15/21

ARBEIDSNOTAT
WORKING PAPER

The influence of media attention on retail price competition

Derek Clark
Øystein Foros
Hans Jarle Kind

SNF

Samfunns- og næringslivsforskning AS
Centre for Applied Research at NHH

SNF
SAMFUNNS- OG NÆRINGSLIVSFORSKNING AS

- er et selskap i NHH-miljøet med oppgave å initiere, organisere og utføre ekstern-finansiert forskning. Norges Handelshøyskole og Stiftelsen SNF er aksjonærer. Virksomheten drives med basis i egen stab og fagmiljøene ved NHH.

SNF er ett av Norges ledende forskningsmiljø innen anvendt økonomisk-administrativ forskning, og har gode samarbeidsrelasjoner til andre forskningsmiljøer i Norge og utlandet. SNF utfører forskning og forskningsbaserte utredninger for sentrale beslutningstakere i privat og offentlig sektor. Forskningen organiseres i program-mer og prosjekter av langsiktig og mer kortsiktig karakter. Alle publikasjoner er offentlig tilgjengelig.

SNF
CENTRE FOR APPLIED RESEARCH AT NHH

- is a company within the NHH group. Its objective is to initiate, organize and conduct externally financed research. The company shareholders are the Norwegian School of Economics (NHH) and the SNF Foundation. Research is carried out by SNF's own staff as well as faculty members at NHH.

SNF is one of Norway's leading research environment within applied economic administrative research. It has excellent working relations with other research environments in Norway as well as abroad. SNF conducts research and prepares research-based reports for major decision-makers both in the private and the public sector. Research is organized in programmes and projects on a long-term as well as a short-term basis. All our publications are publicly available.

SNF Working Paper No. 15/21

The influence of media attention on retail price competition

Derek Clark
Øystein Foros
Hans Jarle Kind

SNF Project No. 10052:
Media competition and media policy

The project is financed by the Research Council of Norway

CENTRE FOR APPLIED RESEARCH AT NHH
BERGEN, DECEMBER 2021
ISSN 1503-2140

The influence of media attention on retail price competition

Derek Clark
School of Business and Economics, UiT - The Arctic University of Norway
derek.clark@uit.no.

Øystein Foros
NHH Norwegian School of Economics
oystein.foros@nhh.no

Hans Jarle Kind
NHH Norwegian School of Economics
hans.kind@nhh.no

December 2021

Abstract: Media attention on price differences between firms is common, e.g., media comparisons of supermarket grocery prices. We consider the effect of such comparisons on competition between sellers in a simple two-period spatial model. When some consumers are uninformed about current prices, media price comparisons provide information which can directly intensify competition. Furthermore, firms that do well in price comparisons can experience an increase in demand for their product over time; to what extent they reap the rewards of this by increasing prices in the future, depends on how likely they regard further price comparisons. Current media attention thus has a contemporaneous effect and an intertemporal one. Each firm is aware of this, and takes into account that due to media attention, an aggressive pricing policy may have effects similar to informative advertising in the current period and to persuasive advertising in the future. We seek to disentangle these effects on price competition in a model where media attention takes place stochastically, and in which some consumers are initially uniformed and sellers can initially have different reputations for adopting a low-price profile. Moreover, we present conditions under which media attention creates a snowball effect in which the current winner remains a low-price seller over time, and under which the victor will be expected to alternate. Both patterns are observed in practice.

1 Introduction

Rankings of prices and qualities of products from competing firms are given a lot of media coverage. Examples are reviews of movies, restaurants, and wine as well as comparisons of supermarket prices.[1] By their very nature, the media zooms in on product attributes about which a large fraction of the consumers has incomplete information. Our focus is on third-party (media) price comparisons, for example of supermarket prices, where it is difficult for consumers to attain complete information since there are many items, and prices may change frequently.

If consumers possess complete information about all product attributes, no one will give attention to media coverage that compares such products. Consequently, consumer ignorance is the fuel that fans the flames of attention from the media. In turn, such comparisons affect firms' competitive behavior. When third-party comparisons inform ignorant consumers about current prices, and ranks the firms according to how cheap they are, competition may be intensified. This resembles the effect of informative advertising (see Stigler, 1961, and a number of subsequent papers on informative advertising).[2] It is also commonly observed that the "winner" of a price comparison uses the result intensively in its own advertising for extended periods; the aim of such advertising campaigns is presumably to persuade consumers that it continues to be the firm with the lowest prices. The information value of such campaigns is limited, though: firms typically do not make any price commitment (neither absolutely nor relative to their competitors), so they are free to change their prices after the media has published the comparison. These campaigns can thus be characterized as persuasive advertising (Dixit and Norman, 1978, is the seminal

[1] Horverak (2009) analyzes how media reviews affect the sales of wine in Norway and shows that a 10% rise in newspapers' scores causes an increase in sales of 16%–18%. Friberg and Grönqvist (2012) show that a favorable expert wine review increases demand by 6% in Sweden, in the week after the review is published. In an experimental study, Hilger et al. (2011) show that if ratings are posted on the shelves for a random selection of wine, a good review increases sales. Chen et al. (2012) show how prerelease movie reviews affect demand and financial value. After the release date, the impact from reviews disappears since sales information is available for consumers and investors (see also Eliashberg and Shugan, 1997; Reinstein and Snyder, 2005, among others).

[2] In the absence of media comparisons (or other types of third-party comparisons), firms face a credibility problem when they publish their own comparison advertisements. This credibility problem is solved if the comparisons are undertaken by a third-party like the media (Van Heerde, Gijsbrechts, and Pauwels, 2015).

paper on persuasive advertising).

In this paper, we do not model advertising per se. However, we show that if a media price comparison is expected to take place, each firm may have incentives to set significantly lower prices than the one that would maximize profit in the present period, in order to increase expected future demand. Such a low-price investment is rational if, until the next price comparison is published, at least a subset of the consumers believes that the ranking holds. In this sense an investment in low prices serves the same purpose as persuasive advertising. Put differently, when the outcome of media price comparisons affects consumer price perception, a low price today becomes an investment that may increase future demand.

To capture these effects, we set up a theoretical model of spatial competition (Hotelling, 1929) where firms compete over two periods. A fraction of the consumers is uninformed about prices but will be fully informed about the current period's prices if a random media price comparison takes place. The higher the probability of a comparison, the more intensified is competition from the informative advertising effect. This is the contemporaneous effect of the media attention.

The two-period set up allows us to analyze competition when uninformed consumers carry the first period learned information to the second period if a media comparison takes place in the first period (but not in the second). A firm may then be able to create a favorable price impression among uninformed consumers by setting a low price in the first period. A media comparison thus has an intertemporal persuasive advertising effect on competition in the second period, implying that a low price in the first period is an investment that increases expected demand in the second. While the intertemporal effect causes firms to reduce prices in the first period, the winner of a comparison has incentives to set a higher price in the second period, to harvest on the investment (the low price) from the first period.

In the literature on informative advertising, a higher degree of consumer ignorance (more uninformed consumers) typically increases prices and reduces competition. In contrast, we show that an increase in consumer ignorance, in the sense that a larger fraction of consumers has incomplete information about firms' prices, may decrease equilibrium prices and profits in the first period (but increase them in the second period). The driving force is the intertemporal persuasive advertising effect.

We present two versions of our model. The baseline model is one in which firms are symmetric, so that - in the absence of a price comparison - uninformed consumers expect them to set identical prices. Price in the first period is lower the more likely is a price comparison in that period, and the less likely a comparison is carried out subsequently. A high probability of a media price comparison in the first period gives the firms less scope to exploit the uninformed customers, driving the price down; furthermore, if there is a small chance that there will be a comparison in the next period, these same consumers become locked into their low-price expectations, increasing their second-period demand. This intensifies the firms' incentives to set a low price in the first period. Similarly, in the second period, the contemporaneous effect of a price comparison disciplines the firms. However, the higher the degree of consumer ignorance, the larger will be the intertemporal effect if there is no price comparison; this tends to increase price in the second period.

We extend the baseline model by allowing uninformed consumers to hold different initial beliefs about the prices that the firms will set.[3] More specifically, we assume that one of the firms has a reputation for having a lower price than the rival in the sense that uninformed consumers expect that retailer to sell the product cheaper than the other. This expectation is given outside of the model, and can be based on previous experience for example, or an earlier price comparison; this allows us to see how a reputation for a low/high-price profile affects the firms' pricing decisions in the intertemporal model with random media price comparisons. The results show that the firm that is expected to set a high price compensates for this by undercutting the rival in the first period; expected media attention - in either period - serves to dampen the price difference. This undercutting behavior extends to the second period if consumers have retained their initial price expectation, i.e., when there has not been a media price comparison in period one.

The seller that is initially expected to set a high price has the potential to reap an intertemporal reward if there has been a price comparison in period one; it sets a low price in the first period to overcome its handicap, and can then set a high price in the next period since a media comparison locks the uninformed consumers into their "low-price" expectation. However, the firm resists this action if there is a large enough possibility of a media price comparison in period two, and can find it optimal to set a lower price than the (expected low-price) rival also in the second period; a low chance of being "exposed" by

[3] This encompasses the baseline model as a special case.

the media gives a high second-period price. Hence, our model can explain observations in which the winner of media price comparisons alternates between periods, and in which the same firm prevails in comparisons over time. The latter would imply that media attention leads to a type of snowball-effect. Our model identifies the factors that can potentially contribute to this effect, as well as those that prevent it from happening. The overall picture is quite nuanced.

The motivation behind our model is retail grocery markets, where evidence shows that media price comparisons affect competitive behavior. Ater and Rigbi (2020) empirically analyze the effects of the introduction a public price portal, where all prices, for all chains, are available in the Israeli grocery market after 2015. Consumers use the portal to a very limited extent. Nevertheless, price competition has been intensified with prices being reduced by 4-5%. According to Ater and Rigbi (2020), the reason is the role of the media who use the portal as an input to provide price comparisons.[4] These (third-party) media price comparisons affect consumers' price perception, and the chains compete harder to perform well on these comparisons. When a chain performs well in media price rankings, it uses the results heavily in its own marketing. In Israel, price has become a more salient attribute in the market, and chains have increased their focus on adopting a low-price profile. The findings of Ater and Rigbi (2020) provide evidence for both the informative and persuasive advertising effects present in our model.

Media price rankings also play a large role in Norway, where the largest newspaper VG has published random comparisons of grocery supermarket prices for more than 20 years. For the chains with a low-price profile, their position on VG's price comparison is important for consumers' perception of price. Figure 1 shows the ranking of the grocery chains on VG's price comparisons from 2010 to 2021.

[4] Interestingly, similar results were found in experimental studies in North American grocery markets 30 years ago. For treatment cities grocery prices were published in media (printed newspapers), while prices were not published in control cities. Media attention lowered prices (Devine and Marion, 1979; Boynton et al., 1983; McCracken et al., 1982).

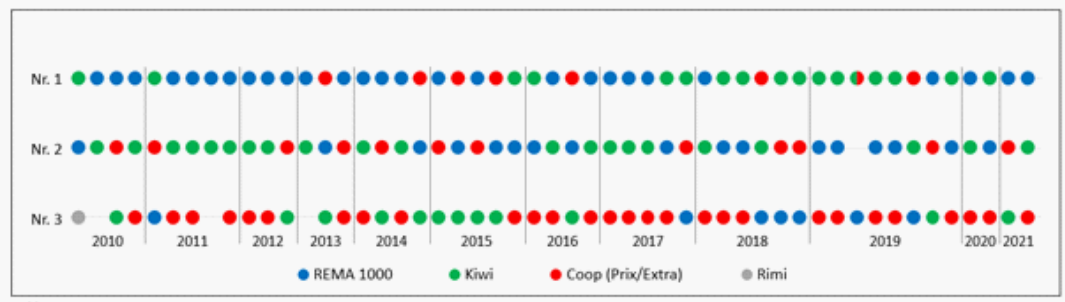

Figure 1: *Ranking of Norwegian grocery chains on VG's price comparison from January 2010 to September 2021. Source: VG.*

The Norwegian case is interesting because of a history of more than 20 years. The fact that VG has published price comparisons over such a long period, also after transitioning to a predominantly online newspaper, strongly indicates reader attention. VG invests a lot of resources in making the price comparisons random for the grocery chains with respect to timing and items included.[5] In turn, this affects competitive behavior. In particular, the low-price chains Rema 1000, Kiwi, and Coop Extra, have focused attention on their position in VG's price comparison. When VG's comparison was introduced in 2000, Rema 1000 was the only chain with a distinct low-price profile. In a feature article in another Norwegian newspaper in 2017, Rema's CEO (Tom Kristiansen) said the following about the introduction of VG's price comparison: "A highlight in Rema's story [...] the whole front page of VG. You can't get better marketing" (Dagens Næringsliv, 2017).

As in Israel, a victory on VG's price comparison is used for months in own advertising. As an example, in early September 2021, Rema 1000 was the winner of VG's price comparison (the latest comparison presented in Figure 1). For more than a month, Rema has instigated a massive advertising campaign with the message that "Rema is the winner of VG's price comparison". This clearly indicates an intertemporal persuasive advertising effect, as in our model. The outcome of VG's price comparison in early September hardly entails any informative advertising effect in late October.[6]

[5] To gain a better understanding, two master students at the NHH Norwegian School of Economics (Halvor Helgø and Thea Kilstad) undertook a semi-structured interview with VG. The interview revealed that VG focuses on picking items that are important for consumers, but at the same time make both the timing and selection of items as random as possible for the grocery chains.

[6] Seaton and Waterson (2013) emphasize how UK grocery supermarkets focus attention on their position in third-party price comparisons.

A driving force in our model is the probability that a media price comparison occurs. Alternatively, this may be interpreted as a measure of expected attention in the media on firms' prices. Van Heerde et al. (2015) use data of a price war between Dutch supermarkets, and show that such price wars trigger media coverage, and in turn, media coverage triggers more aggressive competition and further price cuts. After a while, the news value erodes. Media coverage becomes less frequent, and the downward price cut spiral slows down. This evidence is consistent with the predictions from our model.

The rest of this paper is organized as follows. Section 2 puts our work into the context of related literature. The model with symmetric firms is analyzed in Section 3, and Section 4 presents an extension in which firms initially differ in their reputation for a low-price profile. Section 5 concludes.

2 Literature review

Consumer ignorance has a significant impact on competitive pricing behavior. If consumers have perfect information, and firms produce homogenous products with constant marginal costs, we have marginal cost pricing according to the Bertrand paradox. In contrast, where consumers sequentially search for information about prices at a positive cost, the outcome is monopoly pricing (Diamond, 1971). A third-party, such as a media that informs ignorant consumers, may consequently significantly affect competitive pricing behavior. A comprehensive literature shows how a decrease in the cost of informative advertising (or consumer search costs) may intensify competition (Stigler, 1961; Salop and Stiglitz, 1977; Grossman and Shapiro, 1984; and Robert and Stahl, 1993, among others).[7] Of particular relevance is Robert and Stahl (1993), who show that consumer ignorance may be reduced through consumer searching or informative advertising.

Within the literature on advertising there is typically a distinction between informative and persuasive advertising (see Bagwell, 2007, and Renault, 2015, for surveys).[8] Persuasive advertising implies that advertising alters consumer preferences (Dixit and Norman, 1978). How much consumers' preferences are affected by advertising is typically assumed

[7] Janssen and Non (2009) show that firms may find it profitable to announce prices that are higher than prices for non-announced products when consumers search for firms that carry a given product.

[8] See Graf-Vlachy et al., (2020) for a survey of the literature within management, marketing, finance, and accounting.

to depend on psychological factors exogenous to the model. A crucial feature of firms' responses to (expected) media comparisons is that, in addition to the informative advertising effect, there may be an intertemporal persuasive advertising effect since the outcome of a price ranking may form ignorant consumers' expectations in subsequent periods (until the next comparison takes place). The intertemporal persuasive effect resembles vertical quality differentiation. If perceived quality of one product increases, the demand for that product increases (Shaked and Sutton, 1982). Chen and Xie (2008) set up a monopoly model with both vertical and horizontal differentiation and show the difference between third-party reviews and consumer reviews. The intertemporal mechanism in our model has some similarities with Haan and Moraga-González (2011), who analyze how a firm through advertising may achieve a more salient place in consumer memories. Consequently, consumers visit the firm sooner than the rival.

As in Grossman and Shapiro (1984), among others, we use the spatial competition framework of Hotelling (1929). With respect to consumer information, as found in Salop and Stiglitz (1977) for example, we assume that consumers have perfect information about firms' locations and the qualities of products offered, while not all consumers have perfect information about firms' prices. Salop and Stiglitz (1977) assume that consumers may generate perfect information through a search cost, while in our model perfect information is revealed if a random media price comparison takes place. Hence, our model differs from the literature purporting that consumer search or informative advertising are necessary to ensure that consumers are aware of a product (e.g., Grossman and Shapiro, 1984).[9]

Media attention towards prices can make price a more salient attribute. Analogously, the Michelin restaurant guide draws attention towards quality. Since consumer ignorance with respect to a given attribute is the main ingredient that triggers media attention, the most salient attribute may be the one where consumers at the outset have incomplete information. Firms may choose their most salient attribute endogenously (Bordalo et al., 2016), but media attention may – exogenously from the firms' perspective - move attention

[9] In our set-up a media price comparison will unambiguously be negative for a firm that does not perform well. In contrast, if consumers are not aware of the location or the existence of a firm, even bad reviews may improve profit. Berger et al. (2010) analyze the book publishing market, and find that for a rather unknown author, even negative media coverage may increase sales, since also bad coverage increases consumer awareness.

towards a given attribute. More focus on price from the firms themselves as well as the media may make price a more salient attribute for consumers (Van Heerde et al., 2008, 2015). The choice of profile is outside the scope for the present paper, but it is striking that both in Israel and Norway - the examples used in the introduction - the market shares of low-price chains have increased as media price comparisons have become more important.

3 The model

We consider spatial competition between two intrinsically symmetric firms in a retail consumer market. The firms compete over two periods, $T = 1, 2$, and consumers have no ability to store goods from period one to period two. Consumers have unit demand each period.

The most crucial assumptions describe consumers' beliefs about firms' prices. We make the following assumptions:

Assumption 1: At the outset, a fraction $\alpha \in [0, 1]$ of the consumers has perfect information about the actual price p_{iT} that firm i charges in period T, and a fraction $(1 - \alpha)$ of the consumers forms an expectation $\overline{p}^e_{iT}$ about the price from firm i in period T. It follows that the "average" consumer's best estimate of the price level at firm i is

$$p^e_{iT} = \alpha p_{iT} + (1 - \alpha)\, \overline{p}^e_{iT} \tag{1}$$

Assumption 2: A third-party, hereafter termed "the media", might undertake comparison surveys on firms' prices. If a price comparison is published in period T, all consumers know the exact price level at each firm in that period, such that $p^e_{it} = p_{it}$. With a slight abuse of language, we shall label the consumers who do not have perfect information unless a media test is published as uninformed consumers.

In the literature on informative advertising, consumers may generate perfect information about prices through incurring search cost or the firms themselves may collect information and use this information in informative advertising (Stigler, 1961; Salop and Stiglitz, 1977; Robert and Stahl, 1993; and subsequent papers). In contrast, in our set-up, perfect information is revealed in the current period if a third-party (media) comparison takes place. In period T, the firms first set their prices; then the media undertakes a price comparison

with some positive probability, and any new information is revealed to consumers prior to their purchase decision in that period.

In the basic model, we further make the following assumption (which we later relax):

Assumption 3: Firms are intrinsically symmetric, and the consumers expect the firms to charge identical prices ($\bar{p}^e_{iT} = \bar{p}^e_{jT}$) if there has been no price comparison in either period. If there is a price comparison in period 1 but not in period 2, the uninformed consumers expect the same prices to hold also in period 2, $\bar{p}^e_{i2} = p_{i1}$,with $\bar{p}^e_{i2} \neq \bar{p}^e_{j2}$ if the firms charged different prices in period 1.

We apply the spatial competition model by Hotelling (1929), used to analyze informative advertising by Grossman and Shapiro (1984), among others. Firm 0 is located at the far left on the Hotelling line $(X_0 = 0)$ and firm 1 at the far right $(X_1 = 1)$. The consumers have perfect information about firms' locations and the (vertical) quality of the firms' products. The mismatch cost (transportation cost) for a consumer located at x of buying good i equals $t\,|X_i - x|$, where X_i is the location of firm i and $t > 0$. The expected net utility of buying from firm i in period T for a consumer located at x is given by

$$U^e_i = v - t\,|X_i - x| - p^e_{iT}, \tag{2}$$

where $p^e_{iT} = \alpha p_{iT} + (1-\alpha)\,\bar{p}^e_{iT}$ is given from (1). Throughout, we restrict attention to outcomes where the market is covered (all consumers buy from one of the firms) and both firms have strictly positive sales (market sharing).

3.1 Demand and profit

First, let us consider the case where a media price comparison takes place in period T, such that $p^e_{iT} = p_{iT}$. Solving for the indifferent consumer, $U_0(x) = U_1(x)$, we then find that demand for good i in period T equals

$$D^{P_T}_{iT} = \frac{1}{2} - \frac{p_{iT} - p_{jT}}{2t}, \tag{3}$$

where the superscript P_T denotes that a price comparison has taken place in period T.

Next, suppose that no price comparison takes place in period T (superscript NP_T). Both the informed and uninformed consumers are uniformly distributed along the Hotelling line.

The demand that firm i faces from the informed and the uninformed consumers is thus $\alpha\left(\frac{1}{2}-\frac{p_{iT}-p_{jT}}{2t}\right)$ and $(1-\alpha)\left(\frac{1}{2}-\frac{\overline{p}^e_{iT}-\overline{p}^e_{jT}}{2t}\right)$, respectively. Total demand for firm i is thereby

$$D^{NP_T}_{iT}=\frac{1}{2}-\alpha\frac{p_{iT}-p_{jT}}{2t}-(1-\alpha)\frac{\overline{p}^e_{iT}-\overline{p}^e_{jT}}{2t}. \tag{4}$$

Recall that when the firms set prices for period T, they do not know whether the media will publish a price comparison. Letting ρ_T denote the probability that a price test will be published in period T, and normalizing all marginal costs to zero, firm i's expected profit in that period can be written as

$$\pi_{iT}=p_{iT}\left[\rho_T D^{P_T}_{iT}+(1-\rho_T)\,D^{NP_T}_{iT}\right]. \tag{5}$$

3.2 Period 2 equilibrium

We solve the game by using backward induction, and so start with period $T=2$. Differentiating (5) with respect to p_{i2} we find[10]

$$\frac{\partial\pi_{i2}}{\partial p_{i2}}=\left[\rho_2 D^{P_2}_{i2}+(1-\rho_2)\,D^{NP_2}_{i2}\right]+p_{i2}\left[\rho_2\frac{\partial D^{P_2}_{i2}}{\partial p_{i2}}+(1-\rho_2)\,\frac{\partial D^{NP_2}_{i2}}{\partial p_{i2}}\right], \tag{6}$$

where

$$\frac{\partial D^{P_2}_{i2}}{\partial p_{i2}}=-\frac{1}{2t}\text{ and }\frac{\partial D^{NP_2}_{i2}}{\partial p_{i2}}=-\frac{\alpha}{2t}. \tag{7}$$

From (6) and (7) we can derive (measured at a symmetric situation in which $p_{i2}=p_{j2}$, and $\overline{p}^e_{iT}=\overline{p}^e_{jT}$)

$$\left.\frac{\partial^2\pi_{12}}{\partial\alpha\partial p_{i2}}\right|_{sym}=-\frac{p_{i2}}{2t}(1-\rho_2)<0\text{ and }\left.\frac{\partial^2\pi_{12}}{\partial\rho_2\partial p_{i2}}\right|_{sym}=-\frac{p_{i2}}{2t}(1-\alpha)<0. \tag{8}$$

The equations in (8) indicate that firm i will charge a lower price the greater the number of informed consumers ($\partial^2\pi_{12}/\partial\alpha\partial p_{i2}<0$) and the greater the probability that a price test takes place ($\partial^2\pi_{12}/\partial\rho_2\partial p_{i2}<0$). Intuitively, the reason is that a price increase in period 2 does not affect the *a-priori* price expectations of the uninformed consumers, and therefore not their demand either unless a price comparison has been published; this is why equation (7) shows that $\left|\partial D^{P_2}_{i2}/\partial p_{i2}\right|\geq\left|\partial D^{NP_2}_{i2}/\partial p_{i2}\right|$.

We can state:

[10] The second-order condition is satisfied: $2\left[\rho_2\frac{\partial D^{P_2}_{i2}}{\partial p_{i2}}+(1-\rho_2)\,\frac{\partial D^{NP_2}_{i2}}{\partial p_{i2}}\right]=-\frac{1}{t}\left[\rho_2+(1-\rho_2)\,\alpha\right]<0.$

Lemma 1: *Other things equal, the firms charge lower prices in period 2 the greater the probability of a price comparison in that period (ρ_2) and the greater the fraction of informed consumers (α).*

From (6) we find the reaction functions in $T = 2$:

$$p_{i2}(p_{j2}) = \frac{1}{2}p_{j2} + \frac{t}{2\left(\alpha + \rho_2\left(1-\alpha\right)\right)} - \left(1-\rho_2\right)\left(1-\alpha\right)\frac{\overline{p}^e_{i2} - \overline{p}^e_{j2}}{2\left(\alpha + \rho_2\left(1-\alpha\right)\right)} \tag{9}$$

The first term on the right-hand-side of (9) verifies that prices are strategic complements, while the second term, in accordance with Lemma 1, shows that the reaction function shifts downward if α or ρ_2 increase. The third term is the most interesting one. To see what it tells us, suppose that there was a price comparison in period 1. Then we have $\overline{p}^e_{i2} = p_{i1}$ and $\overline{p}^e_{j2} = p_{j1}$ for the uninformed consumers (from Assumption 2). Consequently, if firm i won the price comparison in period 1 ($p_{i1} - p_{j1} < 0$), there will be an upward shift in the reaction function of firm i in $T = 2$. This reflects the fact that if the media revealed that firm i charged a lower price than its rival in period 1, firm i will face a higher demand from the uninformed consumers in period 2. This makes it optimal to charge a higher price. Note that the price increase will be larger the less likely it is that a new price comparison will be published in period 2.

Solving the reaction function in (9) simultaneously for the two firms, we find the equilibrium prices in $T = 2$:

$$p^*_{i2} = \frac{t}{\alpha + \rho_2\left(1-\alpha\right)} - \left(1-\alpha\right)\left(1-\rho_2\right)\frac{\left(\overline{p}^e_{i2} - \overline{p}^e_{j2}\right)}{3\left(\alpha + \rho_2\left(1-\alpha\right)\right)}. \tag{10}$$

Suppose that no price comparison has taken place in period 1 (we use superscript NP_1 for this case below). Since the firms are intrinsically symmetric, the uninformed consumers then expect the firms to charge identical prices in period 2 (c.f. Assumption 2), $\overline{p}^e_{i2} = \overline{p}^e_{j2}$. Equation (10) thus simplifies to:

$$p^{NP_1}_{i2} = \frac{t}{\alpha + \rho_2\left(1-\alpha\right)}. \tag{11}$$

Whether a price comparison takes place in period 2 does not matter for the equilibrium price, since the firms have already set their prices. However, as we should expect from Lemma 1, the equilibrium price $p^{NP_1}_{i2}$ is decreasing in the probability of a price test in that period ($dp^{NP_1}_{i2}/d\rho_2 < 0$) and the fraction of uninformed consumers ($dp^{NP_1}_{i2}/d\alpha < 0$).

Since the firms will serve half the market each, it follows immediately from (11) that each firm's profit in period 2 is equal to

$$\pi_{i2}^{NP_1} = \frac{t}{2\left(\alpha + \rho_2\left(1-\alpha\right)\right)}. \tag{12}$$

Let us now assume that a price comparison did take place in period 1 (superscript P_1). From (10) and Assumption 2 we then find that the equilibrium price in period 2 is

$$p_{i2}^{P_1} = \frac{t}{\alpha + \rho_2\left(1-\alpha\right)} - \left(1-\alpha\right)\left(1-\rho_2\right)\frac{p_{i1}-p_{j1}}{3\left(\alpha + \rho_2\left(1-\alpha\right)\right)}. \tag{13}$$

Again, it does not matter for the equilibrium price in period 2 whether there actually is a price comparison in that period. The probability of a price comparison in $T = 2$, i.e., ρ_2, still plays a role, since firms when they set their prices in period 2 do not know if such a comparison will takes place. However, if the media has published a price comparison in $T = 2$, all consumers know the true prices when they make their purchasing decisions in that period.

Comparing (12) and (13), it is clear that the price comparison in period 1 introduces a price adjustment in period 2 given by

$$-\left(1-\alpha\right)\left(1-\rho_2\right)\frac{p_{i1}-p_{j1}}{3\left(\alpha + \rho_2\left(1-\alpha\right)\right)}.$$

If firm i has set the largest price in period 1, any ensuing media price comparison will lead that firm to set a lower price than the rival in $T = 2$; the rival sets a correspondingly higher price in period 2. The absolute size of the adjustment induced by the first period media price comparison is decreasing in both α and ρ_2. The lesser the fraction of informed buyers, the larger is the effect on period 2 prices of a media price comparison in period 1. A large probability of information being revealed in the second period through a price comparison reduces the effect that a previous price comparison has on price in $T = 2$.

Inserting (13) into equation (3) we find that firm i faces demand equal to

$$D_{i2}^{P_2} = \frac{1}{2} + \frac{\left(1-\alpha\right)\left(1-\rho_2\right)\left(p_{i1}-p_{j1}\right)}{3t\left(\alpha + \rho_2\left(1-\alpha\right)\right)}, \tag{14}$$

from which we note that $D_{i2}^{P_2} < 1/2$ if firm i sets a lower price than firm j in period 1; this follows from (13).

If no price comparison has been performed in period 2, the combination of (4) and (13) implies that

$$D_{i2}^{NP_2} = \frac{1}{2} - \left(1-\alpha\right)\frac{\alpha + \left(3-\alpha\right)\rho_2}{6t\left(\alpha + \left(1-\alpha\right)\rho_2\right)}\left(p_{i1}-p_{j1}\right), \tag{15}$$

which means that $D_{i2}^{NP_2} > 1/2$ if firm i sets a lower price than firm j in period 1. Even though firm i charges a higher price than its rival in period 2 if it charged a lower price in period 1, it will thus increase its price so little that the sales reduction to the informed consumers is smaller than the sales expansion to the uninformed consumers. Equations (14) and (15) thus reveal that the effect of price changes in period 1 has qualitatively different effects on demand, depending on whether the media publishes a price comparison in period 2:

Lemma 2: *Suppose that a price comparison*

a) is published in period 2. Then firm i's second period sales are increasing in own first-period price ($\partial D_{i2}^{P_2}/\partial p_{i1} > 0$), and decreasing in the rival's first-period price ($\partial D_{i2}^{P_2}/\partial p_{j1} < 0$).

b) is not published in period 2. Then firm i's second period sales are decreasing in own first-period price ($\partial D_{i2}^{NP_2}/\partial p_{i1} < 0$), and increasing in the rival's first-period price ($\partial D_{i2}^{NP_2}/\partial p_{j1} > 0$.

Even though a firm's first-period price has an ambiguous effect on actual demand in period 2, a firm can boost its *expected* second-period sales (D_{i2}^{e}) by reducing its first-period price:

$$D_{i2}^{e} = \rho_2 D_{i2}^{P_2} + (1-\rho_2) D_{i2}^{NP_2} = \frac{1}{2} - \frac{(1-\alpha)(1-\rho_2)(p_{i1}-p_{j1})}{6t} > \frac{1}{2} \text{ if } p_{i1} < p_{j1}.$$

If firm i won the price comparison in period 1, it will consequently have such a good grip on the uninformed consumers if no price comparison is published in period 2 that it expects to sell more than its rival in that period even though it charges a higher price:

Lemma 3: *The lower the price firm i charges relative to its rival in period 1, the greater its expected demand in period 2.*

Using (13), (14) and (15) we find that firm $i's$ expected profit in period 2 if the media published a price comparison in period 1 is equal to

$$\pi_{i2}^{P_1} = \frac{\left[3t - (1-\alpha)(1-\rho_2)(p_{i1}-p_{j1})\right]^2}{18t\left(\alpha + (1-\alpha)\rho_2\right)} \tag{16}$$

3.3 Period 1 equilibrium

Firm i's instantaneous profit in period 1 equals

$$\pi_{i1} = p_{i1}\left[\rho_1 D_{i1}^{P_1} + (1-\rho_1) D_{i1}^{NP_1}\right]. \tag{17}$$

Inserting from (3) and (4) into (17), and using that the firms are intrinsically symmetric, we have

$$\frac{\partial \pi_{i1}}{\partial p_{i1}} = \frac{1}{2} - \frac{\alpha + (1-\alpha)\rho_1}{2t} p_{i1}. \tag{18}$$

If there were no connections between the periods, the optimal price could be found by solving $\partial \pi_{i1}/\partial p_{i1} = 0$ (which would yield $p_{i1} = \frac{t}{\alpha+\rho_1(1-\alpha)}$). However, with probability ρ_1 there is a price comparison in period 1, in which case profit in period 2 depends on the prices that the firms charge in period 1. Firm i will therefore choose p_{i1} so as to maximize expected profit over the two periods:

$$\max_{p_{i1}} \Pi_i = \pi_{i1} + \rho_1 \pi_{i2}^{P_1} + (1-\rho_1)\pi_{i2}^{NP_1}. \tag{19}$$

Differentiating (16) with respect to p_{i1} and then imposing symmetry, we have

$$\frac{\partial \pi_{i2}^{P_1}}{\partial p_{i1}} = -\frac{(1-\rho_2)(1-\alpha)}{3(\alpha + (1-\alpha)\rho_2)}. \tag{20}$$

If the media does not publish any price comparison in period 1, the prices that the firms charge in that period will have no effect on the optimal price in period 2 (such that $\partial \pi_{i2}^{NP_1}/\partial p_{i1} = 0$). We thus find the optimal price in period 1 by solving $\partial \Pi_i / p_{i1} = \partial \pi_{i1}/\partial p_{i1} + \rho_1 \partial \pi_{i2}^{P_1}/\partial p_{i1} = 0$. Since $\partial \Pi_i/\partial p_{i1} = \partial \pi_{i1}/\partial p_{i1} + \rho_1 \partial_{i2}^{P_1}/\partial p_{i1} < \partial \pi_{i1}/\partial p_{i1}$, it follows that each firm increases its intertemporal profit by choosing a lower first-period price than the one that maximizes first-period profit. The loss in period 1 from doing this can be considered as an investment that boosts demand and increases expected profit over the two periods:

Remark 1: *Setting a low price in period 1 can be considered as an investment that increases profit through creating a favorable price impression among uninformed consumers (similar to what might be obtained with persuasive advertising).*

Solving $\partial \Pi_i / \partial p_{i1} = 0$ for the two firms, and skipping subscripts, we can write the equilibrium price in period 1 as[11]

$$p^*_{T=1} = t \frac{3\left[\alpha + \rho_2(1-\alpha)\right] - \left[2\left(1-\alpha\right)\left(1-\rho_2\right)\right]\rho_1}{3\left[\alpha + \rho_1\left(1-\alpha\right)\right]\left[\alpha + \rho_2\left(1-\alpha\right)\right]}. \tag{22}$$

Positive price in the first period is guaranteed for

$$\rho_1 < \rho_1^{crit} \equiv \frac{3\left[\alpha\left(1-\rho_2\right) + \rho_2\right]}{2\left(1-\rho_2\right)\left(1-\alpha\right)}. \tag{23}$$

If the probability of a price comparison is greater than ρ_1^{crit}, each firm will have so strong incentives to stimulate expected demand in period 2 that it is willing to charge a price below marginal costs in period 1. For $\rho_1 > \rho_1^{crit}$, the equilibrium can be found by recalculating the maximization problems above under the constraint that $p^*_{T=1} \geq 0$. As this would not yield much extra insight, we simply assume that $\rho_1 < \rho_1^{crit}$.

From equation (22) we find that the price that each firm charges in period 1 is decreasing in the probability of a price comparison that period:

$$\frac{dp^*_{T=1}}{d\rho_1} = -t\left(1-\alpha\right)\frac{5\alpha\left(1-\rho_2\right) + 3\rho_2}{3\left(\alpha + \rho_1\left(1-\alpha\right)\right)^2\left(\alpha + \rho_2\left(1-\alpha\right)\right)} < 0\ . \tag{24}$$

There are two reasons why $dp^*_{T=1}/d\rho_1 > 0$. First, a higher ρ_1 increases the probability that all consumers are fully informed when they make their purchasing decision in period 1. This reduces each firm's incentive to charge a high price. Second, a higher ρ_1 increases the likelihood that the uninformed consumers will become aware of the true market prices, and therefore incentives each firm to charge a lower price than it otherwise would do.

Perhaps more surprising is the fact that market prices in period 1 are increasing in the probability of a price comparison in the next period:

$$\frac{dp^*_{T=1}}{d\rho_2} = \frac{2\left(1-\alpha\right)t\rho_1}{3\left(\alpha + \rho_1\left(1-\alpha\right)\right)\left(\alpha + \rho_2\left(1-\alpha\right)\right)^2} > 0. \tag{25}$$

[11] The second-order condition is

$$2\left(\rho_1\frac{\partial D^{P_1}_{i1}}{\partial p_{i1}} + \left(1-\rho_1\right)\frac{\partial D^{NP_1}_{i1}}{\partial p_{i1}}\right) + \rho_1\frac{\partial^2 \pi^{P_1}_{i2}}{\partial p^2_{i1}} < 0$$

which reduces to

$$-9\left(\rho_1 + \left(1 - P\rho_1\right)\alpha\right)\left(\alpha + \rho_2 - \alpha\rho_2\right) + \rho_1\left(1-\alpha\right)^2\left(1-\rho_2\right)^2 < 0. \tag{21}$$

The intuition for (25) is that the greater the likelihood of a price comparison in period 2, the less likely it is that a firm by charging a low price in period 1 is able to persuade uninformed consumers that it will remain a low-cost firm in the future.

Summing up (24) and (25), we can state:

Proposition 1: *The price that each firm charges in period* 1 *is (i) decreasing in the probability of a price comparison in period* 1 *and (ii) increasing in the probability of a price comparison in period* 2*.*

The following corollary follows from Proposition 1 and the discussion above:

Corollary 1: *With a price comparison in the first period, the uninformed consumers carry the learned first-period price over to the second period as long as* $\rho_2 < 1$*. This effect induces the firms to lower their prices in period 1.*

It is well known from the literature that a higher degree of consumer ignorance typically increases prices. Interestingly, this need not be true in our case. Indeed, the first-period price might fall if the number of uninformed consumers increases. To see this, note that in the neighborhood of $\alpha = 1$ we have:

$$\left.\frac{\partial p^*_{T=1}}{-\partial \alpha}\right|_{\alpha=1} = -t\left(\frac{5-2\rho_2}{3}\right)(\rho_1 - \widehat{\rho}_1),$$

where

$$\widehat{\rho}_1 \equiv \frac{3}{5-2\rho_2}.$$

If the likelihood of a price comparison in period 1 is sufficiently large ($\rho_1 > \widehat{\rho}_1$), the expected demand expansion in period 2 of reducing the price in period 1 thus makes it profitable to lower the price in period 1 if the number of uninformed consumers increases:

Proposition 2: *A small increase in consumer price ignorance around* $\alpha = 1$ (*i.e.* α is *slightly reduced below 1) decreases the equilibrium price and profit in period* $T = 1$ *if* $\rho_1 > \widehat{\rho}_1$*.*

Figure 2 illustrates the result in Proposition 2, but extends it to cover the whole range $\alpha \in [0, 1]$. For $\rho_1 = 1/5$ (low probability that the media publishes a price comparison in period 1) we have the standard result that the first-period price is decreasing in the number

of informed consumers. However, for $\rho_2 = 4/5$ (high probability of a price comparison), the price is increasing in the number of informed consumers.

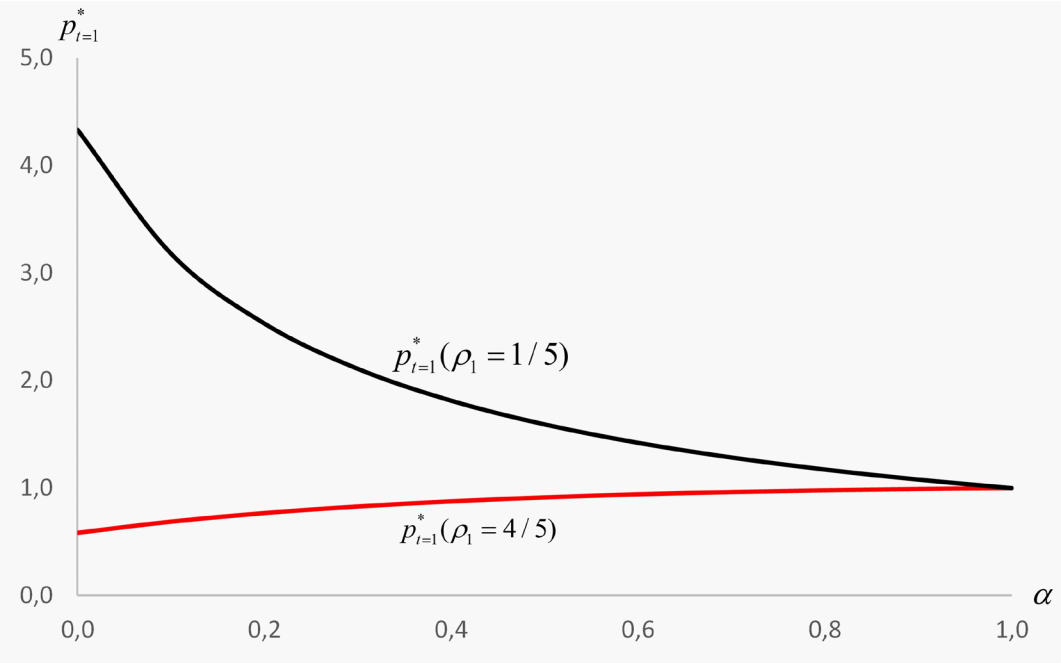

Figure 2: *Prices in the first period.*

In a symmetric equilibrium we have $p_{i1} = p_{j1}$. Equations (12) and (16) therefore imply that $p_{i2}^{P_1} = p_{i2}^{NP_1}$, such that the equilibrium price in period 2 is independent of whether a price comparison took place in period 1:

$$p^*_{T=2} = \frac{t}{\alpha + \rho_2 (1 - \alpha)}. \tag{26}$$

Since the firms serve half of the market each, we have $\pi^*_{T=1} = p^*_{T=1}/2$ and $\pi^*_{T=2} = p^*_{T=2}/2$.

Equation (26) yields

$$\frac{\partial p^*_{T=2}}{\partial \alpha} < 0 \ , \ \frac{\partial p^*_{T=2}}{\partial \rho_2} < 0 \ \text{ and } \frac{\partial^2 p^*_{T=2}}{\partial \rho_2 \partial \alpha} > 0 \ .$$

We can state:

Proposition 3: *In $T = 2$ (i) Prices increase if consumers become more ignorant (α decreases). (ii) Prices fall if the probability for a media price comparison increases. (iii) An informative media price comparison intensifies price competition, and more so the higher the degree of customer ignorance (the lower α).*

Each consumer buys one unit of either of the goods each period. Consumer utility is therefore directly related to the sum of the prices over the two periods. Above, we saw that the consumers are worse off this period if the probability of future price comparisons increases, but over the lifespan they nonetheless gain from more price comparisons both now and in the future. This follows because

$$\begin{aligned}\frac{d(p^*_{T=1}+p^*_{T=2})}{d\rho_1} &= -t\,(1-\alpha)\,\frac{5\alpha\,(1-\rho_2)+3\rho_2}{6\,(\alpha+\rho_1\,(1-\alpha))^2\,(\alpha+\rho_2\,(1-\alpha))} < 0 \text{ and}\\ \frac{d(p^*_{T=1}+p^*_{T=2})}{d\rho_2} &= -t\,(1-\alpha)\,\frac{3\alpha+\rho_1\,(1-3\alpha)}{6\,(\alpha+\rho_1\,(1-\alpha))\,(\alpha+\rho_2\,(1-\alpha))^2} < 0.\end{aligned}$$

4 Asymmetric price expectations

The previous discussion considers how the proportion of uninformed consumers and the possibility that they become informed by the media effects price setting between two competitors. With full symmetry, prices set by the firms are identical. We now consider how price differences might arise between symmetric firms by dispensing with Assumption 3, and opening up for the possibility that the consumers expect the firms to charge different prices ($\overline{p}^e_{iT} \neq \overline{p}^e_{jT}$). Let $R^e_i = \overline{p}^e_{i1} - \overline{p}^e_{j1}$ define the uninformed consumers' expectation about the price difference between firm i and firm j. When $R^e_i > 0$, firm i has an initial expectation among the uninformed buyers of being a high-price supplier (and a low-price supplier if $R^e_i < 0$); $R^e_i = 0$ is the case of symmetry, which is analyzed above. We restrict attention to cases where $|R^e_i|$ is sufficiently small that each firm will have a positive market share (with non-negative prices). We hold on to the assumption that the firms are intrinsically symmetric (and have the same marginal costs, normalized to zero). However, we shall see that the firms nonetheless might charge different prices in equilibrium if $R^e_i \neq 0$.

Seen from $T = 1$, firm i maximizes the profit function (similar to equation (19))

$$\max_{p_{i1}} \Pi^a_i = \pi^a_{i1} + \rho_1 \pi^{aP_1}_{i2} + (1-\rho_1)\pi^{aNP_1}_{i2},$$

where the a superscript denotes the asymmetric case.

To find firm i's optimal price if the consumers initially expect the firms to charge different prices, we start out by considering second period profit. If the media did not publish any price comparison in period 1, its second-period profit clearly depends on both

the initial price expectation, R_i^e, and on the prices that the firms actually charge. The optimal price in period two is given by equations (10), with $R_i^e = \overline{p}_{i2}^e - \overline{p}_{j2}^e$, and combining this with (3) and (4) we find

$$\pi_{i2}^{aNP_1} = \frac{\left[3t - (1-\alpha)(1-\rho_2) R_i^e\right]^2}{18t\left(\alpha + (1-\alpha)\rho_2\right)}.$$

In absence of public price comparisons, the price that firm i charges in period 1 does not influence the uninformed consumers' beliefs in period 2 about the price differences between the firms . This explains why

$$\frac{\partial \pi_{i2}^{aNP_1}}{\partial p_{i1}} = 0. \tag{27}$$

If a price comparison was published in period 1, the uninformed consumers' initial price expectation R_i^e does not matter for their demand in period 2. This is because the uninformed consumers will have revised their expectations, and believe that the firms will charge the same prices in period 2 as in period 1. We therefore have that $\pi_{i2}^{aP_1} = \pi_{i2}^{P_1}$. The latter is given by equation (16), which we for convenience repeat here:

$$\pi_{i2}^{aP_1} = \frac{\left[3t - (1-\alpha)(1-\rho_2)(p_{i1} - p_{j1})\right]^2}{18t\left(\alpha + (1-\alpha)\rho_2\right)}.$$

We see that

$$\frac{\partial \pi_{i2}^{aP_1}}{\partial p_{i1}} = -(1-\alpha)(1-\rho_2)\frac{\left[3t - (1-\alpha)(1-\rho_2)(p_{i1} - p_{j1})\right]}{9t\left(\alpha + (1-\alpha)\rho_2\right)}, \tag{28}$$

such that a higher price in period 1 reduces firm i's demand and thus profit in period 2 if $p_{i1} > p_{j1}$. The size of the demand reduction is the same as in the case with symmetric expectations; the sign and magnitude of R_i^e plays no role.

Since R_i^e has no effect on either $\partial \pi_{i2}^{aNP_1}/\partial p_{i1}$ or $\partial \pi_{i2}^{aP_1}/\partial p_{i1}$, we can state:

Lemma 4: *Firm i's second-period marginal profit of increasing its first-period price ($\partial \pi_{i2}^{a}/\partial p_{i1}$) is independent of the uninformed consumers' initial price expectation R_i^e.*

Let us now analyze how the consumers' initial price expectations affect firm i's profit in period 1. Expected demand (D_{i1}^e) in period 1 can be decomposed into the demand that arises if there is a public price comparison ($D_{i1}^{P_1}$) that period and the demand that arises if there is no such price comparison ($D_{i1}^{NP_1}$):

$$D_{i1}^{P_1} = \frac{1}{2} - \frac{p_{i1} - p_{j1}}{2t} \text{ and } D_{i1}^{NP_1} = \frac{1}{2} - \alpha\frac{p_{i1} - p_{j1}}{2t} - (1-\alpha)\frac{R_i^e}{2t}.$$

Firm i's first-period profit equals $\pi_{i1}^a = p_{i1}\left(\rho_1 D_{i1}^{P_1} + (1-\rho_1)D_{i1}^{NP_1}\right)$. If firm i were to maximize first-period profit, it would set $\partial \pi_{i1}^{aNP_1}/\partial p_{i1} = 0$. Let $\widehat{p}_{i1}$ and $\widehat{D}_{i1}^e$ be the solution to this optimization problem when $R_i^e = \widehat{R}_i^e$. Now, suppose that R_i^e increases. Other things equal, expected demand for firm i will then fall below the optimal level $\widehat{D}_{i1}^e$. To restore demand at its optimal level, firm i will therefore optimally reduce it price, and set $p_{i1} < \widehat{p}_{i1}$. This indicates that there is negative relationship between firm's i profit maximizing first-period price and the consumers' initial price expectation. To verify this, we note that

$$\begin{aligned}
\frac{\partial \pi_{i1}^a}{\partial p_{i1}} &= \left[\rho_1 D_{i1}^{P_1} + (1-\rho_1)D_{i1}^{NP_1}\right] + p_i \frac{\partial\left(\rho_1 D_{i1}^{P_1} + (1-\rho_1)D_{i1}^{NP_1}\right)}{\partial p_{i1}}. \\
&= \left[\rho_1\left(\frac{1}{2} - \frac{p_{i1}-p_{j1}}{2t}\right) + (1-\rho_1)\left(\frac{1}{2} - \alpha\frac{p_{i1}-p_{j1}}{2t} - (1-\alpha)\frac{R_i^e}{2t}\right)\right] \qquad (29) \\
&\quad -p_i\left(\frac{\rho_1}{2t} + \frac{\alpha(1-\rho_1)}{2t}\right)
\end{aligned}$$

From (29) we find that

$$\frac{\partial}{\partial R_i^e}\left(\frac{\partial \pi_{i1}^a}{\partial p_{i1}}\right) = \frac{-(1-\rho_1)(1-\alpha)}{2t} < 0,$$

which verifies that firm i will increase its first-period profit by reducing p_{i1} if R_i^e increases. The intuition is that demand falls if there is no price comparison and the uninformed consumers expect that firm i's price increases (relative to its rival). However, by responding to this by charging a lower price, firm i will increase demand from the uninformed consumers if a price comparison is published.

We have:

Lemma 5: *Firm i increases its first-period profit (π_{i1}^a) by reducing its first period price p_{1i} if R_i^e increases.*

Summing up, Lemma 4 and Lemma 5 tell us that the marginal profit in period 2 and 1 of increasing p_{i1} is independent of and decreasing in R_i^e, respectively. We can therefore conclude:

Proposition 4: *If the uninformed consumers a priori expect firm i to have a higher price than firm j ($R_i^e > 0$), firm i will set a lower price than firm j in $T = 1$.*

Before we solve for the equilibrium prices in the model, it is worth considering how an increase in p_{j1} affects firm i's pricing incentives

$$\frac{\partial}{\partial p_{j1}}\left(\frac{\partial \Pi_i^a}{\partial p_{i1}}\right) = \frac{\partial}{\partial p_{j1}}\left(\frac{\partial \pi_{i1}^a}{\partial p_{i1}}\right) + \rho_1 \frac{\partial}{\partial p_{j1}}\left(\frac{\partial \pi_{i2}^{aP_1}}{\partial p_{i1}}\right) + (1-\rho_1)\frac{\partial}{\partial p_{j1}}\left(\frac{\partial \pi_{i2}^{aNP_1}}{\partial p_{i1}}\right). \tag{30}$$

We already know from (27) that the last term on the right-hand side of (30) is equal to zero. We further have

$$\frac{\partial}{\partial p_{j1}}\left(\frac{\partial \pi_{i1}^a}{\partial p_{i1}}\right) = \rho_1 \frac{1}{2t} + (1-\rho_1)\frac{\alpha}{2t} > 0. \tag{31}$$

There are two reasons why (31) is positive. First, if firm j increases its first-period price, firm i will observe higher demand in that period, both from the informed and the uninformed consumers if there is a media price comparison in that period. It will also observe higher demand if there is no price comparison in period 1, but then only from the informed consumers. In any case, expected first-period demand for firm i will increase if the rival charges a higher first-period price. This indicates that prices are strategic complements. However, from (28) we have

$$\frac{\partial}{\partial p_{j1}}\left(\frac{\partial \pi_{i2}^{aP_1}}{\partial p_{i1}}\right) = -(1-\alpha)(1-\rho_2)\frac{(1-\alpha)(1-\rho_2)}{9t(\alpha+(1-\alpha)\rho_2)} < 0, \tag{32}$$

which indicates that prices are strategic substitutes if we look at the second-period profit. The explanation is that if firm j increases its first-period price, then the uninformed consumers will carry this price information over to the second period if a price comparison is published in period 1. This results in a lower demand in the second period for firm j than otherwise would be the case. To prevent second-period demand to become unduly low, firm j will therefore have an incentive to reduce its second-period price, which in turn reduces demand for firm i's good (c.f. Lemma 1, which shows that $\partial D_{i2}^{P_2}/\partial p_{j1} < 0$). Other things equal, it will therefore be optimal for firm i to reduce its first-period price as a response to a higher price from firm j. This will be the case if (32) dominates over (31), in which case prices are strategic substitutes.

This analysis helps to explain some of the effects at work in the model. However, whether prices are strategic substitutes or complements is not crucial for what we focus on, and we will therefore not dwell more on this.

We shall now derive equilibrium prices in the two periods when uninformed customers have asymmetric expectations. To most easily see the main economic mechanisms at work,

we here focus on the case where all consumers are uninformed ($\alpha = 0$). Solving $\partial \Pi_i^a / \partial p_{i1} = 0$, and inserting from equations (27), (28) and (29) with $\alpha = 0$, we arrive at the first-order condition

$$\frac{\partial \Pi_i^a}{\partial p_{i1}} = \left(\frac{1}{2} - \frac{2p_{i1} - p_{j1}}{2t} \rho_1 - \frac{1 - \rho_1}{2t} R_i^e \right) - \rho_1 (1 - \rho_2) \frac{3t - (1 - \rho_2)(p_{i1} - p_{j1})}{9t\rho_2} = 0. \quad (33)$$

The second-order condition reads

$$\frac{\partial^2 \Pi_i^a}{\partial p_{i1}^2} = -\frac{N_1}{9t\rho_2} \rho_1 < 0$$

where $N_1 = 11\rho_2 - \rho_2^2 - 1$. The second-order condition ($\partial^2 \Pi_i^a / \partial p_{i1}^2 < 0$) is fulfilled if $N_1 > 0$, i.e. $\rho_2 > \frac{11}{2} - \frac{3}{2}\sqrt{13} \approx 0.0917$.

Solving (33) with respect to p_{i1}, we find firm i's reaction function:

$$p_{i1} = \frac{3(3\rho_2 - 2\rho_1(1 - \rho_2))}{2\rho_1 N_1} t - \frac{9(1 - \rho_1)\rho_2}{2\rho_1 N_1} R_i^e + \frac{13\rho_2 - 2\rho_2^2 - 2}{2N_1} p_{j1}. \quad (34)$$

Stability requires that $|dp_{i1}/dp_{j1}| < 1$. From (34) we find that this holds for $N_2 = 35\rho_2 - 4\rho_2^2 - 4 > 0$, or $\rho_2 > \frac{35}{8} - \frac{3}{8}\sqrt{129} \approx 0.115\,8$.[12] We shall assume that this condition is satisfied (which also ensures that the second-order condition is fulfilled):

Assumption 4: $\rho_2 > \frac{35}{8} - \frac{3}{8}\sqrt{129}$

Relating to our previous discussion, from equation (34) we can note the following:

Remark 2: *First-period prices are strategic substitutes if* $\rho_2 < \frac{13}{4} - \frac{3}{4}\sqrt{17} \approx 0.158$ *and strategic complements if* $\rho_2 > \frac{13}{4} - \frac{3}{4}\sqrt{17} \approx 0.158$.

Solving (34) simultaneously for the two firms, we find

$$p_{i1}^{a*} = \frac{3\rho_2 - 2\rho_1(1 - \rho_2)}{3\rho_1\rho_2} t - \frac{9(1 - \rho_1)\rho_2}{\rho_1 N_2} R_i^e. \quad (35)$$

In correspondence with Proposition 4, we consequently find that $dp_{i1}/dR_i^e < 0$ in a stable equilibrium. From (35), we note that the magnitude of the deviation from symmetry due to expectation asymmetry - measured by the term $\frac{9(1-\rho_1)\rho_2}{\rho_1 N_2}$ - is decreasing in the probability

[12] If $\frac{13\rho_2 - 2\rho_2^2 - 2}{2N_1}$ is positive, stability is satisfied if $N_1 > 0$, while it is satisfied for $N_2 > 0$ if $\frac{13\rho_2 - 2\rho_2^2 - 2}{2N_1}$ is negative.

of a media price comparison in both periods. Media attention dampens down the price difference between the firms in the first period.

Second-period prices are given by (10). With no price comparison at $T = 1$, we have

$$p_{i2}^{aNP_1*} = \frac{t}{\rho_2} - \frac{1-\rho_2}{3\rho_2} R_i^e. \tag{36}$$

In this case firm i will therefore charge a lower price than its rival if $R_i^e > 0$. The intuition for this is that if there is no price comparison in period 2 either, firm i will sell too little if it is perceived as being a high-cost supplier. In order to increase expected demand, it will therefore set a lower price than its rival. This will have a positive effect on profit if a price comparison actually takes place in period two (recall that we have assumed that the firms have identical marginal costs).

Now, suppose that there was a price comparison in the first period. Then the uninformed consumers carry the learned first-period price over to the second period, and by inserting for equation (35) into (10) we arrive at

$$p_{i2}^{aP_1*} = \frac{t}{\rho_2} + \frac{6\left(1-\rho_1\right)\left(1-\rho_2\right)}{\rho_1 N_2} R_i^e. \tag{37}$$

Firm i sets a lower price than its rival in period 1 if $R_i^e > 0$. This is discovered also by the uninformed consumers if there was a price comparison that period, and the price information will be carried over by the (uninformed) consumers to period 2. The subsequent relatively high demand that firm i then faces in period 2 induces it to set a higher price than its rival (unless it is certain that the media will publish a price comparison in period 2, $\rho_2 = 1$).

We can conclude:

Proposition 5: *Suppose that the uninformed consumers initially expect firm i to be a high-cost supplier ($R_i^e > 0$). In period $T = 2$, firm i will charge a*

- lower price than its rival if there was no price comparison in period 1, and

- higher price than its rival if there was a price comparison in period 1.

The expected price that firm i will charge in period two equals $E\left(p_{i,T=2}^{a*}\right) = \rho_1 p_{i2}^{aP_1*} + \left(1-\rho_1\right) p_{i2}^{aNP_1*}$, where $p_{i2}^{aP_1*}$ and $p_{i2}^{aNP_1*}$ are given by (37) and (36), respectively. This implies that

$$E\left(p_{i,T=2}^{a*}\right) = \frac{t}{\rho_2} - \left(\rho_2 - \frac{1}{4}\right) \frac{4\left(4-\rho_2\right)\left(1-\rho_1\right)\left(1-\rho_2\right)}{3\rho_2 N_2} R_i^e. \tag{38}$$

Interestingly, but in accordance with Proposition 5, it is thus ambiguous whether an initial expectation that firm i is a high-cost supplier induces it to set a higher or lower price than its rival in period 2.

From equation (38) we can conclude:

Proposition 6: *Suppose that the uninformed consumers initially expect firm i to be a high-cost supplier ($R_i^e > 0$). Firm i will then be expected to charge a higher price in $T = 2$ than its rival if $\rho_2 \in \left(\frac{35}{8} - \frac{3}{8}\sqrt{129}, 1/4\right)$ and a lower price than its rival if $\rho_2 > 1/4$.*

Let us finally ask whether the initial expectation that firm i is a high-price firm is self-fulfilling, in the sense that firm i on average over the two periods will have a higher price than its rival if $R_i^e > 0$. The answer is no; the opposite could be true. This can be seen by adding the price that firm i charges in period 1 and its expected price in period 2. We then find that

$$p_{i1}^{a*} + E\left(p_{i,T=2}^{a*}\right) = \frac{\rho_1 + 3\rho_2 + 2\rho_1\rho_2}{3\rho_1\rho_2}t - (1-\rho_1)\frac{27\rho_2^2 - 4\rho_1\left(\frac{1}{4} - \rho_2\right)(1-\rho_2)(4-\rho_2)}{3\rho_1\rho_2 N_2}R_i^e. \tag{39}$$

From (39) we see that the numerator in the second term of (39) will be negative if $\rho_2 < 1/4$ and ρ_1 is sufficiently large.

We can state:

Proposition 7: *If firm i initially is expected to be a high-cost firm, it will on average charge a lower price than its rival unless $\rho_2 < 1/4$ and $\rho_1 > 27\rho_2^2/\left[4\left(\frac{1}{4} - \rho_2\right)(1-\rho_2)(4-\rho_2)\right]$.*

It is only for a relatively small range of parameter values that the expectation that firm i is a high-price firm will be self-fulfilling (for instance, it will hold if $\rho_2 < 0.177$ and $\rho_1 = 9/10$; then we have $d\left[p_{i1}^{a*} + E\left(p_{i,T=2}^{a*}\right)\right]/dR_i^e > 0$). The reason is that if the consumers expect firm i to be relatively expensive, the firm will have an incentive to price aggressively in order to increase expected sales. Loosely speaking, this is true unless it is very likely that firm i's low first-period price is revealed (ρ_1 close to one) through a media price comparison and that it is unlikely that there will be a media price comparison in the second period (ρ_2 well below 1/4).[13]

[13] If $\rho_1 = 1$, we find that the numerator in (39) is negative only if $\rho_2 < \frac{2\left(\frac{3}{16}\sqrt{177} + \frac{27}{16}\right)^{\frac{2}{3}} - 3}{2\left(\frac{3}{16}\sqrt{177} + \frac{27}{16}\right)^{\frac{1}{3}}} - \frac{1}{2} \approx 0.18$. A necessary condition for the initially expected high-cost firm to actually charge higher prices than its rival on average is thus that $\rho_2 < 0.18$.

5 Conclusion

A widely-held view is that information that reduces consumer ignorance also reduces consumer prices. In a static setting this is generally true, and one can think of media attention though e.g., price comparison as one instrument that disciplines the price-setting behavior of firms. Our analysis has attempted to introduce a dynamic element in which media attention can inform, but at the same time lock some consumers into their expectations. Added to the standard logic is then a countervailing effect of information provision. The larger the share of uninformed consumers, the more important it is to win a price comparison since this can increase expected future demand. We have called this an intertemporal advertising effect; in practice, winners of media price tests often use their victory to convince consumers of their low-price profile a long time after the initial prices have been revealed. The more often the comparisons are expected to take place, the less scope a firm has to reap benefits from a previous price test in which it was victorious. The stochastic element behind the timing of price comparisons, that we see in practice, has an important disciplining effect on firms' pricing behavior; a more deterministic timing would allow firms to "game the system" and rise prices in periods where there are sure no comparison will take place.

Our baseline symmetric model was extended to allow uninformed consumers to harbor an initial belief that a firm has a low or high price reputation. The initial reputation of the firms has been assumed exogenous to the model. A natural next step for future research would be to allow the firms themselves to choose their profile as part of an optimal strategy. Here, it would also be prudent to allow for differences in the firms' operating costs. Supermarket retailers are often a part of a wider group that affects their bargaining power and cost structure. Furthermore, one can seek to extend our analysis to encompass the marketing strategies of firms in the light of a published price comparison.

6 Literature

Ater, I. and O. Rigbi, O. (2020). Price Transparency, Media and Informative Advertising. http://dx.doi.org/10.2139/ssrn.3455183

Bagwell, K. (2007). The Economic Analysis of Advertising, in M. Armstrong and R. Porter (eds.), Handbook of Industrial Organization, Volume 3, 1702-1844. Elsevier.

Berger, J., A.T. Sorensen, S.J. Rasmussen, S. J. (2010). Positive effects of negative publicity: When negative reviews increase sales. Marketing Science, 29, 815-827. http://dx.doi.org/10.2139/ssrn.1344363

Bordalo, P. N. Gennaioli and A. Shleifer. (2016). Competition for Attention, The Review of Economic Studies, Volume 83, Issue 2, Pages 481–513, https://doi.org/10.1093/restud/rdv048

Boynton, R.D., B. F. Blake and J.N. Uhl. (1983). Retail Price Reporting Effects in Local Food Markets, American Journal of Agricultural Economics, 65(1), 20-29.

Chen, Y., Y. Liu and J. Zhang, J. (2012). When Do Third-party Product Reviews Affect Firm Value and What Can Firms Do? The Case of Media Critics and Professional Movie Reviews. Journal of Marketing, 76(2), 116-134. https://doi.org/10.1509%2Fjm.09.0034.

Chen, Y. and J. Xie. (2008). Online Consumer Review: Word-of-Mouth as a New Element of Marketing Communication Mix, Management Science, 54(3), 477-491. https://doi.org/10.1287/mnsc.1070.0810

Dagens Næringsliv (2017, 07.10). Slik opererer dagligvarekjedenes prisspioner. DN Magasinet. https://www.dn.no/magasinet/naringsliv/dagligvarer/handel/rema/slik-opererer-dagligvarekjedenes-prisspioner/2-1-153699

Devine, D. and B.W. Marion. (1979). The Influence of Consumer Price Information on Retail Pricing and Consumer Behavior, American Journal of Agricultural Economics, 61(2), 228-237.

Diamond, P. A. (1971). A Model of Price Adjustment. Journal of Economics Theory, 3, 156–168. https://doi.org/10.1016/0022-0531(74)90023-4.

Dixit, A. and V. Norman. (1978). Advertising and Welfare. Bell Journal of Economics, 9(1) 1–17. https://doi.org/10.2307/3003609.

Eliashberg, J. and S.M. Shugan. (1997). Film Critics: Influencers or Predictors?, Journal of Marketing, 61(2), 68-78. https://doi.org/10.1177%2F002224299706100205.

Friberg, R. and E. Grönqvist. (2012). Do Expert Reviews Affect the Demand for Wine? American Economic Journal: Applied Economics, 4 (1), 193-211, https://doi.org/10.1257/app.4.1.193

Graf-Vlachy L., A. G. Oliver, R. Banfield, A. König, and J. Bundy. (2020). Media Coverage of Firms: Background, Integration, and Directions for Future Research. Journal of Management, 46(1), 36–69. https://doi.org/10.1177/0149206319864155

Grossman, G. M. and C. Shapiro. (1984), Informative Advertising with Differentiated Products, The Review of Economic Studies, 51, 63-81. https://doi.org/10.2307/2297705.

Haan, M.A. and J.L. Moraga-González. (2011). Advertising for Attention in a Consumer Search Model. The Economic Journal, 121 (552), 552-579. https://doi.org/10.1111/j.1468-0297.2011.02423.x.

van Heerde, H., E. Gijsbrechts and K. Pauwels, K. (2008). Winners and Losers in a Major Price War. Journal of Marketing Research, 45(5), 499–518. https://doi.org/10.1509/jmkr.45.5.499

van Heerde, H.J., E. Gijsbrechts, and K. Pauwels. (2015). Fanning the Flames? How Media Coverage of a Price War Affects Retailers, Consumers, and Investors. Journal of Marketing Research , 52(5), 674-693. https://doi.org/10.1509%2Fjmr.13.0260.

Horverak, Ø. (2009). Research note—wine journalism—marketing or consumers' guide?, Marketing Science, 28(3), 573-579. https://doi.org/10.1287/mksc.1090.0489.

Hilger, J, G. Rafert, and S. Villas-Boas. (2011). Expert Opinion and the Demand for Experience Goods: An Experimental Approach in the Retail Wine Market, Review of Economics and Statistics, 93(4), 1289-1296. https://doi.org/10.1162/REST_a_00117.

Hotelling, H. (1929). Stability in Competition. Economic Journal, 39, 41-57. https://doi.org/10.2307/2224214.

Janssen, M.C.W. and M.C. Non. (2009). Going Where the Ad Leads You: On High Advertised Prices and Searching Where to Buy. Marketing Science, 28(1), 87–98. https://doi.org/10.1287/mksc.1080.0377.

McCracken, V.A., R.D. Boynton and B.F. Blake (1982). The Impact of Comparative Food Price Information on Consumer and Grocery Retailers: Some Preliminary Findings of a Field Experiment, The Journal of Consumer Affairs, 16(2).

Reinstein, D.A. and C.M. Snyder. (2005). The Influence of Expert Reviews on Consumer Demand for Experience Goods: A Case Study of Movie Critics. Journal of Industrial Economics, 53(1), 27–51. https://doi.org/10.1111/j.0022-1821.2005.00244.x.

Renault, R. (2015). Advertising in Markets. In S.P. Anderson, J. Waldfogel, and D. Stromberg (eds), Handbook of Media Economics, volume 1, 121–204, Elsevier.

Robert, J. and D. O. Stahl, (1993), Informative Price Advertising in a Sequential Search Model, Econometrica, 61, 657-86. https://doi.org/10.2307/2951722.

Salop, S. and J. Stiglitz (1977). Bargains and Ripoffs: A Model of Monopolisti-

cally Competitive Price Dispersion, The Review of Economic Studies, 44, (3), 493–510, https://doi.org/10.2307/2296903

Seaton, J.S. and M. Waterson (2013). Identifying and Characterising Price Leadership in British supermarkets, International Journal of Industrial Organization, 31(5), 392-403. https://doi.org/10.1016/j.ijindorg.2013.07.002.

Shaked, A., and J. Sutton. (1982). Relaxing Price Competition Through Product Differentiation. The Review of Economic Studies, 49(1), 3-13. https://doi.org/10.2307/2297136

Stigler, G. J. (1961). The Economics of Information. Journal of Political Economy, 69(3), 213-225. https://doi.org/10.1086/258464

VG. (2021). VG's price comparison. https://www.vg.no/spesial/matborsen/

Media attention on price differences between firms is common, e.g., media comparisons of supermarket grocery prices. We consider the effect of such comparisons on competition between sellers in a simple two-period spatial model. When some consumers are uninformed about current prices, media price comparisons provide information which can directly intensify competition. Furthermore, firms that do well in price comparisons can experience an increase in demand for their product over time; to what extent they reap the rewards of this by increasing prices in the future, depends on how likely they regard further price comparisons. Current media attention thus has a contemporaneous effect and an intertemporal one. Each firm is aware of this, and takes into account that due to media attention, an aggressive pricing policy may have effects similar to informative advertising in the current period and to persuasive advertising in the future. We seek to disentangle these effects on price competition in a model where media attention takes place stochastically, and in which some consumers are initially uniformed and sellers can initially have different reputations for adopting a low-price profile. Moreover, we present conditions under which media attention creates a snowball effect in which the current winner remains a low-price seller over time, and under which the victor will be expected to alternate. Both patterns are observed in practice.

SNF

Samfunns- og næringslivsforskning AS
Centre for Applied Research at NHH

Helleveien 30
NO-5045 Bergen
Norway

P +47 55 95 95 00
E snf@snf.no
W snf.no

Trykk: Allkopi Bergen