

Stühmeier, Torben

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Price disclosure rules and consumer price comparison

Torben Stühmeier*

Universität Münster, Center of Applied Economic Research Münster (CAWM), Am Stadtgraben 9, 48143 Münster, Germany

Abstract

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

JEL Classification: D83, L13, L51

Keywords: Mixed Strategies; Price Comparison; Regulation

1 Introduction

In 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 firms' demand increases, so equilibrium prices tend to be low. In many industries it is moreover documented that firms strategically limit

*Tel. +49 (0)251 83-22974. E-mail address: torben.stuehmeier@uni-muenster.de.

consumers' price recognition. Firms take advantage of consumers' different information levels leading to price dispersion for almost identical products, see, e.g., Hortacsu and Syverson (2004) for evidence on financial markets and Ellison and Ellison (2009) for evidence on Internet retailers. In 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 search for prices, search costs would, however, often deter consumers from price-shopping. According to a study by the General German Automobile Association (ADAC), 40% of consumers always buy at the same gasoline station.¹ Thus, the search intensity seems at best to be moderate.

Governments and consumer protection agencies therefore act to enhance consumers' incentives to acquire price information in the markets. In utility markets, especially in retail gasoline markets, some governments legally mandate price reporting of retail gasoline 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, since 2011 a similar service was rolled-out in Austria. Consumers should then be able to compare prices via, for example, a mobile device.² As of 01 September 2013 a statutory obligation to report price data came into effect in Germany. The obligation calls for the mandatory reporting of price changes to a market transparency unit of the federal cartel office, 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 launched several initiatives in bank fee transparency and comparability of personal current accounts.³ 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 industry. Similarly, in the UK, an ini-

¹<http://www.adac.de/infotestrat/tanken-kraftstoffe-und-antrieb/kraftstoffpreise/medienberichte/>.

²See www.fuelwatch.com.au for Australia and www.spritpreisrechner.at for Austria.

³For a survey on different instruments in the member states see http://ec.europa.eu/consumers/rights/docs/1912012_market_study_en.pdf.

tiative 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 disclosure of 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.

In the literature, the effect of price comparison on market prices is still discussed. While some studies conclude lower prices for commodity products (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. Studies also find a high degree of price dispersion even for homogenous goods (see, e.g., Baye *et al.*, 2004). In their empirical study, Baye and Morgan (2009) find that price dispersion is a persistent phenomenon which remains quite stable at 35 to 40 %. In their theoretical model, Anderson and Renault (2000) show that when some consumers are uninformed about prices and their valuation for the goods, a greater proportion of uninformed consumers leads to lower prices, which is in contrast to standard intuition.

Hence, it turns out that predictions of a mandatory price reporting regulation cannot be made on a priori grounds. A regulation on the firm side of the market will lead to changes of consumer behavior on the other side. We compare equilibrium expected 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. 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 will be shown that the regulation can feed back into firms' strategies and may result in higher prices and in turn lower consumer surplus. The article is also related to Janssen and Non (2008) who analyze the interdependency between firms' advertising and consumers' search decision and show that search and advertising are strategic substitutes over a wide parameter range.

The article is organized as follows: Section 2 provides the basic model. Sec-

tion 2.1 provides the firms' strategy sets and the consumers' price comparison decision in an unregulated market equilibrium and section 2.2 provides the decisions in a regulated market. Section 2.3 compares the outcomes. Section 3 introduces consumers, which are always informed about prices. Finally, section 4 concludes.

2 The basic model

We present 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 . Consumers are initially uninformed about market prices. They divide into two groups. A fraction $1 - \mu$ does not subscribe to a price comparison service and decides to search for the firms' offer. Each search action costs a consumer a cost of $\epsilon > 0$. We concentrate on the case where non-subscribers search for exactly one firm and provide the equilibrium condition for this case. This low or moderate search intensity is in line with empirical evidence by Chandra and Tappata (2011) and the ADAC, which state that most of consumers do not search beyond the first offer in gasoline markets.

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 to obtain price quotations. We assume that $c < 2\epsilon$, otherwise no consumer would subscribe.

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 f .⁴ Firms simultaneously

⁴As is pointed out by Brynjolfsson *et al.* (2004) price comparison services have been changing over time. They have gone from 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 a 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 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.

decide on their prices and listing on the price comparison web site. Firms truthfully list their prices.⁵ 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, depending on the model setup, draws a price from the distribution function $F_{0i}(p)$, where the subscript 0 denotes no listing, or does not randomize prices at all. So a firm's strategy is given by the set of $\{\phi_i, F_{1i}(p)\}$ and possibly $F_{0i}(p)$, where we assume symmetric mixed strategy equilibria (SMSE) henceforth and drop the index i . Prices are drawn from $F_1(p)$ and possibly from $F_0(p)$ and consumers visit the price comparison web site with probability μ .

The timing of the game is as follows. First, consumers decide about their subscription to the price comparison web site. In the second stage, firms simultaneously decide about their pricing and listing. Finally, consumers decide to search and to buy. 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 the 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. This equilibrium follows the "moderate search intensity equilibrium" by Janssen and Moraga-González (2004).⁶ Each firm balances the well-known trade-off (Varian, 1980) of charging the reservation value v to extract the rent from non-subscribers (and from subscribers, in case they find no price on the price comparison web site) or competing for subscribers and listing a lower

⁵In practice, some consumers may refrain from price comparison, if they expect the listed prices to be of low quality.

⁶Importantly, consumers search non-sequentially but upfront decide 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 to obtain none or one and one or two price quotations. A similar analysis is outside the scope of this paper but certainly interesting for further research on this topic. We make some comments on sequential search in the conclusion.

price but incurring a listing fee of f .⁷ It is clear that no firm will set a price below zero as this yields non-positive profits, whereas by setting a price at v and not listing its price, a firm always at least serves the 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

$$\bar{\Pi}_0 = v \left(\frac{1-\mu}{2} + (1-\phi)\frac{\mu}{2} \right). \quad (1)$$

A listing firm's expected profit is denoted as

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

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

If a firm decides to be listed (equation (2)) and the other firm also decides to be listed, all subscribers are aware of both offers and that firm captures these consumers which posts the lower price on the rival's distribution function which happens 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 f .

In a mixed strategy equilibrium, the expected profits have to be equal to the profits firms can guarantee by charging consumers' reservation value. By setting $p = v$ in equation (2), a firm's guaranteed profit in case it puts its offer on listing is given by

$$\bar{\Pi}_1 = v \left(\frac{1-\mu}{2} + (1-\phi)\mu \right) - f. \quad (3)$$

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

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

$$\phi^* = 1 - \frac{2f}{v\mu}. \quad (4)$$

That is, there is an interaction between firms' listing propensity and consumers' subscription propensity. The higher the subscription propensity, the more likely firms will list their prices, i.e., $\frac{\partial \phi^*}{\partial \mu} > 0$. A firm will list with probability $\phi^* \in (0, 1)$ if $f \leq \hat{f} = \frac{v\mu}{2}$, that is, if the expected benefit from listing (the additional revenue from subscribers $\frac{v\mu}{2}$) is larger than the fixed cost of listing. This is assumed in the following calculations.

A non-listing firm optimally sets $p = v$ and serves consumers which obtained its offer, whereas a listing firm attracts more consumers and draws prices on

$$F_1(p) = \frac{v}{2} \left(\frac{1 + \mu}{v\mu - 2f} - \frac{v(1 - \mu) + 4f}{p(v\mu - 2f)} \right) \quad (5)$$

with

$$p_1 = \frac{v(1 - \mu) + 4f}{1 + \mu}. \quad (6)$$

At equilibrium prices, non-subscribers (and subscribers, which do not find any offer) search for a firms' offer with equal probability if the expected benefit from search 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 $p = v$, so 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

$$U_{nsub} = v - (\phi E(p_1) + (1 - \phi)v) > \epsilon, \quad (7)$$

where with probability ϕ the searched firm lists and sets an expected price $E(p_1) = \int_{p_1}^v F_1(p) dp$ and with probability $(1 - \phi)$ does not list and sets a price of v .

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. The gross expected surplus from subscription is denoted as

$$U_{sub} = v - (\phi^2 E(\min(p_{1i}, p_{1j})) + 2\phi(1 - \phi)E(p_1) + (1 - \phi)^2 v). \quad (8)$$

A subscriber faces a probability of ϕ^2 that both firms are listed in which case she buys at the lower of both 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 v . With the remaining probability only one firm is listed in which case the consumer purchases at an expected price $E(p_1)$.

To discourage non-subscribers to search beyond the first firm it has to hold that

$$v - (\phi E(p_1) + (1 - \phi)v) - \epsilon > v - (\phi^2 E(\min(p_{1i}, p_{1j})) + 2\phi(1 - \phi)E(p_1) + (1 - \phi)^2 v) - 2\epsilon. \quad (9)$$

Equations 7 and 9 then determine the range of $\underline{\epsilon} \leq \epsilon \leq \bar{\epsilon}$, which will be technically provided in the Appendix.

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

$$\Gamma(\mu) = U_{sub} - U_{nsub} = c \quad (10)$$

implicitly gives the equilibrium subscription rate μ^* . By inserting the equilibrium listing propensity of equation (4) we can characterize equilibria where firms optimally list their prices on the web site, given consumer subscription and consumers optimally subscribe, given the decision of firms and of other consumers. This is technically given as

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

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

of equation (5) and the benefit from subscription is

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

Then, given subscription costs of c , it can be seen, that

$$\lim_{\mu \rightarrow 1} \Gamma(\mu) = 0 \quad (13)$$

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

Because $\frac{\partial \phi^*}{\partial \mu} > 0$ we can directly state that $\frac{\partial \Gamma(\mu)}{\partial \mu} \leq 0$, which figure 1 illustrates for parameter values of $v = 1$ and $f = 0.01$.

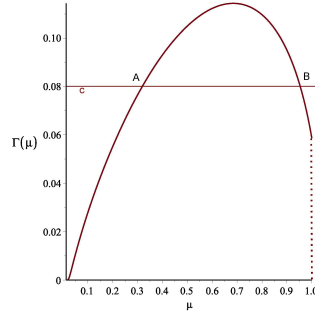


Figure 1: Eq. subscription propensity in the unregulated market.

Due to the concave shape of $\Gamma(\mu)$ there exist two equilibria which solve $\Gamma(\mu^*) = c$ for μ . Following the arguments provided by Fershtman and Fishman (1992), only the equilibrium with the high subscription intensity (point B) is a stable equilibrium. In 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 less consumers to subscribe. Hence, consumers will move away from point A.

Following Baye and Morgan (2001) a SMSE may be of the following types:

Proposition 1. There exists three types of market equilibria:

- i) No participation equilibrium: If $c > \Gamma(\mu)$ or $f \geq \hat{f}$ there exists an equilibrium in which no consumer subscribes ($\mu^* = 0$) and no firm lists its price ($\phi^* = 0$). Then, all firms charge $p = v$.
- ii) Partial consumer subscription: If $f < \hat{f}$ there exists an equilibrium where $\mu^* \in (0, 1)$, μ^* solve $\Gamma(\mu) = c$ and firms list with probability $\phi^* = 1 - \frac{2f}{\mu^*v}$.
- iii) Full consumer subscription: If $f < \hat{f}$ and $c < \Gamma(\mu)$ there exists an equilibrium where $\mu^* = 1$ and firms list with probability $\phi^* = 1 - \frac{2f}{v}$.

2.2 Regulated equilibrium

Next, we provide the equilibrium outcome in a regulated market and compare it to the unregulated market equilibrium. As noted in the introduction, e.g., in financial and in gasoline markets, there are initiatives of a 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 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 a permission to disclose the prices to consumers. The price comparison services are free to charge fees to consumers. Austria and Western-Australia have additionally introduced accompanying price restrictions.⁸

We mirror the price reporting regulation as follows. As price reporting is mandatory, a firm's strategy reduces to draw a retail price of $F_1^{reg}(p)$ from the cdf. of listed prices where the superscript *reg* denotes the outcomes in the regulated regime.⁹

⁸In 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 possible. Different kind of price regulation are also imposed in Luxembourg and in Canadian provinces and territories, e.g., in Quebec and the Atlantic provinces.

⁹One may also imagine other effects of the regulation. 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 of low quality. Then, due to the regulation, the price data becomes

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

$$\bar{\Pi}^{reg} = v \left[\frac{(1-\mu)}{2} \right] - f. \quad (14)$$

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

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

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

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

A firm randomizes over serving the non-subscribers or competing for subscribers. A consumers surplus from subscription is denoted as

$$U_{sub}^{reg} = v - E(\min(p_i, p_j)) - c \quad (16)$$

and from not subscribing as

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

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

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

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

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

Figure 2 illustrates the benefit from subscription in the unregulated market equilibrium (the solid green line) and the benefit from subscription in the regulated regime. It shows that the benefit is again concave in μ and there

official and consumers may regard them as more reliable. We abstract from these possible effects.

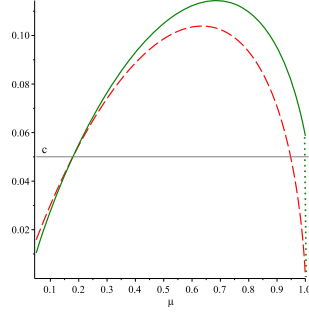


Figure 2: Eq. subscription in a regulated market vs. the unregulated market.

is again one or two equilibria where only a high subscription equilibrium is stable.

We derived in the previous section that there cannot be a 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, there cannot be an equilibrium where all consumers subscribe. Then, 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 subscription, i.e., $\mu^* < 1$. We showed that in the unregulated case there is an equilibrium where all consumers subscribe (case iii of proposition 1), thus, 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 equations (1) and (2) are higher the less likely consumers subscribe, it is ad hoc unclear whether firms indeed suffer and consumers benefit from the regulation.

2.3 Comparison of the regimes

Proposition 2. 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, i.e.,

$$F(p)^{reg} - F_1(p) = \frac{f(v-p)(1+\mu)}{p(v\mu - 2f)\mu} > 0 \quad (20)$$

$\forall f < \frac{v\mu}{2}$ and thus, $\phi^* > 0$ (see equation 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 3. If $f \geq \hat{f}$ a compulsory price reporting leads to strictly lower expected prices, lower profits and higher consumer surplus. If $f < \hat{f}$, there is always more equilibrium subscription in the unregulated regime. Then, the regulation may lead to higher expected prices, higher profits, and lower consumer surplus.

We showed above that for $f \geq \hat{f}$, consumers will not subscribe to price comparison services and firms will not list. Then, firms will set $p = v$. The regulation will clearly promote competition in this case.

Otherwise, for $f < \hat{f}$, firms randomize over their decision to list and over their pricing. Then, it can be shown that there is always more equilibrium subscription in the unregulated regime since 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. Here, an additional benefit only stems from finding both prices. In the unregulated regime, non-subscribers find a non-listed price of $p = v$ with some probability and thus, will especially gain from finding a lower listed price on the price comparison web site. In general, it is not the level of prices which encourages consumers to compare prices but the dispersion of prices.

Technically, observe in figure 2 that there exists an $\hat{\mu}$ that solve $\Gamma(\mu)^{reg} = \Gamma(\mu)$ and $\Gamma(\mu) > \Gamma(\mu)^{reg}$ if $\mu > \hat{\mu}$. It can be numerically shown that $\frac{\partial \Gamma^{reg}}{\partial \mu} \big|_{\mu=\hat{\mu}} > 0$, thus, $\hat{\mu}$ is in the increasing part of the $\Gamma(\mu)$ -curve in the regulated regime. We showed above, though, that the subscription equilibrium is in the decreasing part of $\Gamma^{reg}(\mu)$, which confirms the statement.¹⁰ Moreover, it can be shown that for $\hat{f} > f > \tilde{f}$, it follows that $\frac{\partial \Gamma}{\partial \mu} > 0$ in equation 11. In words, if the listing costs of firms are high, firms will list with low probability, so

¹⁰We are unable to provide the explicit analytical expressions but confirm the statements numerically.

firms charge $p = v$ with high probability. Then, it does pay for consumers to subscribe to find a lower listed price of $E(p_1) < v$. For $\hat{f} > f > \tilde{f}$ it holds that $\Gamma(\mu)$ is continuously increasing in μ (and not concave any longer) and there is either full subscription or no subscription in the unregulated regime, whereas there is only partial or no subscription in the regulated regime.

We directly provide an example to show a case where regulation hurts consumers and benefits firms.

Consider parameter values of $v = 1$, a cost of listing of $f = 0.01$ and see figure 2. Directly observe that if subscription costs are too high ($c \geq 0.104$), consumers do not subscribe in the regulated regime, whereas there is active subscription in the unregulated market equilibrium. Direct inspection of the two graphs shows that there is always more equilibrium subscription in an unregulated market than in a regulated market. Take for instance subscription cost of $c = 0.05$. In an unregulated market equilibrium all consumers will subscribe ($\mu^* = 1$) and firms will list with probability $\phi^* = 0.980$. Then, firms can guarantee a profit of $\bar{\Pi} = 0.010$ and consumers obtain a surplus of $U_{sub} = 0.901$. In a regulated market, consumers will only subscribe with probability $\mu^* = 0.944$, leading to higher firms' profits of $\bar{\Pi} = 0.018$ and lower consumer surplus of $U_{sub} = 0.895$. Hence, the regulation harms consumers in this case and would harm them even more, if subscription cost would discourage them from subscribing at all under regulation, i.e., in our numerical example, if $c > 0.104$. 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.

In turn, if subscription costs are low, so many consumers initially compare prices, the regulation indeed benefits consumers. One may, however, then scrutinize the rationale for a price transparency regulation in a market where consumers can easily compare prices. If firms, however, 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 should not be made on a priori grounds. To conclude, one may derive a testable hypothesis that the regulation should benefit consumers (or at least leads to no harm) if subscription costs are

low, so many consumers compare prices. Otherwise, the regulation may have detrimental effects.

The next section provides an extension to the basic model.

3 A model with shoppers

In the basic model we assumed that all consumers are initially uninformed about prices. We now assume that a share λ always samples both prices without costs, e.g., because they have low opportunity cost of time. As standard in the literature we label this group as shoppers. Non-shoppers of share $1 - \lambda$ face the same decision as before. We show that our results hold in this setting.

3.1 Unregulated market equilibrium

A non-listing firm's expected profit is denoted as

$$E\Pi_0 = p \left(\lambda [\phi(1 - F_1(p)) + (1 - \phi)(1 - F_0(p))] + (1 - \lambda) \left[\frac{1 - \mu}{2} + (1 - \phi)\frac{\mu}{2} \right] \right) \quad (21)$$

and a listing firm's expected profit as

$$E\Pi_1 = p \left(\lambda [\phi(1 - F_1(p)) + (1 - \phi)(1 - F_0(p))] + (1 - \lambda) \left[\frac{1 - \mu}{2} + \phi\mu(1 - F_1(p)) + (1 - \phi)\mu \right] \right) - f. \quad (22)$$

A firm always serves the shoppers, if it draws the lowest price on the rival's distribution function, taking into account that the rival sets different prices depending on whether it lists or not. If the firm does not list, it attracts half of the non-subscribers and half of the subscribers, only if they find no offer on the price comparison service. A listing firm attracts more consumers, namely all subscribers, but has to pay the listing cost of f .

In a mixed strategy equilibrium, the expected profits have to be equal to the profits firms can guarantee by setting $p = v$. Then, a firm's guaranteed profit in case it does not put its product on listing is denoted as

$$\bar{\Pi}_0 = v(1 - \lambda) \left(\frac{1 - \mu}{2} + (1 - \phi)\frac{\mu}{2} \right) \quad (23)$$

and in case it puts it on listing is given by

$$\bar{\Pi}_1 = v(1 - \lambda) \left(\frac{1 - \mu}{2} + (1 - \phi)\mu \right) - f, \quad (24)$$

where ϕ solves $\bar{\Pi}_0 = \bar{\Pi}_1$ and is given as

$$\phi^* = 1 - \frac{2f}{v\mu(1 - \lambda)}. \quad (25)$$

We have to take account for the fact that firms price differently when listing or not listing. As noted above, in either case, firms will price up to $p = v$, but the lower bound \underline{p} may differ. If firms draw prices in $(\max\{\underline{p}_0, \underline{p}_1\}, v)$, the price distribution can be obtained by standard method of setting $E\Pi_0 = E\Pi_1$ and solving for $F_1(p)$ which implicitly gives the cdf. $F_1(p)$ and $F_0(p)$.

Otherwise, if $\underline{p}_1 < \underline{p}_0$ the cdf. $F_0(p) = 0$ for $p \in [\underline{p}_1, \underline{p}_0]$ and a listing firm draws price on $F_1(p)$. Similarly, if $\underline{p}_0 < \underline{p}_1$ the cdf. $F_1(p) = 0$ for $p \in [\underline{p}_0, \underline{p}_1]$ and thus, and non-listing firm draws prices on $F_0(p)$.

We concentrate on the case that $\underline{p}_1 < \underline{p}_0$ which can be established if $f < \tilde{f}$. In the opposite case, it can be shown that $F_1(p) < F_0(p)$ and a listing firm sets higher expected prices than a non-listing firm.¹¹ In equilibrium, non-shoppers do not search beyond the first offer received, so non-shoppers find it less beneficial to subscribe to the price comparison service and directly search for one of the firms.¹²

Proposition 4. If the listing cost is not too high, i.e., if $f < \tilde{f}$, expected listed prices are always lower than expected non-listed prices.

For

$$f < \tilde{f} = \frac{v}{4} \left(\sqrt{1 - 4\lambda\mu(1 - \lambda)} + 2\mu(1 - \lambda) - 1 \right) \quad (26)$$

¹¹We provide the technical proof in the Appendix.

¹²It might still be beneficial for non-shoppers to subscribe to a price comparison service because then, they see both listed prices with probability ϕ^2 and buy at $p = \min\{\min\{E(p_{1i}), E(p_{1j})\}, E(p_0)\}$ with $\min\{E(p_{1i}), E(p_{1j})\}$ drawn from $1 - (1 - F_1(p))^2$. Analytically, it seems unfeasible to comment on the ranking of prices.

a non-listing firm draws prices on

$$F_0(p) = 1 - \left(\frac{\mu v(1-\lambda)^2(v-p)(1-\mu) - 2f(v-p)(\lambda - \mu(1-\lambda))}{4p\lambda f} \right) \quad (27)$$

and a listing firm draws prices on

$$F_1(p) = \frac{f(v+p) - vp\mu(1-\lambda)}{p(2f - v\mu(1-\lambda))} \quad (28)$$

for $p \in (\underline{p}_0, v)$ and otherwise for $p \in (\underline{p}_1, \underline{p}_0)$ on

$$F_1(p) = \frac{v\mu(1-\lambda)[p(1+\lambda+\mu(1-\lambda)) - v((1-\lambda)(1-\mu)) - 4f]}{2p(v\mu(1-\lambda) - 2f)(\lambda(1-\mu) + \mu)}, \quad (29)$$

with

$$\underline{p}_1 = \frac{v(1-\lambda)(1-\mu) + 4f}{\lambda(1-\mu) + 1 + \mu} \quad (30)$$

and

$$\underline{p}_0 = \frac{v(2\lambda(v\mu(1-\mu) + f(1+\mu)) - v\mu\lambda^2(1-\mu) - \mu(v(1-\mu) + 2f))}{2\lambda(v\mu(1-\mu) - f(1-\mu)) - v\mu\lambda^2(1-\mu) - \mu(v(1-\mu) + 2f)}. \quad (31)$$

One may observe that for $\lambda = 0$ the model corresponds to the basic model. Then, it follows that $\underline{p}_0 = v$ and $\tilde{f} = \frac{v\mu}{2}$. Otherwise, for $\lambda = 1$ the market is perfectly competitive and firms will clearly forego costly listing. All prices are driven down to the Bertrand equilibrium and consumers have no incentive to subscribe.¹³ One may further note that $\tilde{f} < \hat{f} = \frac{v\mu(1-\lambda)}{2}$, which guarantees $\phi^* > 0$ (see equation 25). That is, in the presence of shoppers, an active subscription market will more likely collapse not because firms find it too costly to list but because consumers expect no benefit from subscription.

3.2 Regulated equilibrium

In the regulated regime, firms draw prices on the cdf.

$$F^{reg}(p) = \frac{1}{2} \left(\frac{(1+\lambda+\mu(1-\lambda))}{(1-\mu)\lambda + \mu} - \frac{v(1-\mu)(1-\lambda)}{p((1-\mu)\lambda + \mu)} \right) \quad (32)$$

¹³This can be seen by evaluation of \tilde{f} at $\lambda = 1$, which gives $\tilde{f} = 0$. From evaluation of $\underline{p}_1|_{\lambda=1} = 2f$, together with $f \leq \tilde{f} = 0$ follows that $\underline{p}_1 = 0$.

with $\underline{p}^{reg} = \frac{v(1-\mu)(1-\lambda)}{(1-\mu)\lambda + \mu}$.

As a first observation, firms charge lower prices with higher probability in the regulated regime, i.e., $\underline{p}_1 - \underline{p}^{reg} = \frac{4f}{1+\lambda+\mu(1-\lambda)} > 0$. Furthermore, directly observe that $\lambda = 0$ restores the basic model and for $\lambda = 1$ firms charge $p = 0$ with certainty.

3.3 Comparison of the regimes

We first treat the subscription propensity μ as exogenous.

Proposition 5. For a given level of μ , regulated expected prices are strictly lower than expected non-listed prices. Regulated expected prices may be lower or higher than expected listed prices.

The first statement of the proposition can be shown by using the criterium of first order statistical dominance, i.e., $F^{reg}(p) > F_0(p)$. We provide the proofs of this section in the Appendix. The listed price $F_1(p)$ and $F(p)^{reg}$ cannot be ranked using the criterion of first-order stochastic dominance. It thus remains an open question whether expected price increases or decreases with the mandatory price regulation. It follows that there is no simple relationship between expected listed prices in the unregulated market equilibrium and in the regulated regime. The expected regulated price is strictly lower, if firms' listing propensity in the unregulated market equilibrium is not too high, i.e., if $f > \frac{1}{2}v\mu(1-\lambda)^2(1-\mu)$. Otherwise, depending on the other parameter values, the regulation may lead to higher expected prices.

Treating consumers' subscription decision as endogenous, the same effects as above can be confirmed. Consumers subscribe more intensively in the unregulated market. Figure 3 plots the benefit from subscription for $v = 1$, $f = 0.01$ and a share of shoppers of $\lambda = 0.2$ both for the unregulated market (the solid green curve) and the regulated market (the dashed red curve). In equilibrium, the subscription propensity is always higher in the unregulated market.

Then, again, for low levels of subscription costs, consumers subscribe inten-

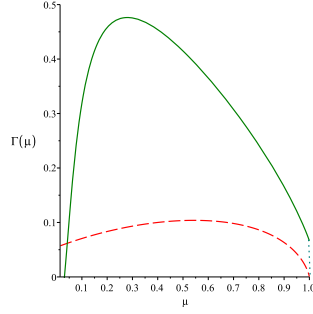


Figure 3: Eq. subscription for $\lambda = 0.2$.

sively in both scenarios and the regulation leads to lower expected prices. If subscription costs are high, however, consumers subscribe less intensively in the regulated market, which may lead to higher expected prices in the regulated regime. Take subscription cost of $c = 0.10$. Then, in the unregulated market equilibrium consumers subscribe with probability $\mu^* = 0.971$ and firms list with probability $\phi^* = 0.974$. Firms earn an expected profit of $\bar{\Pi} = 0.022$ and consumer obtain an expected surplus of $U_{sub} = 0.870$. In the regulated regime consumers subscribe with lower probability of $\mu^* = 0.674$, firms earn higher expected profits of $\bar{\Pi} = 0.120$ and consumer obtain a lower expected surplus of $U_{sub} = 0.765$.

4 Discussion and Conclusion

Consumer protection policy aims at increasing price transparency to trigger consumers to compare prices in several markets. We show that a mandatory price reporting can lead to adverse effects because it may reduce consumers' incentives to compare prices. In financial market, governments and consumer protection agencies act to enhance consumer incentives to compare fees of banking products. Governments of Western countries have imposed measures to increase transparency of 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 put into 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 thereby, to trigger consumers

to more intensively compare prices which, finally should 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 of consumer behavior. In different model setups we highlight adverse effects of a mandatory price transparency regulation. The regulation may lead fewer consumers to compare prices compared to an unregulated market equilibrium, where firms endogenously decide on their reporting, given consumers' subscription propensity to price comparison services. The regulation can feed back into firms' strategies. Over a wide parameter range, for a fixed subscription propensity, the regulation leads to lower expected prices. However, the indirect effect on the listing propensity may overturn the effect of mandatory price listing and may result in higher prices and, in turn, lower consumer surplus when firms are regulated.

There is yet very limited evidence on the effects of price disclosure rules. The policy reform in Germany could be viewed as a natural experiment that provides a comparison of firms' and consumers' behavior before and after the regulation. It would be interesting to observe, to what extent the regulation indeed encourages consumers to compare prices. The opportunity to compare price, e.g., via a mobile device already existed before, consumer, however, only very moderately used these services. Hence, it may be more appropriate to impose measures on decreasing search or subscription cost on the demand side, e.g., by fostering investments in more innovative price comparison services. This would directly lead to more subscription to price comparison services in our setup which directly promotes competition in the market.

In the present article we assumed that the data quality remains unaffected by the regulation. In practice, some consumers may refrain from price comparison in the unregulated market, if they expect the posted data to be of low quality. Then, due to the regulation, the price data becomes official and consumers may regard them as more reliable, which may foster price comparison. There is still scope for more research on this topic.

In the present setup we used a standard and simple consumer search strategy where non-subscribers randomly choose one firm. For future research

in would be interesting to consider different consumers' search strategies, e.g., to allow consumers to search sequentially. We expect that this will add some new aspects to the analysis. For instance, if listing is costly and only one firm joins the web site, subscribers may get a negative signal about the other, non-listed price. This might imply that subscribers are even less willing to search a second time than non-subscribers, and thus, listing firms may even charge higher prices in equilibrium compared to non-listing firms.

5 Appendix

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

$$v - (\phi E(p_1) + (1 - \phi)v) > \epsilon \quad (33)$$

and

$$v - (\phi E(p_1) + (1 - \phi)v) - \epsilon > v - (\phi^2 E(\min(p_{1i}, p_{1j})) + 2\phi(1 - \phi)E(p_1) + (1 - \phi)^2 v) - 2\epsilon. \quad (34)$$

Solving at equilibrium prices it follows that $\underline{\epsilon} \leq \epsilon \leq \bar{\epsilon}$, with

$$\underline{\epsilon} = \frac{v^2 + 4vf - v^2\mu}{2v\mu} \ln \left(\frac{v(1 - \mu)}{v(1 - \mu) + 4f} \right) - \frac{(v(1 - \mu) + 2f)(v\mu - 2f)}{v\mu^2} \quad (35)$$

and

$$\bar{\epsilon} = \frac{v(1 - \mu) + 4f}{2\mu} \ln \left(\frac{v(1 - \mu) + 4f}{(1 + \mu)v} \right) - \frac{2f - v\mu}{\mu}. \quad (36)$$

Proofs of section 3:

We show that for $f > \tilde{f}$ the expected listed prices are higher than expected non-listed prices. In this case for

$$f > \tilde{f} = \frac{v}{4} \left(\sqrt{1 - 4\lambda\mu(1 - \lambda)} + 2\mu(1 - \lambda) - 1 \right) \quad (37)$$

a listing firm draws prices on

$$F_1(p) = \frac{f(v + p) - vp\mu(1 - \lambda)}{p(2f - v\mu(1 - \lambda))} \quad (38)$$

for $p \in (\underline{p}_1, v)$. A non-listing firm draws prices on

$$F_0(p) = \frac{(1-\lambda)\mu(pv(1-\mu+\lambda(1-\mu)) - v^2(1-\lambda)(1-\mu) - 2f(v-p))}{4p\lambda f} \quad (39)$$

on $p \in (\underline{p}_0, \underline{p}_1)$ and otherwise, for $p \in (\underline{p}_1, v)$ on

$$F_0(p) = 1 - \left(\frac{\mu v(1-\lambda)^2(v-p)(1-\mu) - 2f(v-p)(\lambda - \mu(1-\lambda))}{4p\lambda f} \right). \quad (40)$$

It suffices to show that $F_1(p) < F_0(p)$ of equations (38) and (40) because for $F_0(p)$ of equation (39) it holds that $F_1(p) = 0$. It follows that

$$F_0(p) - F_1(p) = \frac{(1-\lambda)(v-p)\mu(4f^2 + 2vf((1-2\mu(1-\lambda))) - \mu v^2(1-\lambda)^2(1-\mu))}{4p\lambda f(v\mu(1-\lambda) - 2f)} > 0 \quad (41)$$

for $f > \tilde{f}$, $\lambda \in (0, 1)$, and $\mu \in (0, 1)$. Hence, it follows that $E(p_1) > E(p_0)$.

We next show that the regulated expected prices are strictly lower than expected non-listed prices. This is again shown by using the criterium of first-order statistical dominance, with

$$F^{reg}(p) - F_0(p) = \frac{(v-p)[v\mu(1-\mu)(1-\lambda)^2(\lambda(1-\mu)+\mu) + f(2\mu^2 - \lambda(2(1-\mu)+4\mu^2) - \lambda^2(2\mu(1-\mu)))]}{4p\lambda f(\lambda(1-\mu)+\mu)}. \quad (42)$$

It can be observed that $F^{reg}(p) = F_0(p)$ only if $p = v$. Otherwise, from $\underline{p}^{reg} < \underline{p}_0$ it directly holds that $F^{reg}(p) > F_0(p) \forall p$ and $\lambda \in (0, 1)$ and $\mu \in (0, 1)$.

A listed firm draws prices on $F_1(p)$ of equation (28) or (29). In the latter case it holds that

$$F^{reg}(p) - F_1(p) = \frac{f(p(1+\lambda+\mu(1-\lambda)) - v(1-\lambda)(1+\mu))}{p((v\mu(1-\lambda) - 2f)(\lambda(1-\mu) + \mu))}. \quad (43)$$

Here it can be directly seen that $F^{reg}(p) > F_1(p)$ for any $p < v$ and $f < \hat{f} = \frac{1}{2}v\mu(1-\lambda)$ which necessarily holds because $\phi^* > 0$ (see equation (25)).

For prices $p \in (\underline{p}_1, \underline{p}_0)$ firms draw prices on $F_1(p)$ of equation (29) and it follows that

$$F^{reg}(p) - F_1(p) = \frac{(v-p)(v\mu(1-\mu)(1-\lambda)^2 - 2f)}{2p((\mu(1-\lambda) - 2f)(\lambda(1-\mu) + \mu))} \geq 0. \quad (44)$$

It follows that $F^{reg}(p) > F_1(p)$ only if $f > \frac{1}{2}v\mu(1-\lambda)^2(1-\mu)$. In the other case, it can be numerically shown that there are instances where $E(p)^{reg} > E_1(p)$. This is especially true if only few consumers subscribe, i.e., if μ is low.

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