

CORVINUS ECONOMICS WORKING PAPERS



Faculty of Economics

CEWP 10/2014

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by

Barna Bakó,

András Kálec-Simon

<http://unipub.lib.uni-corvinus.hu/1639>

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Barna Bakó * András Kálec-Simon †

June 29, 2014

Abstract

Anchoring is a well-known decision-making bias: original guesses for a certain question could act as anchors and could influence our final answers. Reference prices – in a similar fashion – can lead to a bias in consumer valuations, and thus consumer demand will be coherent but not one derived from a utility framework. In our paper we investigate the effect of the existence of anchoring on how oligopolistic firms might change their pricing strategy. More specifically, we analyze the effect of anchoring on pricing when differentiated firms compete in Bertrand fashion. We show that if the anchoring effect is smaller than a threshold the average price is lower compared to the no-anchoring case.

JEL codes: D43, D11, C72

Keywords: anchoring, consumer bias, Bertrand competition

*MTA-BCE 'Lendület' Strategic Interactions Research Group, Department of Microeconomics, Corvinus University of Budapest, Fővám tér 8, E225-A, Budapest, 1093, Hungary, e-mail: barna.bako@uni-corvinus.hu

†Department of Macroeconomics, Corvinus University of Budapest, Fővám tér 8, E225-A, Budapest, 1093, Hungary, e-mail: revelation.principle@gmail.com

1 Introduction

Even though economic models usually posit rational actors, behavioral economics have established the existence of quite a handful of well-researched decision-making biases. One of these is anchoring, which refers to the phenomenon that original guesses for a certain question could act as anchors and could influence our final answers. For example if we are asked first whether we would be willing to pay \$10 for a watch, our valuation for it could be lower then if we are first asked a similar question but with \$1000. Of course, this is clearly not consistent with our model of the rational consumers who derive their valuations from their system of preferences.

Many studies tried to deepen our understanding of this regular quirk of consumer behavior. Tversky and Kahneman [1974] asked subjects about the percentage of African nations in the United Nations. However, firstly a wheel of fortune (with numbers between 0 and 100) was used to obtain an initial guess and before giving their own guess, the subjects had to answer whether the percentage is higher or lower than the one drawn. This chance number has clearly influenced the final guess given by the subject. Early research on anchoring and reference points and the connection of these phenomena with prospect theory is presented by Kahneman [1992].

Northcraft and Neale [1987] have shown that experts are also susceptible to this phenomenon. Students and real estate agents had to make pricing choices about properties they were shown. According to the results of the experiment, subjects in both groups were influenced by the other listings provided before the decision.

Kalyanaram and Winer [1995] have found three general conclusions based on the previous empirical literature. Reference prices do have a non-neglectable effect on consumer valuations, past prices play an important role in shaping this reference price and in a way not inconsistent with loss aversion, there is an asymmetrical reaction to price increases and price decreases.

Ariely et al. [2003] carried out ground-breaking experiments on how anchoring affects consumer valuation. They have found that the last digits of the social security numbers – used in a similar fashion as the wheel of fortune in the experiment by Tversky and Kahneman – could be used to influence the subjects' willingness to pay. At the same time, the valuation of related products is also influenced in a consistent fashion. To use the example of one of the experiments detailed in the article: recalling the last two digits of the Social Security Number in a priming question influences how much someone is willing to pay for a bottle of average wine, but everyone is willing to pay more for a bottle of "rare" wine than for the "average" one. Subjects acted in a somewhat similar way when their willingness-to-accept was tested. The originally provided anchor influenced how much they accepted to endure a 30-second high-pitched voice, however the sums accepted for a 10-second or a 60-second

voice were consistent with this. The authors thus find that valuations are originally resilient. After the encounter with an anchor however, they have been "imprinted", and they create a system of valuations that is internally consistent, even though its foundation (the anchor) was arbitrary.

Simonson and Drolet [2004] investigated whether there is an asymmetric anchoring effect on willingness-to-pay and willingness-to-accept. They have found that although smaller differences might exist, the impacts of anchoring are very similar in these cases. In the experiment some subjects set selling prices under the assumption that they want to sell their item, while others were instructed to assume that they are not sure whether they want to sell. The experiment has shown that anchoring effects are the strongest if there is an uncertainty in the desire to trade. Nunes and Boatwright [2004] argued that anchors can affect the willingness-to-pay in case of unrelated goods as well. In their experiment they have found that displaying a T-shirt with an expensive (\$80) or a cheap (\$10) price tag at their stand affected how much visitors are willing to pay for the CD they were selling. They used the term "incidental prices" for the advertised or observed prices of completely unrelated products which were still able to influence consumer decisions.

Amir et al. [2008] asked the question whether there is a strong relationship between predicted pleasure (utility) and reservation prices. Subjects had to answer survey questions about a hypothetical concert where different cues were given about the details of the event. They have found that there is no such relationship: some cues (like the production costs) would affect the reservation price, other factors (like the details about the temperature in the auditorium) would affect predicted pleasure. This further hints towards the fact that numerical data which does not affect utility (such as past prices) can affect consumers' willingnesses to pay and thus demand. Beggs and Graddy [2009] have shown that data from art auctions strongly supports the existence of the anchoring effect amongst buyers in this market.

Baucells et al. [2011] based on their laboratory experiment tried to estimate how subjects create reference prices. According to their model, early and most recent data gets a larger weight, while intermediate data gets a lower weight. Adaval and Wyer Jr [2011] found that extreme prices can serve as anchors not only for related goods, but unrelated products as well if anchoring occurs unconsciously, when consumers encounter prices by chance. On the other hand, if the consumer consciously seeks out information on prices, the anchors will only influence the valuations of similar products.

However, Fudenberg et al. [2012] raised questions regarding the robustness of anchoring results. Their laboratory experiments regarding common market goods and lotteries have found only very weak effect on the subjects' willingness to pay. Mazar et al. [2013] on the

other hand argue that market dependent valuations¹ support the hypothesis that consumers focus on other factors than the utility obtained from consuming the product and thus could hint at the significance of anchoring. In their experiments, they exposed potential buyers of mugs and gift vouchers to different a priori price distributions before soliciting their valuations. They have found that the exposure to different price distributions had significant effect on the subjects' willingnesses-to-pay.

As seen above, the study of price anchoring as a phenomenon has a very expansive literature, however, the logical follow-up of behavioral economics findings (as seen for example in Koszegi and Rabin [2006], Schipper [2009], or in Jansen et al. [2009]) would be to extend our previous models of consumer behavior and markets using these results. The first step in this direction was taken by Nasiry and Popescu [2011], who have investigated the effect of anchoring on the dynamic pricing problem of the monopoly and found that ignoring the behavioral effects can lead to under- or overpricing. Under the peak-end rule they applied (ie. the reference price is a combination of the lowest price and the last price), they have shown that optimal price path will always be monotone; thus the monopoly will employ skimming or penetration pricing.

In this paper we continue this direction by incorporating the effects of anchoring into oligopoly models. Even though one might expect that firms can exploit anchoring to increase their revenues, as they are able to do in other cases of consumer bias², we find that in our finite-horizon Bertrand game, anchoring can lead to lower prices on average. Furthermore, we find stronger price-decreasing effect in less competitive markets, thus the existence of anchoring in some sense protects the consumers from firms taking advantage of product differentiation.

In Section 2, we formally describe our oligopoly game and solve it for the equilibrium values. Based on this, in Section 3, we compare the benchmark no-anchoring case to the anchoring case, thus investigating the effects of anchoring. Finally, we reiterate and discuss our results in Section 4.

¹I.e the phenomenon that the valuation of the consumer is influenced by the prices encountered in the market.

²See e.g. Koszegi et al. [2012] or Wenzel [2014].

2 The Model

Suppose that two firms produce differentiated products with zero marginal costs.³ Demands are given by ($i = 1, 2$)⁴:

$$D_{i,t}(\mathbf{p}_t, r_t) = d_{i,t}(\mathbf{p}_t) + h_t(r_t, p_{i,t}) \quad (1)$$

where $\mathbf{p}_t = (p_{1,t}, p_{2,t})$, $d_{i,t}(\mathbf{p}_t) = 1 - p_{i,t} + \beta p_{j,t}$ and $0 < \beta < 1$, while $t = 1, \dots, T$. Furthermore, $h_t(r_t, p_{i,t})$ captures the price anchoring effect, with r_t representing the reference price in period t . We assume, that $h_t(r_t, p_{i,t}) = \lambda(\sum_i p_{i,t-1}/2 - p_{i,t})$, where $\lambda \in (0, 1)$ and $h_1(\cdot, \cdot) = 0$.⁵ That is, we assume that the effective reference price in period t is the industry average price of period $t - 1$.⁶

For the sake of simplicity, we solve the game for $T = 2$ using backward induction. In this case firms' profit functions in period 2 can be written as ($i = 1, 2$):

$$\begin{aligned} \pi_{i,2}(\mathbf{p}_2) &= p_{i,2} D_{i,2}(\mathbf{p}_2, r_2) \\ &= p_{i,2} \left[1 - p_{i,2} + \beta p_{j,2} + \lambda \left(\frac{\sum_i p_{i,1}}{2} - p_{i,2} \right) \right] \end{aligned} \quad (2)$$

Maximizing (2) with respect to $p_{i,2}$ and imposing symmetry, we have that:

$$p_{i,2}^* = \frac{\lambda \sum_i p_{i,1} + 2}{2[2(1 + \lambda) - \beta]} \quad \text{for } i = 1, 2. \quad (3)$$

Firms' objective functions in the first period are ($i = 1, 2$):

$$\begin{aligned} \Pi_i(\mathbf{p}_1) &= \pi_{i,1} + \pi_{i,2} = p_{i,1} d_{i,1}(\mathbf{p}_1) + p_{i,2} D_{i,2}(\mathbf{p}_2, r_2) \\ &= p_{i,1} (1 - p_{i,1} + \beta p_{j,1}) + p_{i,2} \left[1 - p_{i,2} + \beta p_{j,2} + \lambda \left(\frac{\sum_i p_{i,1}}{2} - p_{i,2} \right) \right] \end{aligned} \quad (4)$$

Plugging into this $p_{i,2}$ given by (3) and maximizing it with respect to $p_{i,1}$, yields to:

Lemma 1 *Equilibrium prices and profits are as follows:*

$$p_{i,1}^* = \frac{(1 + \lambda)[4(1 - \beta) + 5\lambda] + \beta^2}{(2 - \beta)^3 + 4(2 - \beta)^2\lambda + (7 - 4\beta)\lambda^2 - \lambda^3}$$

³All our results would hold if we assume positive marginal costs, however the expressions would be more complicated. Therefore, for simplicity, we assume symmetric firms with zero marginal costs.

⁴Our demand function is based on Nasiry and Popescu [2011].

⁵We restrict our attention to cases when gains and losses have symmetric effects. That is, we use the same λ even when the actual price is higher or lower than the average price of the previous period.

⁶As pointed out by Biswas et al. [1999], the competitors' prices can also influence the reference price for a product.

$$p_{i,2}^* = \frac{(2 - \beta + \lambda)[2(1 + \lambda) - \beta]}{(2 - \beta)^3 + 4(2 - \beta)^2\lambda + (7 - 4\beta)\lambda^2 - \lambda^3}$$

and

$$\pi_i^* = \frac{\beta^4(2 + \lambda) - \beta^3(1 + \lambda)(16 + 5\lambda) + 8\beta^2(1 + \lambda)^2(6 + \lambda)}{[(7 - 4\beta)\lambda^2 + 4(2 - \beta)^2\lambda + (2 - \beta)^3 - \lambda^3]^2} - \frac{\beta(1 + \lambda)^2[\lambda(68 + 3\lambda) + 64] - (1 + \lambda)^3[(32 - \lambda)\lambda + 32]}{[(7 - 4\beta)\lambda^2 + 4(2 - \beta)^2\lambda + (2 - \beta)^3 - \lambda^3]^2}$$

for $i = 1, 2$.

Comparing equilibrium prices we have that firms set higher prices in the first period than in the second period. The intuition behind this is that in the first period they give up sales in order to provide a high anchor for the second period, where they can finally reap what they have sown, so to speak. More formally:

Remark 1 $p_{i,2}^* < p_{i,1}^*$ for $i = 1, 2$, whenever $\beta \in (0, 1)$.

3 Results

To examine the effect of price anchoring, let us consider the case when there is no price anchoring. In this case firms' per period profits can be given as ($i = 1, 2$):

$$\pi_{i,t}(\mathbf{p}_t) = p_{i,t}d_{i,t}(\mathbf{p}_t) = p_{i,t}(1 - p_{i,t} + \beta p_{j,t}) \quad (5)$$

Maximizing (5) with respect to $p_{i,t}$ ($i, t = 1, 2$), straightforward computation yields to:

Lemma 2 *With no price anchoring in equilibrium firms choose $p_{i,t}^{**} = \frac{1}{2-\beta}$ in each sequence of period and profits can be given by:*

$$\pi_i^{**} = \frac{2(1 + \beta)}{(2 - \beta)^2}$$

for $i = 1, 2$.

This leads to the following result.

Proposition 1 *If β is sufficiently small the average price of the two periods is lower compared to the no-anchoring case.*

Proof: To show this, we need:

$$\frac{\sum_{t=1}^2 p_{i,t}^*}{2} < p_{i,t}^{**}$$

Plugging into this the equilibrium prices we have that

$$\frac{-2\beta^2 + \beta(7\lambda + 8) - (\lambda + 1)(7\lambda + 8)}{2[(4\beta - 7)\lambda^2 - 4(\beta - 2)^2\lambda + (\beta - 2)^3 + \lambda^3]} < \frac{1}{2 - \beta}$$

This inequality holds true whenever:

$$\beta < \bar{\beta} \equiv 1 - \lambda$$

■

This result is depicted on Figure 1. The shaded area corresponds to the cases when anchoring yields lower average prices.

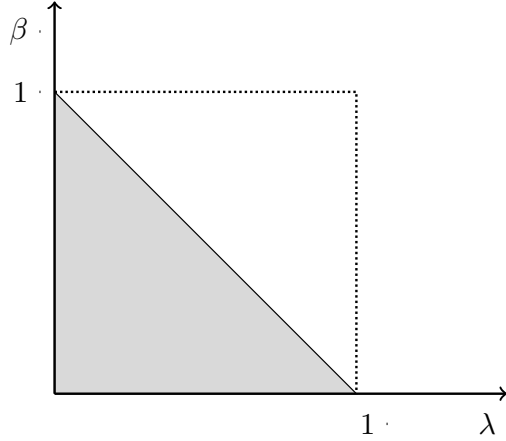


Figure 1: Change of average prices.

Remark 2 Notice, that the output-weighted average price is even lower than the average price, since with anchoring the second period equilibrium prices are lower and the equilibrium quantities are greater than in the first period.

The intuition behind the above result is that in the first period, firms are increasing prices in order to create a favorable anchor for the second period where they can make up for the lost sales. However, prices in a Bertrand setup are strategic complements, hence

when demands are more interrelated, this leads to a more significant price increase in the first period. Of course this implies that the firms are also able to charge a higher price in the second period as well. Therefore the average price increases if the products are close substitutes and decreases when demands are relatively independent of each other.

Proposition 2 *There is a threshold $\underline{\beta}$ such that if $\beta < \underline{\beta}$, then $\pi_i^* > \pi_i^{**}$ for $i = 1, 2$.*

Proof: Solving $\pi_i^* - \pi_i^{**} > 0$ we get the following critical product differentiation level

$$\beta < \underline{\beta}$$

where $\underline{\beta}$ is the smallest root of the polynomial equation $2\beta^7 - \beta^6(24 + 17\lambda) + \beta^5(53\lambda^2 + 169\lambda + 120) - \beta^4(68\lambda^3 + 416\lambda^2 + 672\lambda + 320) + \beta^3(19\lambda^4 + 390\lambda^3 + 1227\lambda^2 + 1336\lambda + 480) + \beta^2(17\lambda^5 - 73\lambda^4 - 765\lambda^3 - 1619\lambda^2 - 1328\lambda - 384) + \beta(2\lambda^6 - 16\lambda^5 + 114\lambda^4 + 556\lambda^3 + 824\lambda^2 + 528\lambda + 128) + 2\lambda^6 - 24\lambda^5 - 82\lambda^4 - 84\lambda^3 - 28\lambda^2 = 0$ ■

Proposition 2 suggests that anchoring can be beneficial for firms if the degree of product differentiation is sufficiently high. Furthermore, according to Proposition 1 if $\beta < \bar{\beta}$ then consumers benefit from price anchoring as well. Since $\underline{\beta} < \bar{\beta}$ for every $\lambda \in (0, 1)$, these results yield to the following:

Corollary 1 *If $\beta < \underline{\beta}$, the existence of price anchoring increases social welfare.*

4 Conclusion

Previous literature warns us that in certain cases firms are able to exploit consumer bias to increase their profits, while harming their consumers. Anchoring is well-known and well-researched bias for psychologists as well as marketing professionals. Little research was done however on the issue how price anchoring affects the conclusions of our market models. To at least partially answer this question, we investigated these effects within a finite horizon Bertrand game with differentiated products. We assumed that the average price of the previous period serves as an anchor for the consumers, furthermore we assumed that this fact is common knowledge for the firms. Solving our model, we find that in the case of anchoring, the consumer bias might lead to lower prices. Somewhat surprisingly, we also find that this price-lowering effect is more likely in more differentiated markets, thus firms with higher market power are even less likely to exploit anchoring. Furthermore, we have shown that in the case of highly differentiated products, anchoring most certainly increases social welfare.

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