-off of serving uninformed consumers or competing for informed ones.

7 In practice, some consumers may refrain from price comparison, if they expect the listed prices to be unreliable.

8 In line with Baye and Morgan (2001), we assume that the consumer surplus at the monopoly price of 1 is sufficient to cover ε; see footnote 7 in Baye and Morgan (2001).

price below zero, as this would yield negative profits, whereas by setting a price at 1 and not listing its price, a firm always at least sells to non-subscribers and makes positive profits. We compare the expected profits for a firm that chooses not to list its price with the expected profits if it does list.

A non-listing firm can always guarantee a profit of

$$\overline{\Pi}_0 = \left(\frac{1-\mu}{2} + (1-\phi)\frac{\mu}{2}\right). \tag{1}$$

A listing firm's expected profit is given as

$$E\Pi_1 = p\left(\frac{1-\mu}{2} + \phi\mu(1 - F_1(p)) + (1-\phi)\mu\right) - \kappa. \tag{2}$$

The profit functions can be understood as follows. Independent of the rival's listing decision, a firm always serves an equal share of non-subscribers of share $\frac{1-\mu}{2}$. If the firm decides not to be listed (eq. [1]), it only additionally serves an equal share of subscribers, if they did not find any offer at the price comparison service at all. In the other case, all consumers buy from the rival, because $\int_{\underline{p}}^{1} F_1(p)dp < 1$ and subscribers clearly have no incentive to search for a non-listed firm.

If a firm decides to be listed (eq. [2]) and the other firm also decides to be listed, all subscribers are aware of both offers and the firm which posts the lower price on the rival's distribution function captures these consumers, which occurs with probability $1 - F_1(p)$. If the rival is not listed, the firm attracts all subscribers with the same argument as above. Finally, listing costs a fixed amount of κ.

In a mixed-strategy equilibrium, expected profits must equal the profits firms can guarantee by charging consumers reservation value. By setting $p = 1$ in eq. [2], a firm's guaranteed profit if it lists its offer is given by

$$\overline{\Pi}_1 = \left(\frac{1-\mu}{2} + (1-\phi)\mu\right) - \kappa. \tag{3}$$

Next, in a mixed-strategy equilibrium, firms must be indifferent between listing and not listing. Setting $\overline{\Pi}_0 = \overline{\Pi}_1$ and solving for ϕ, the equilibrium listing propensity is given as

$$\phi^* = 1 - \frac{2\kappa}{\mu^*}. \tag{4}$$

That is, there is an interaction between firms' listing propensity and consumers' subscription propensity. The higher the subscription propensity, the more likely firms list their prices, that is, $\frac{\partial \phi^*}{\partial \mu} > 0$. A firm lists with probability $\phi^* \in (0,1)$ if $\kappa \le \hat{\kappa} = \frac{\mu}{2}$, that is, if the expected benefit from listing (the additional revenue

from subscribers $\frac{\mu}{2}$) exceeds the fixed cost of listing. This is assumed in the following calculations.

A non-listing firm optimally sets $p = 1$ and sells to consumers who obtained its offer, whereas a listing firm attracts more consumers and draws prices on

$$F_1(p) = \frac{1}{2}\left(\frac{1+\mu}{\mu - 2\kappa} - \frac{(1-\mu) + 4\kappa}{p(\mu - 2\kappa)}\right), \tag{5}$$

with

$$\underline{p}_1 = \frac{(1-\mu) + 4\kappa}{1+\mu}. \tag{6}$$

At equilibrium prices, non-subscribers (and subscribers, who do not find any offer) search for a firm's offer with equal probability if the expected benefit from searching outweighs the search costs. Subscribers only search if they did not find any offer on the price comparison web site. They know that both firms do not list and set prices of $p = 1$, so that for a subscriber it does not pay to incur an additional search cost ε to see both prices. Non-subscribers search for one of the firms with equal probability if

$$U_{nsub} = 1 - (\phi E(p_1) + (1 - \phi)) > \varepsilon, \tag{7}$$

where with probability ϕ the searched firm lists and sets an expected price $E(p_1) = \int_{\underline{p}_1}^{1} F_1(p)dp$ and with probability $1 - \phi$ does not list and sets a price of 1. To discourage non-subscribers to search beyond the first firm,

$$\begin{aligned} &1 - (\phi E(p_1) + (1 - \phi)) - \varepsilon > 1 \\ &- \left(\phi^2 E(\min(p_{1i}, p_{1j})) + 2\phi(1 - \phi)E(p_1) + (1 - \phi)^2\right) - 2\varepsilon \end{aligned} \tag{8}$$

must hold. With probability ϕ^2 both firms are listed and a non-subscriber purchases at the lower of the two listed prices, where $E(\min(p_{1i}, p_{1j}))$ is the expected price of the distribution of the lowest market price given by the distribution function of $M(p) = 1 - (1 - F_1(p))^2$. With probability $(1 - \phi)^2$, no firm is listed and the expected price is 1. With the remaining probability, only one firm is listed, in which case the consumer purchases at an expected price $E(p_1)$. Equations [7] and [8] then determine the range of $\underline{\varepsilon} \leq \varepsilon \leq \bar{\varepsilon}$, which is mathematically derived in the Appendix. If search costs are low, non-subscribers search twice, otherwise, if search costs are high, non-subscribers do not search at all.

Given the firms' pricing and listing strategies, a consumer decides to subscribe to the price comparison web site in the first stage. The decision is guided

by the expected purchase prices net of the subscription cost and the saving of the search cost. The gross expected surplus from subscription is denoted as

$$U_{sub} = 1 - \left(\phi^2 E(\min(p_{1i}, p_{1j})) + 2\phi(1 - \phi)E(p_1) + (1 - \phi)^2 \right). \quad [9]$$

Subscribers receive the same benefit as non-subscribers which (hypothetically) search twice, have to pay a subscription cost of c but save the search cost ε.[9] That is, a subscriber considers the net cost of subscription $r = c - \varepsilon$.

The difference $\Gamma(\mu) = U_{sub} - U_{nsub}$ represents a consumer's expected gross benefit from subscription. Solving

$$\Gamma(\mu) = U_{sub} - U_{nsub} = r \quad [10]$$

implicitly yields the equilibrium subscription rate μ^*. By inserting the equilibrium listing propensity of eq. [4] into eq. [10] we can characterize equilibria at which firms optimally list their prices on the web site, given that consumers subscribe to an optimal degree and consumers subscribe optimally, given the optimal decision of firms and of other consumers. This is technically given as

$$\Gamma(\mu) = \frac{((1 - \mu) + 4\kappa)\ln\left(\frac{(1+\mu)}{(1-\mu)+4\kappa}\right)}{2\mu^2} - \frac{((1 - \mu) + 2\kappa)(\mu - 2\kappa)}{\mu^2}. \quad [11]$$

Without explicitly solving for μ^*, we can directly comment on the equilibrium subscription rate. A consumer will always subscribe if $U_{sub} - r > U_{nsub}$. If all firms list ($\kappa = 0$ and thus $\phi^* = 1$), prices are drawn from $F_1(p)$ of eq. [5] and the benefit from subscription is

$$\Gamma(\mu) = \frac{1}{2}\frac{(1 - \mu)\left(\ln\left(\frac{1+\mu}{1-\mu}\right) - 2\mu\right)}{\mu^2}. \quad [12]$$

Then, given net subscription costs of r, it can be seen that

$$\lim_{\mu \to 1} \Gamma(\mu)|_{\phi^*=1} = 0 \quad [13]$$

and thus, if all firms list, the subscription propensity is strictly less than one. Similarly, if no firm lists its product ($\kappa \geq \frac{\mu}{2}$ and thus $\phi^* = 0$), consumers will also naturally not subscribe. Hence, both firms charge the same non-listed price and all consumers buy at $p = 1$.

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9 We assume that subscribers fully save the search cost. Even if they find no offer, they know that the non-listed price is 1. One may also argue that subscribers still have to physically visit the firm to make a purchase. Thus, we interpret ε as a cost to obtain a price information, rather than as a cost of physically visiting a firm.
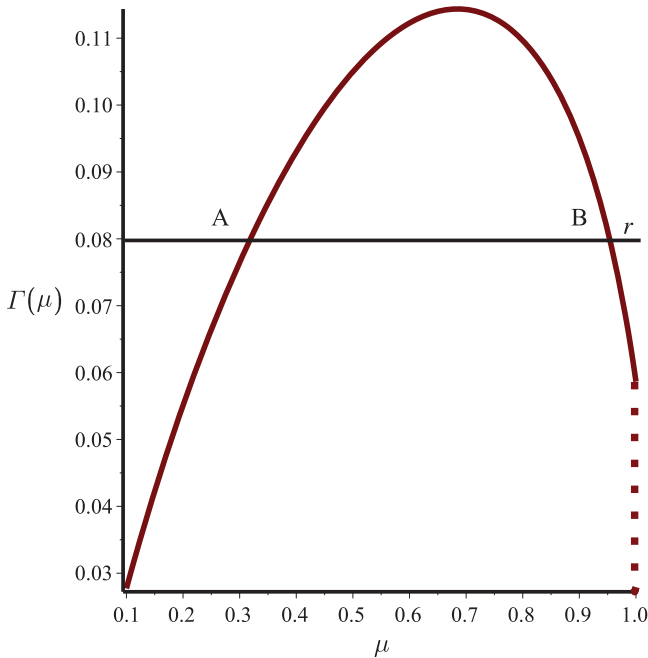
Figure 1: Equilibrium subscription propensity in the unregulated market

Because $\frac{\partial \phi^*}{\partial \mu} > 0$, we can state directly that $\frac{\partial \Gamma(\mu)}{\partial \mu} \lessgtr 0$, which Figure 1 illustrates for a parameter value $\kappa = 0.01$. Due to the concave shape of $\Gamma(\mu)$ there are two equilibria which solve $\Gamma(\mu^*) = r$ for μ.

Following the arguments provided by Fershtman and Fishman (1992) (see also the discussion in Proposition 7 by Janssen and Moraga-González (2004)), only the equilibrium with the high subscription intensity (point B) is a stable equilibrium. At the low subscription intensity equilibrium (point A), more consumers wish to subscribe, because $\Gamma(\mu) > 0$ for any $\mu' > \mu^*$. Similarly, a small change so that $\mu' < \mu^*$ would lead fewer consumers to subscribe. Hence, consumers will move away from point A. This suggests that the low subscription equilibrium represented by point A is not stable. Therefore, in line with Proposition 7 of Janssen and Moraga-González (2004), we only consider the stable equilibrium represented by point B in the present analysis.

Following Proposition 4 of Baye and Morgan (2001), we are now able to characterize possible equilibria when consumers and firms optimally determine their decision. If listing costs are too high, that is, if $\kappa \geq \hat{\kappa}$ firms will not list and thus, consumers will not subscribe. The unique equilibrium is $\phi^* = 0$ and $\mu^* = 0$

and firms charge the monopoly price. SMSE thus arise when subscription costs and listing costs are not prohibitive.

Proposition 1 *In the unregulated market there are three types of market equilibria*:

1. No participation equilibrium: If $r > \Gamma(\mu)$ and $\kappa < \hat{\kappa}$ there is an equilibrium at which no consumer subscribes ($\mu^* = 0$) and no firm lists its price ($\phi^* = 0$). Then, all firms charge $p = 1$.
2. Partial consumer subscription: If $r \leq \Gamma(\mu)$ and $\kappa < \hat{\kappa}$ there is an equilibrium where $\mu^* \in (0, 1)$, μ^* solve $\Gamma(\mu) = r$ and firms list with probability $\phi^* = 1 - \frac{2\kappa}{\mu^*}$.
3. Full consumer subscription: If $r \leq \Gamma(\mu)$ and $\kappa < \hat{\kappa}$ there is an equilibrium where $\mu^* = 1$ and firms list with probability $\phi^* = 1 - 2\kappa$.

2.2 Regulated equilibrium

Next, we derive the equilibrium outcome in a regulated market and compare it with the unregulated market equilibrium. As noted in the introduction, in financial and in gasoline markets, for example, there are initiatives for compulsory price reporting. Some governments such as in Austria, in Germany and in Western Australia mandate price disclosure rules in retail gasoline markets. Since 2001 in Western Australia and since 2011 in Austria, the governments themselves disclose the retail prices to the public via web, mobile devices or telephone services. Since 2013, gasoline stations in Germany have to submit their prices to a database organized by the Federal Cartel Office. Commercial services can then register for permission to disclose the prices to consumers. The price comparison services are allowed to charge fees to consumers. Austria and Western Australia have additionally introduced accompanying price restrictions.[10]

We model the price reporting regulation as follows. As price reporting is mandatory, a firm's strategy is reduced to drawing a retail price of $F_1^{reg}(p)$ from the cumulative distribution function (cdf) of listed prices where the superscript

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10 In Western Australia, gasoline stations may change their prices at most once a day. In Austria, gasoline stations may only increase their prices once a day, while price cuts are always allowed. Different kinds of price regulation are also imposed in Luxembourg and in Canadian provinces and territories, for example, in Quebec and the Atlantic provinces.

reg denotes the outcomes in the regulated regime.[11] The model corresponds to Varian (1980) where we additionally introduce endogenous subscription to a price comparison service.[12]

For simplicity, we suppress the index 1 henceforth. A firm's guaranteed profit then reduces to

$$\overline{\Pi}^{reg} = \left[\frac{(1-\mu)}{2}\right] - \kappa. \tag{14}$$

A firm's strategy set reduces to mix over prices where prices are drawn from the cdf.

$$F(p)^{reg} = \frac{1}{2}\left(\frac{1+\mu}{\mu} - \frac{(1-\mu)}{\mu p}\right) \tag{15}$$

on $p \in (\frac{1-\mu}{1+\mu}, 1)$.

Similarly, non-subscribers divide equally between the two firms and buy at $E(p)$, whereas subscribers buy at $E(\min\{p_i, p_j\})$.

A firm randomizes its decision of serving non-subscribers or competing for subscribers. Gross consumer surplus from subscription is denoted as

$$U_{sub}^{reg} = 1 - E(\min(p_i, p_j)), \tag{16}$$

and from not subscribing as

$$U_{nsub}^{reg} = 1 - E(p). \tag{17}$$

A subscriber always observes both prices and buys at the minimum, but incurs net subscription cost r, whereas a non-subscriber gets a random draw from $F(p)^{reg}$, economizes on the subscription cost, but pays the search cost ε. The gross benefit from subscription in the regulated regime is thus simply denoted as

$$\Gamma(\mu)^{reg} = E(p) - E(\min(p_i, p_j)). \tag{18}$$

An equilibrium subscription rate solves $\Gamma(\mu^*) = r$ for μ, with

$$\Gamma(\mu)^{reg} = \frac{1}{2}\frac{(1-\mu)\left(\ln\left(\frac{1+\mu}{1-\mu}\right) - 2\mu\right)}{\mu^2}. \tag{19}$$

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11 Other effects of the regulation are also conceivable. Some consumers may only learn about the existence of price comparison services due to the regulation. Moreover, some consumers may refrain from price comparison in the unregulated market because they expect the posted data to be inaccurate. Due to the regulation, the price data will become official and reliable. We do not consider these possible effects.

12 Tappata (2009) extents his model to endogenous consumer search and incorporates uncertainty over production costs.
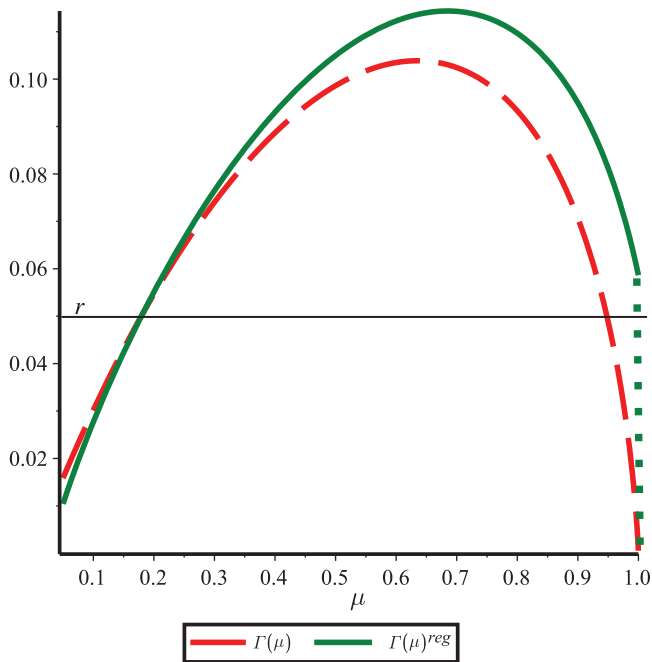
Figure 2: Equilibrium subscription in the regulated market vs. equilibrium subscription in the unregulated market

Figure 2 depicts the benefit from subscription in the unregulated market equilibrium (the solid green line) of Figure 1 and additionally illustrates the benefit from subscription in the regulated regime (the dashed red line) for the same parameter values as Figure 1. The figure shows that either benefit is concave in μ and there are again one or two equilibria, where due to the same arguments as provided in the discussion of Figure 1 only a high subscription equilibrium is stable.

Proposition 2 *In the regulated market there are two types of market equilibria*:

1. No participation equilibrium: If $r > \Gamma(\mu)$ there is an equilibrium at which no consumer subscribes ($\mu^* = 0$). Then, all firms charge $p = 1$.
2. Partial consumer subscription: If $r \leq \Gamma(\mu)$ there is an equilibrium where $\mu^* \in (0, 1)$, μ^* solve $\Gamma(\mu) = r$.

The following section compares the equilibria in the unregulated and in the regulated market.

2.3 Comparison of the regimes

Lemma 1 *In the regulated regime, the consumer subscription propensity to a price comparison service is strictly less than one.*

In the previous section we found that there is no mixed-strategy equilibrium where firms list with probability $\phi^* = 1$ and consumers subscribe with probability $\mu^* = 1$. Now, due to the regulation, firms have to list, so that there is no equilibrium at which all consumers subscribe. Therefore, both firms would set the same price of $p = 0$ and, because there would be no price dispersion, it would not pay for consumers to incur costly subscriptions, that is, $\mu^* < 1$. We showed that in the unregulated case, there is an equilibrium at which all consumers subscribe (case iii of proposition 1), so that it follows that there are instances where consumers subscribe less when firms are regulated. Consumers will only subscribe if they expect prices to be sufficiently dispersed. If the regulation leads to less price dispersion, subscription intensity will decrease. As the guaranteed profits of eqs [1] and [3] are higher the less likely consumers are to subscribe, it is ad hoc unclear whether firms indeed suffer and consumers benefit from the regulation.

Proposition 3 *For a fixed level of μ, the regulation leads to lower expected prices.*

This can be shown by using the criterium of first-order stochastic dominance, that is,

$$F(p)^{reg} - F_1(p) = \frac{\kappa(1-p)(1+\mu)}{p(\mu - 2\kappa)\mu} > 0 \qquad [20]$$

$\forall \kappa < \frac{\mu}{2}$ and thus, $\phi^* > 0$ (see eq. [4]). Hence, it follows that $E_1(p)^{reg} < E_1(p)$. However, we know from the above analysis that there is an interaction between firms' listing propensity and consumers' subscription propensity; thus, consumers' subscription propensity will be affected by the regulation.

Proposition 4 *If $\kappa < \hat{\kappa}$, there is always more subscription at equilibrium in the unregulated regime.*

We have shown that for $\kappa \geq \hat{\kappa}$, listing is too costly for firms and thus, consumers will not subscribe either. Firms will then set $p = 1$. The regulation will clearly promote competition in this case.[13] Otherwise, for $\kappa < \hat{\kappa}$, firms randomize their decision to list and their pricing.

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13 Also in the regulated regime there exists an equilibrium in which no consumer subscribes. Then, again, all firms will charge the monopoly price and thus, consumers have no incentive to compare prices.

Technically, observe in Figure 2 that there is a $\hat{\mu}$ that solves $\Gamma(\mu)^{reg} = \Gamma(\mu)$ and $\Gamma(\mu) > \Gamma(\mu)^{reg}$ if $\mu > \hat{\mu}$. It can be shown numerically that $\frac{\partial \Gamma^{reg}}{\partial \mu}|_{\mu = \hat{\mu}} > 0$; thus, $\hat{\mu}$ is on the increasing segment of the $\Gamma(\mu)$ curve in the regulated regime. We showed, though, that the subscription equilibrium is on the decreasing segment of $\Gamma^{reg}(\mu)$, which confirms the statement.[14]

Firms benefit from the regulation if many consumers are discouraged to compare prices in the regulated market compared with the unregulated market. Comparing the guaranteed profits of eqs [1] and [3], this holds if

$$\mu^{reg} < \mu^* - 4\kappa, \qquad [21]$$

where μ^{reg} and μ^* are endogenously defined. We confirmed that there is indeed always more subscription in equilibrium in the unregulated regime ($\mu^{reg} < \mu^*$) because the benefit from subscription is higher than in the regulated regime. There, consumers know for certain that they will find a listed price drawn from $F^{reg}(p)$ even without subscription. Thus, an additional benefit only stems from finding both prices. In the unregulated regime, non-subscribers find a non-listed price of $p = 1$ with some probability and, thus, will especially gain from finding a lower listed price on the price comparison web site. This is especially true if many firms list, that is, if κ is small. In general, it is not the level of prices which encourages consumers to compare prices, but their dispersion.

Accordingly, consumers may also benefit or suffer from the regulation. Denote $CS = \mu^* U_{sub} + (1 - \mu^*)U_{nsub}$ and $CS^{reg} = \mu^{reg} U_{sub}^{reg} + (1 - \mu^{reg})U_{nsub}^{reg}$ as the gross consumer surplus which weighs the expected surplus of subscribers and of non-subscribers with their equilibrium shares, which are determined by firms' pricing at equilibrium in the two regimes.[15] This yields simple expressions of

$$CS^{reg} = \mu^{reg} \qquad [22]$$

for the regulated regime and of

$$CS^* = \frac{(\mu^* - 2\kappa)^2}{\mu^*} \qquad [23]$$

for the non-regulated regime. We know from the previous analysis, if no consumer compares prices in the regulated regime ($\mu^{reg} = 0$), firms set $p = 1$ and

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14 We are unable to provide the explicit analytical expressions but confirm the statements numerically.

15 A total welfare analysis also has to take account for potential savings of search costs. Here, we conduct a partial welfare analysis to focus on the effect of firms' decisions on the welfare of consumers.

thus, $CS^{reg} = 0$. To the contrary, if all consumers compare prices, prices are driven down to the Bertrand outcome and thus, $CS^{reg} = 1$. In the unregulated regime, consumer surplus additionally depends on firms' listing decision. Observe from eq. [4] that for $\kappa \geq \frac{\mu}{2}$ firms do not list, set $p = 1$, and accordingly consumer surplus is $CS^* = 0$. Otherwise, if all firms list, that is, if $\kappa = 0$, it follows that $CS^* = \mu$. Comparing consumer surplus in the two regimes, consumers benefit from the regulation only if

$$\mu^{reg} > \mu^* - \frac{4\kappa(\mu^* - \kappa)}{\mu^*}. \tag{24}$$

It follows from the previous analysis that $\mu^* > \mu^{reg}$. Note that the right-hand side of the inequality is decreasing in the cost of listing (κ). It follows if κ is small, that is, if firms very likely list in the unregulated regime, consumers may suffer from the regulation. Otherwise, if listing is costly, consumers indeed benefit. Hence, one may derive a testable hypothesis that the regulation should benefit consumers and hurt firms if few firms have listed in the unregulated regime and otherwise may lead to unintended effects.

This result shows some similarity to the results of Moraga-González, Sandor, and Wildenbeest (2014).[16] There, the authors identify critical conditions for higher search costs to result in lower prices. In their model of search cost heterogeneity this happens because an increase in search costs affects two margins, a search intensity margin and a participation margin. Higher search costs result in less search intensity, making demand more inelastic. However, higher search costs also lower the participation of consumers who happen to search little, which makes demand more elastic. Moraga-González, Sandor, and Wildenbeest (2014) generally show that the latter effect dominates if the search cost distribution has a decreasing elasticity with respect to the parameter that shifts the distribution.

We provide an example of a case in which the regulation hurts consumers and benefits firms. Consider a cost of listing of $\kappa = 0.010$ and see Figure 2. Note that if net subscription costs are too high ($r \geq 0.104$), consumers do not subscribe in the regulated regime, whereas there is active subscription in the unregulated market equilibrium. An inspection of the two graphs shows that there is always more equilibrium subscription in an unregulated market than in a regulated one. Take, for instance, a net subscription cost of $r = 0.050$. In an unregulated market equilibrium, all consumers subscribe ($\mu^* = 1$) and firms list with probability $\phi^* = 0.980$. Then, firms can guarantee a profit of $\overline{\Pi} = 0.010$ and consumers obtain a surplus of $U_{sub} = 0.960$. In a regulated market,

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16 I thank an anonymous referee for pointing me on this similarity.

consumers only subscribe with probability $\mu^* = 0.947$, leading to higher firms' profits of $\overline{\overline{\Pi}} = 0.017$ and a lower consumer surplus of $U_{sub} = 0.947$. Hence, the regulation harms consumers in this case and would harm them even more, if the net subscription cost were to discourage them from subscribing at all under regulation, that is, in our numerical example, if $r > 0.104$. In this example, the regulation has little effect on the listing propensity on the firm side, but leads to an adverse effect on the subscription propensity on the consumer side.

Table 1 confirms the results for various levels of listing cost (κ) and net subscription costs (r).[17] It provides the equilibrium subscription propensity both in the unregulated regime (μ^*) and in the regulated regime (μ^{reg}) and the according effect on firms' guaranteed profits and consumer surplus given by eqs [22] and [23].

Since consumers generally subscribe less intensively in the regulated regime, firms may benefit from the regulation and accordingly, consumers may be worse off. In line with conditions [21] and [24] this is true if the subscription propensity sufficiently declines. This especially holds if net subscription costs (r) are relatively high.

Table 1: Effects of the regulation on firms and consumers

r	μ^*	μ^{reg}	$\overline{\overline{\Pi}}^*$	$\overline{\overline{\Pi}}^*$	CS^*	CS^{reg}
$\kappa = 0.005$						
0.025	1	0.982	0.005	0.004	0.980	0.982
0.050	0.979	0.947	0.016	0.022	0.961	0.947
0.075	0.928	0.886	0.041	0.052	0.920	0.886
0.100	0.818	0.739	0.096	0.126	0.850	0.739
$\kappa = 0.0075$						
0.025	1	0.982	0.008	0.002	0.970	0.982
0.050	0.966	0.947	0.025	0.020	0.941	0.947
0.075	0.946	0.886	0.035	0.050	0.925	0.886
0.100	0.847	0.739	0.084	0.123	0.858	0.739
$\kappa = 0.010$						
0.025	1	0.982	0.010	0.000	0.960	0.982
0.050	1	0.947	0.010	0.017	0.960	0.947
0.075	0.966	0.886	0.027	0.047	0.931	0.886
0.100	0.872	0.739	0.074	0.121	0.865	0.739

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17 The levels are chosen such that firms and consumers participate in the market. Moreover, to ensure that non-subscribers search exactly once in each of the equilibria, the search cost has to be $\varepsilon \in [0.107, 0.616]$ (see Appendix).

Proposition 5 *If $\kappa < \hat{\kappa}$, the regulation may lead to higher profits and lower consumer surplus. This especially holds if the subscription propensity is sufficiently lower in the regulated regime compared to the unregulated regime.*

In turn, if net subscription costs are low, so that many consumers initially compare prices, the regulation indeed benefits consumers. One may, however, then scrutinize the rationale for price transparency regulation in a market where consumers can easily compare prices. However, if firms do find it too costly to list their prices in an unregulated market equilibrium, the regulation will again lead to lower prices to the benefit of consumers. Hence, predictions of the regulation impact should not be made on a priori grounds. To conclude, the regulation may benefit consumers (or at least not harm them) if the net subscription costs are low, so that many consumers compare prices. Otherwise, the regulation may have detrimental effects.

3 Discussion and conclusion

Consumer protection policy aims at increasing price transparency so as to encourage consumers to compare prices in several markets. We show that mandatory price reporting can lead to adverse effects, because it may reduce consumers' incentives to compare prices. In financial markets, governments and consumer protection agencies act to enhance consumer incentives to compare fees of banking products. Some countries have imposed measures to increase the transparency of retail gasoline prices. Since 2008, South Korea publishes retail gasoline prices. As of September 2013, German gasoline stations have to report their prices in real time to a central database organized by the Federal Cartel Office. Similar measures have already been in force in Western Australia since 2001 ("Fuel-Watch") and in Austria since 2011. The rationale for the mandatory price reporting is to increase price transparency and thus encourage consumers to compare prices more intensively which should ultimately lead to lower market prices.

We show that such a conclusion cannot be made on a priori grounds. A regulation on the firm side of the market will lead to changes in consumer behavior. We highlight the adverse effects of a mandatory price transparency regulation. The regulation leads fewer consumers to compare prices compared to an unregulated market equilibrium, where firms endogenously decide on their reporting, given consumers' propensity to subscribe to price comparison services. The regulation can feed back into firms' strategies. For a fixed

subscription propensity, the regulation leads to lower expected prices. However, the indirect effect on the lower subscription propensity may outweigh the effect of mandatory price listing, resulting in higher prices and, in turn, a lower consumer surplus when firms are regulated.

We used a model setup where all consumers are initially uninformed about the prices in the market and decide to become informed by subscribing to a price comparison service. As an extension, one could introduce another group of consumers which is always informed about the market prices. In search models, these consumers are typically labeled as shoppers. This would, however, not alter our main results. The more consumers are initially informed about market prices, the more elastic is the market demand. In the presence of shoppers, non-shoppers might then be even less inclined to subscribe, since the probability of finding lower prices is also low. A mandatory price reporting regulation might then additionally reduce the subscription incentives.

In the present article, we interpret the regulation as a mandatory transparency regulation. One may further argue that the regulation also reduces the search cost. This would soften our results but the general effects will prevail. Moreover, we assumed that the data quality remains unaffected by regulation. In practice, some consumers may refrain from price comparison in the unregulated market, if they expect the posted data to be inaccurate. Then, due to the regulation, the price data becomes official and reliable, which may foster price comparison. There is scope for more research on this topic.

We use a standard and simple consumer search strategy where non-subscribers randomly choose one firm. For future research, it would be useful to consider different consumers' search strategies, for example, to allow consumers to search sequentially. We believe that this would add some new aspects to the analysis. Subscribers who observe only one price on the web site know that the other firm charges a non-listed price. This could imply that subscribers are even less willing to search a second time than non-subscribers, and thus, listing firms may even charge higher prices at equilibrium compared to non-listing firms.

There is very limited evidence on the effects of price disclosure rules. The policy reform in Germany could be viewed as a natural experiment that allows a comparison of firm and consumer behavior before and after the regulation. It would be interesting to observe to what extent the regulation indeed encourages consumers to compare prices. The potential to compare prices, for instance, via a mobile device, already existed before, but few consumers used these services.

Hence, it may be more appropriate to impose measures aimed at decreasing search or subscription costs on the demand side, by, for example, fostering investments in more innovative price comparison services. This would lead to more subscriptions to price comparison services, which directly promotes competition in the market.

Appendix. Equilibrium search intensity of non-subscribers

We determine the range of search cost ε such that non-subscribers search exactly once. This is true if

$$v - (\phi E(p_1) + (1 - \phi)v) > \varepsilon, \tag{25}$$

and

$$
\begin{aligned}
v - (\phi E(p_1) + (1 - \phi)v) - \varepsilon > v \\
- \left(\phi^2 E(\min(p_{1i}, p_{1j})) + 2\phi(1 - \phi)E(p_1) + (1 - \phi)^2 v \right) - 2\varepsilon.
\end{aligned}
\tag{26}
$$

Solving at equilibrium prices, it follows that $\underline{\varepsilon} \le \varepsilon \le \bar{\varepsilon}$, with

$$\underline{\varepsilon} = \frac{v^2(1-\mu) + 4vf}{2v\mu} \ln\left(\frac{v(1-\mu)}{v(1-\mu) + 4\kappa} \right) - \frac{(v(1-\mu) + 2\kappa)(v\mu - 2\kappa)}{v\mu^2} \tag{27}$$

and

$$\bar{\varepsilon} = \frac{v(1-\mu) + 4\kappa}{2\mu} \ln\left(\frac{v(1-\mu) + 4\kappa}{(1+\mu)v} \right) - \frac{2\kappa - v\mu}{\mu}. \tag{28}$$

Figure 3 shows the relevant range of search costs ε such that non-subscribers search exactly once for parameter values of $v = 1$ and $\kappa = 0.01$.
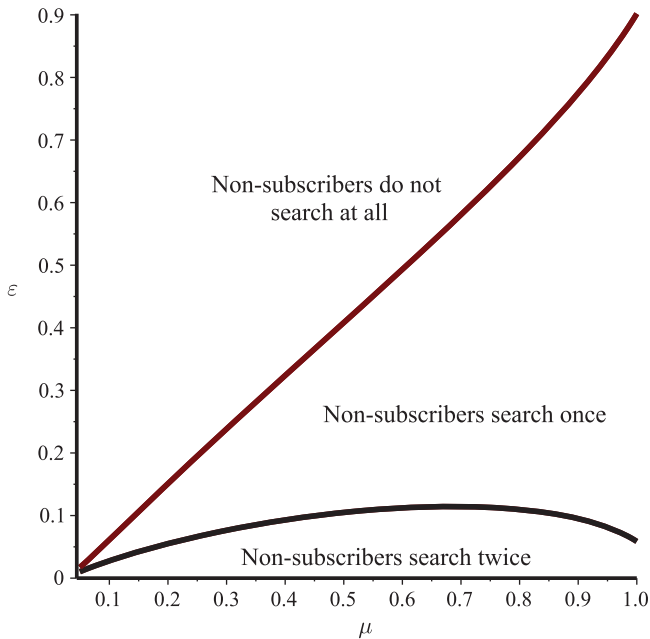
Figure 3: Range of relevant search costs

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