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The effect of relative thinking on firm strategy and market outcomes: A location differentiation model with endogenous transportation costs

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Abstract

Consumers often have to decide whether to go to a remote store for a lower price. Only the absolute price difference between the stores should be relevant in this case, but several experiments showed that people exhibit "relative thinking": they are affected also by the relative savings (relative to the good's price). This article analyzes the effects of this bias on firm strategy and market outcomes using a two-period game-theoretic model of location differentiation. Relative thinking causes consumers to make less effort to save a constant amount when they buy more expensive goods. In the location differentiation context this behavior can be modeled by consumers who behave as if their transportation costs are an increasing function of the good's price. This gives firms an additional incentive to raise prices, in order to increase the perceived transportation costs of consumers, which consequently softens competition and allows higher profits. Therefore, the response of firms to relative thinking raises prices and profits and reduces consumer surplus, in both periods. Total welfare is unchanged in the first period, and in the second period it is either unchanged or reduced, depending on whether the objective or subjective transportation costs are used to compute welfare. The main results of the model (firms' response to relative thinking increases prices and reduces consumer surplus) are likely to hold also in the context of search. The article also explains why "relative thinking" is a more appropriate term than "mental accounting" (which was often used before) to describe this behavior, and discusses why people might exhibit relative thinking.

1. Introduction

One of the decisions that consumers face often is the decision whether to spend time and effort to find a cheaper price of the good they want to buy. This can happen when the consumer does not know which is the cheapest store, and by spending time and going to additional stores (or calling them, or looking at their websites, etc.) he can find the prices in these stores, which might be lower than the best price found so far. In another common situation, the consumer might know where goods can be purchased for the cheapest prices, but the location of the cheapest store is more remote. For example, outlet stores are often located in the suburbs, while many consumers live in the big cities. Another example is that the consumer often has a close-by privately-owned grocery store, but the closest store of the big and cheaper chains is usually several blocks away and sometimes even more remote than that.

The former context (of searching to find which is the cheapest store) is more complex to analyze than the latter (the cheapest store is known but is more remote), because in the search context the consumer has to figure out the expected value of an additional search based on the distribution of prices and the ones he found so far. Therefore, to simplify the discussion and the analysis, this article focuses on the latter context. However, it seems reasonable that the main results might apply to search contexts as well, as I discuss in more detail in the conclusion. In addition, in order to further simplify the discussion as well as the model and its analysis, in what follows I consider a consumer who wants to buy a single good.

The decision whether to incur the transportation costs that are required to go to a more remote store (the value of time spent, gasoline costs, etc.) or to pay a higher price (at a closer store) and save the transportation costs should depend on the comparison between the price difference (which is the benefit of going to the remote store) and the transportation costs (that are the cost of going to the remote store). The good's price should play no role for a rational decision maker. That is, if a rational consumer is willing to drive 30 minutes to save $10 when he buys a $50 telephone, he should also be willing to drive 30 minutes to save $10 when he buys a $500 camera. The difference in the relative savings (20% vs. 2%) is irrelevant from the perspective of a rational consumer.

To illustrate this, consider for example a consumer who is affected partially also by the relative savings, and consequentially he decides to make a 50-minutes trip (including the return) to save $8 on a $50 telephone (16% savings), but he buys in the nearer store (which takes 20 minutes to go there and return) and forgoes savings of $20 when he purchases a $500 camera (because it is only 4% savings). This consumer buys the telephone for $42 and the camera for $500 and spends 70 minutes.[1] If the consumer made the opposite choices, driving to the remote store for the camera but not for the phone, he would be strictly better off: he would have the exact same goods, would spend the same time (70 minutes), but would save $12 dollars (paying $530 = $50 + $480 instead of $542). Therefore the decisions made by the consumer who is affected by the relative savings are inconsistent with rational decision making.

Although the principle that one should care about how much he saves in dollars and not in percentages is simple, several experiments show that people do not behave in this manner. Instead, people are also affected by the relative savings, and therefore they make less effort to save a constant amount when they buy a more expensive good. The idea that people are affected by relative price differences even when only absolute price differences matter has been termed "relative thinking" (see Azar, 2004a) and I also use this term below, although several articles referred to the same behavior as "mental accounting" (the reasons why I deviate from the use of "mental accounting" are detailed in section 1.1).

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[1] The assumption in this example is that the consumer cannot buy the two goods together. For example, he did not know that he would buy a camera when he first purchased the phone, so he could not use the single trip to buy both goods. Alternatively, the remote store that sells the camera for a cheaper price is at a completely different location from the remote store that sells the phone for a cheaper price, so going to both stores requires two trips.

Several articles addressed the idea that people are affected by relative price differences. Thaler (1980), in an article that proposes prospect theory as the basis for a positive theory of consumer choice, conjectures that people exert more effort to save $5 on a $25 radio than on a $500 TV. Tversky and Kahneman (1981) asked people whether they would drive 20 minutes to save $5 on a calculator when they are about to buy a calculator and a jacket. When the calculator's price was $15 and the jacket's price was $125, 68 percent of the subjects were willing to drive, but when the calculator's price was $125 and the jacket's price $15, only 29 percent wanted to drive 20 minutes to save $5. Mowen and Mowen (1986) show that the effect holds similarly for student subjects and for business managers subjects. Frisch (1993) shows that the effect holds also when only a calculator is being purchased, and Ranyard and Abdel-Nabi (1993) vary the price of the second item (the jacket) and obtain similar results. Darke and Freedman (1993) find that both the amount of money and the percentage of the base price that can be saved affect consumers' decisions whether to exert effort to save money. Moon et al. (1999) find that the effect of relative savings is not detected when the level of absolute saving to be gained increases.

Azar (2004a, 2004b) showed that consumers' willingness to add money for a high-quality good or service (over the price of a low-quality substitute good or service) is higher when the good's price is higher, even though the quality difference was unrelated to the good's price and therefore the willingness to add should be independent of the good's price. Azar (2005a) showed that when subjects can purchase a certain good either in a store they currently visit or in a remote store, the minimal price difference for which they are willing to travel to the remote store is an increasing function of the price of the good they want to purchase. In an experiment that included 9 different price treatments, he found that people behave (on average) as if the value of their time is approximately proportional to the square root of the good's price.

Duxbury et al. (2005) replicate the prior findings under the classical conditions where individuals trade-off time spent for money saved, but show that relative savings have no effect when the scenario is reversed (individuals trade-off money spent for time saved). Azar (2005b) conducts a field experiment in which people could purchase either a low-quality good (a bagel) or a high-quality good (a bagel with cream cheese). The price difference between the two goods was always $0.20 but varied in percentage, because the price of the bagel was different in the two treatments. Behavior was similar in the two treatments, i.e., people did not seem to be affected by the relative price difference. Azar (2006a) examines whether the level of the flat participation fee can affect relative thinking in hypothetical consumer decision scenarios. He finds that subjects who received a higher participation fee exhibited relative thinking a little less, but the difference was not statistically significant.

Azar (2006b) tests experimentally whether relative thinking exists in the context of task performance with mixed compensation schemes that include both fixed and pay-for-performance components. Surprisingly, relative thinking disappears in this context: the ratio between the pay-for-performance compensation and the fixed compensation does not affect effort. To test whether the different context or the introduction of financial incentives (which were not used in previous studies of relative thinking) is the reason that relative thinking disappears, a hypothetical condition where subjects make similar decisions but without incentives was run. Relative thinking was again not documented, suggesting that in the context of task performance people do not exhibit relative thinking regardless of financial incentives. Azar (2007) provides a theoretical framework that models the relative thinking behavior, and discusses related issues, for example, whether the relative thinking bias can be beneficial, and its implications for economics and management.

1.1. Is it relative thinking or mental accounting?

Much of the previous literature refers to the behavior that was denoted here "relative thinking" as "mental accounting." Mental accounting refers to a situation where people do not treat all their money as one resource, but rather split it into different mental accounts (see Thaler, 1985, 1999). The reason that mental accounting was also used to describe relative thinking is probably that in the seminal experiment reported by Tversky and Kahneman (1981), mental accounting played a role: even though the price of the bundle (the jacket and the calculator) remained constant across treatments, behavior was affected by the price of the calculator (on which the $5 savings could be obtained). That is, without mental accounting that puts the calculator in one mental account and the jacket in another, the calculator's price should have no effect because the bundle's price remains constant.

I argue, however, that describing the more general phenomenon that people consider relative price differences (when these are irrelevant) as "mental accounting" is misleading and that "relative thinking" is a better term. The exact name given to a phenomenon is sometimes not very important, but in this case it is important because calling this behavior mental accounting can be misleading and confuse, obscuring the real meaning of this behavior. There are several reasons for this claim.

First, "mental accounting" is used to describe many other behaviors that are not related to relative thinking, for example when someone is happy to receive a gift from his spouse that he did not want to purchase himself, although they have a joint bank account (Thaler, 1985), or when someone is unwilling to purchase another theater ticket when he loses the original ticket, but is willing to purchase a ticket if he lost money (Kahneman and Tversky, 1984).

Second, "relative thinking" captures the essence of this behavior – that people think about relative magnitudes (for example, the relative price difference between goods), while "mental accounting" does not.

Third, people can use mental accounts and still not be affected by relative price differences, suggesting that mental accounting and relative thinking are two separate things. For example, one could treat the calculator and the jacket in the classic experiment by Tversky and Kahneman (1981) as belonging to different mental accounts, but he can still treat a $5 discount on the two items in the same manner and be willing to make the same effort to save $5 regardless of the good's price.

Finally, people can also exhibit relative thinking without having any mental accounting. For example, one can treat differently savings of $10 on a $20 good and on a $500 good, without exhibiting mental accounting. Maybe such a person will not exhibit relative thinking when he buys the two goods together because in that case he will compare the $10 savings to the bundle price of $520, but in cases where he buys only one of the two goods he may exhibit relative thinking even though he does not present any mental accounting.

1.2. Why do people exhibit relative thinking?

A natural and interesting question to ask when a behavior that deviates from rationality is discovered is why do people exhibit this behavior. There seem to be two main explanations for the relative thinking behavior. One is related to the way we perceive various stimuli. The Weber-Fechner Law states that our ability to distinguish between two stimuli depends on their relative difference and not on their absolute difference. That is, for each type of stimulus we have a constant k and we can tell that two stimuli x_1 and x_2 (assume without loss of generality that $x_2 > x_1$) are different in their magnitudes if and only if $x_2 > kx_1$, where $k > 1$. This law was found to be true for various senses and stimuli and for almost all levels of stimulus except for very high or very low ones (Miller, 1962). Figure 1 provides an illustration of this law.

[Figure 1 here]

The Weber-Fechner Law applies to the ability to distinguish between stimuli using our senses and not to our cognitive ability of thinking and reasoning, and therefore it is not directly applicable to economic decision making. We can understand, for example, that $100 is different from $100.01 even though they are very similar. Nevertheless, the Weber-Fechner Law can be related to the reason for relative thinking, because intuitive judgments often resemble the automatic operations of perceptions (Kahneman, 2003)[2], and it may be the case that in many situations in which relative thinking is present, the decision maker made intuitive judgments without further reasoning and monitoring of these judgments (i.e., he used only system 1 without further processing in system 2, in the terminology of Kahneman, 2003).

A second possible explanation for relative thinking is that it might be a helpful rule of thumb to consider relative price differences in many situations, and people fail to recognize that in other cases this rule of thumb is irrelevant and can lead to non-optimal decisions. For example, cheap goods are often purchased more frequently than expensive ones, and then it makes sense to exert more effort to save \$1 on a \$5 good than \$1 on a \$200 good, when the effort is made to find the cheapest store (and not to drive to a remote location of a store that is known to be the cheapest). The reason is that once the consumer finds the cheapest store, he can use this information to save money also in the future when he needs to buy this good again. The more frequently a good is purchased, the more times the savings can be realized, and therefore it is rational to make more effort to save \$1 on a \$5 good that is purchased frequently than to save \$1 on a \$200 good that is not purchased frequently. Thinking about the relative savings may therefore be a reasonable rule of thumb[3], but the problem is that people keep on using it when it is irrelevant (for example,

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[2] Kahneman (2003, p. 1452), for example, writes that "… intuitive judgments occupy a position—perhaps corresponding to evolutionary history—between the automatic operations of perception and the deliberate operations of reasoning. All the characteristics that students of intuition have attributed to System 1 [System 1 is intuition, as opposed to perception and to System 2 which is reasoning] are also properties of perceptual operations… This view of intuition suggests that the vast store of scientific knowledge available about perceptual phenomena can be a source of useful hypotheses about the workings of intuition."

[3] The optimal decision procedure, however (at least absent explicit cost of thinking), is to consider the absolute savings, but to account for the future savings that can be realized by searching more today.

when they exert too much effort to save on a low-price good that is not purchased often), or use it too strongly.[4]

Another example for this useful-rule-of-thumb explanation is that more expensive firms sometimes sell better goods or services than cheaper firms. For example, a more expensive car mechanic might use higher-quality parts, or be more professional and knowledgeable. It then makes sense to consider (at least partially) the relative price difference between two mechanics and not only the absolute one, because the quality advantage of the better (and more expensive) mechanic is probably worth more in a $2000 repair than in a $50 repair. The problem (i.e., the relative thinking bias) arises when the quality difference between the mechanics has nothing to do with the cost of the repair (for example, one is more centrally located and therefore charges higher prices), but the consumer is still affected by the relative price difference even though now only the absolute price difference is relevant (because the costs associated with driving to a more remote mechanic are the same regardless of how much you pay for the repair).

1.3. How does relative thinking affect firm strategy and market outcomes?

When experiments document a behavior that departs from that of a selfish and unboundedly rational agent, two questions that usually attract much attention by economists, marketing researchers, and others in related disciplines, are whether firms can exploit this behavior, and whether it affects market outcomes. In the context of relative thinking, however, the only paper dedicated to examining how relative thinking affects firm strategy and market outcomes is Azar (2005c). Azar shows that if price dispersion is caused by location differentiation it should be

[4] Even for the most expensive goods, the savings from finding a cheaper price (or from bargaining) will be realized at least once. However, people often seem not to exert enough effort to save when buying an expensive good even when we take into account that the savings will only be realized once. For example, people might give up hundreds of dollars relatively easily when buying (or selling) a car or a house (for a more detailed discussion of this idea see Azar, 2005a).

independent of the good's price, and explains why a similar conclusion can be reached if price dispersion is caused by search costs. Azar shows, however, that empirical evidence on price dispersion documents a strong positive correlation between price dispersion and the good's price (or cost), in conflict with the theoretical predictions, a discrepancy that Azar denotes "the price dispersion puzzle." Finally, Azar shows that this puzzle could be explained if we consider how firms should respond to relative thinking of consumers.

One of the main results of the experiments mentioned in the introduction is that people make more effort to save a constant amount when the good's price is lower, because then the relative savings are higher. In location differentiation models, the parameter that affects the willingness of people to travel in order to save money is the transportation cost parameter. When transportation costs are higher, people are less willing to travel. Therefore the interpretation of the experimental evidence on relative thinking in terms of location differentiation models is that people behave as if their transportation costs are an increasing function of the price of the good they want to purchase.

It is interesting to explore what is the effect on firm pricing strategy and on market outcomes if firms take into account that choosing higher prices will also increase the perceived transportation costs of consumers. Azar (2005c), however, does not address this question; in order to simplify his model and because his focus is different (on price dispersion), he treats the transportation costs as being unrelated to the pricing decisions of the firms. The model developed in the following sections, however, shows that if firms do acknowledge that their pricing strategy influences perceived transportation costs, this affects the level of prices, and consequently also markups, profits, and consumer surplus.

2. A model of price competition with location differentiation and relative thinking

To examine how firms should choose their pricing strategy if they are aware that their prices affect consumers' perceived transportation costs, I use a variation of the commonly-used linear city model, originally developed by Hotelling (1929). Two firms compete in a linear city in which consumers are uniformly distributed over the city line. The mass of consumers is normalized to 1, the length of the city line is also normalized to 1, and for simplicity I abstract away from issues of location choice and assume that the firms are located at the endpoints of the city – firm 1 at the left end (denoted as 0) and firm 2 at the right end (denoted as 1).[5] The price of firm i is denoted by p_i (i = 1, 2). The cost per unit sold is equal to c for both firms, and there are no other costs for the firms.

In order to buy the good from one of the firms, consumers have to incur transportation costs that depend on the distance they need to travel. I assume quadratic transportation costs and denote the transportation cost parameter by t (more on this below). Consequently, a consumer located at point x has to incur a total cost (price + transportation cost) of $p_1 + tx^2$ in order to buy from firm 1 and $p_2 + t(1–x)^2$ in order to buy from firm 2. This is illustrated in Figure 2.

[Figure 2 here]

Each consumer derives a utility of U from consuming the first unit of the good and a utility of 0 from consuming additional units. Therefore, each consumer buys only one unit of the good from the firm that offers him a lower total cost, if that total cost is lower than U. I assume that U is high enough that in equilibrium it is higher than the total cost for every consumer, and therefore in equilibrium each consumer buys one unit from one of the firms.

The innovative idea that the model attempts to address is that a firm should consider the effect that its price has on transportation costs, and consequently on the other firm's price. But because in a Nash equilibrium each firm takes its opponent's price as given, in order to examine this effect, a two-period model is needed.[6] Consequently, the game evolves in two stages.

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[5] It can be shown that with quadratic transportation costs, even if we allow firms to locate wherever they want over the line, they will indeed choose the two endpoints (see d'Aspremont et al., 1979).

[6] Of course, one can also consider models of more than two periods, but for the sake of simplicity, here I adopt the simplest model that is relevant, which involves only two periods.

In the first stage (period 0), the firms choose prices given that the consumers' transportation cost per unit of distance is $t^0 = T$. T is a parameter that captures the various factors (other than the good's price) that affect transportation cost, such as the time value of consumers, the actual length of the city[7], gasoline prices, etc. In the second stage (period 1), consumers change their perceived transportation cost, which is now affected by the prices chosen by the firms in period 0; the perceived transportation cost becomes $t(p_1^0, p_2^0, T)$, where p_1^0 and p_2^0 are the prices chosen by the firms in period 0.[8] The experimental evidence on relative thinking implies that t is an increasing function of both p_1^0 and p_2^0. The experimental evidence reported in Azar (2005a) suggests that t is concave in p_1^0 and p_2^0. I therefore assume that t is weakly concave in p_1^0 and p_2^0. Indeed, it will be strange if t is not weakly concave in the prices, because that means that for some prices, multiplying the prices by a factor of z increases the perceived transportation cost by a factor of more than z.[9] Assumption 1 summarizes the properties of $t(p_1^0, p_2^0, T)$.

Assumption 1. The transportation cost parameter in period 1, $t(p_1^0, p_2^0, T)$, is a strictly increasing and weakly concave function of the prices chosen in period 0.

The firms maximize the present value of their profits, which is equal to $\pi^0 + \beta\pi^1$, where π^0 and π^1 are the profits in periods 0 and 1, and $\beta > 0$. I assume, for simplicity, that the profits are

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[7] In the model the city length is normalized to 1; the difference between cities in their size nevertheless can be captured in the model, through the parameter T. It is more expensive to travel a constant percentage of a larger city, and this can be taken into account in the model by a larger value of T.

[8] I adopt here and below the following notation: the subscripts 1 and 2 refer to firms 1 and 2, and the superscripts 0 and 1 refer to periods 0 and 1.

[9] Recall that from a rational perspective (i.e., without the relative thinking bias), the transportation cost should not depend on the good's price at all. Relative thinking can explain why the perceived transportation cost can increase with the good's price, but there is no apparent reason why it may increase even more than the increase in the good's price.

received at the beginning of each period. The value of β has two interpretations, depending on what period 1 represents. One possibility is that period 1 is a period of the same length as period 0. In this case, if r is the periodical discount rate, then $\beta = 1/(1+r)$ is the appropriate discount factor because the profits of period 1 are received one period after period-0 profits. Another interpretation is that period 1 represents not only one period, but the entire future, under the assumption that the transportation costs do not change anymore but remain $t(p_1^0, p_2^0, T)$ in all future periods. In this case, because the problem the firms face in each period is unchanged, their optimal prices remain constant starting from period 1 (i.e., $p_1^1 = p_1^2 = p_1^3 = \ldots$ and similarly $p_2^1 = p_2^2 = p_2^3 = \ldots$). It follows that the firms will also make the same profits in each period starting from period 1, and if we denote this per-period profit by π^1 and the discount rate is r, the present value of all these future profits is $(1/\mathrm{r})\pi^1$ (recall that the profits are received at the beginning of each period). This alternative interpretation of the model also fits the assumption that the firms maximize $\pi^0 + \beta\pi^1$, with $\beta = 1/r$.

3. Analysis and results

To find the subgame-perfect Nash equilibrium of the game, the game should be solved backwards, starting with the second stage and then analyzing the optimal decisions in the first stage given the anticipated decisions in the second stage. Proposition 1 characterizes the outcome in the second stage.

Proposition 1. In the equilibrium of the second stage (regardless of whether the firms take into account the relative thinking of consumers), $p_1^1 = p_2^1 = t(p_1^0, p_2^0, T) + c$, and $\pi_1^1 = \pi_2^1 = t(p_1^0, p_2^0, T)/2$.

Proof. First let us find the demand of each firm. As a consumer's location gets closer to 0, his total cost for buying from firm 1 (firm 2) becomes lower (higher). Consequently, there is a single location (denoted by y) in which the consumer is indifferent between the two firms, whereas everyone to the left of y buys from firm 1 and everyone to the right of y buys from firm 2. This implies that firm 1 sells y units of the good and firm 2 sells $(1-y)$ units. The location of y is found by equating the total cost for buying from the two firms: $p_1^1 + ty^2 = p_2^1 + t(1-y)^2$, where t is a shorthand for $t(p_1^0, p_2^0, T)$. A few simple algebraic manipulations then yield $y = 0.5 + (p_2^1 - p_1^1)/2t$. The profits of firm 1 are $\pi_1^1 = (p_1^1 - c)y = (p_1^1 - c)[0.5 + (p_2^1 - p_1^1)/2t]$. Taking the first derivative of this with respect to p_1^1 and equating it to zero yields the first-order condition:

$$\partial\pi_1^1/\partial p_1^1 = 0.5 + (p_2^1 - p_1^1)/2t - (p_1^1 - c)/2t = 0. \quad (1)$$

Following a similar procedure for firm 2 shows that its profit is given by $\pi_2^1 = (p_2^1 - c)(1-y) = (p_2^1 - c)[0.5 + (p_1^1 - p_2^1)/2t]$ and its first-order condition for profit maximization is:

$$\partial\pi_2^1/\partial p_2^1 = 0.5 + (p_1^1 - p_2^1)/2t - (p_2^1 - c)/2t = 0. \quad (2)$$

It is easy to see that the second-order conditions are satisfied. Solving equations (1) and (2) simultaneously yields the second-stage equilibrium prices: $p_1^1 = p_2^1 = t + c$. Substituting the prices in the profit equations reveals that $\pi_1^1 = \pi_2^1 = t/2$. The analysis above applies regardless of whether the firms take into account the relative thinking of consumers. *Q.E.D.*

Proposition 1 shows that prices and profits depend crucially on the transportation cost parameter, t. The reason is that when t is higher, it becomes more costly to travel, and this increases the tendency of consumers to purchase in the firm that is closer to them. This softens the competition between the firms, and decreases the ability of a firm to attract its rival's customers by reducing its price (the increase in sales following a constant price reduction becomes smaller). Consequently, the equilibrium has higher prices and higher profits. In the other direction, notice that as t approaches zero, the equilibrium approaches the one in the famous Bertrand model: prices approach marginal cost, and profits approach zero.

Now we can turn back to the first stage. In the first stage, the behavior of firms depends on whether they take into account the relative thinking of consumers or not. Proposition 2 describes the effects that firms' response to relative thinking has on the market equilibrium in period 0.

Proposition 2. In period 0, firms' response to relative thinking increases equilibrium prices and profits, reduces consumer surplus, and leaves total welfare unchanged.

Proof. If the firms do not take into account the relative thinking of consumers, then they do not realize that their prices in the first stage affect the perceived transportation cost in the second stage (because the transportation cost of a consumer without relative thinking is not affected by the good's price). In this case, each firm fails to recognize that its profits in the second stage are affected by its period-0 prices. The firm still maximizes the present value of its profits, $\pi^0 + \beta\pi^1$, but it assumes that the choice of p^0 does not affect π^1. Consequently, in the first-order condition for profit maximization in period 0 the term $\beta\pi^1$ has no effect and the firm solves in period 0 the same problem that was analyzed in period 1. Then the analysis is similar to that in Proposition 1, and the first-order condition for profit maximization by firm 1 is given by:

$$\partial\pi_1^0/\partial p_1^0 = 0.5 + (p_2^0 - p_1^0)/2T - (p_1^0 - c)/2T = 0. \quad (3)$$

Let us define $Z \equiv 0.5 + (p_2^0 - p_1^0)/2T - (p_1^0 - c)/2T = 0.5 + (p_2^0 + c)/2T - p_1^0/T$. When the firms do not respond to relative thinking of consumers, equation (3) implies that we have $Z = 0$. When the firms respond to relative thinking, they take into account that their period-0 prices will affect the perceived transportation cost in period 1. Firm 1 maximizes $\pi_1^0 + \beta\pi_1^1 = \pi_1^0 + \beta t(p_1^0, p_2^0, T)/2$. The first-order condition for profit maximization becomes:

$$\partial\pi_1^0/\partial p_1^0 = 0.5 + (p_2^0 - p_1^0)/2T - (p_1^0 - c)/2T + (\partial t/\partial p_1^0)\beta/2 = Z + (\partial t/\partial p_1^0)\beta/2 = 0. \quad (4)$$

It is easy to see that the second-order condition is satisfied, because by Assumption 1, $t(p_1^0, p_2^0, T)$ is weakly concave in both prices. Because Z is a decreasing function of p_1^0, and because $(\partial t/\partial p_1^0)\beta/2 > 0$ (recall that Assumption 1 implies that $\partial t/\partial p_1^0 > 0$), the value of p_1^0 that satisfies equation (3) is smaller than the value of p_1^0 that satisfies equation (4). This is illustrated in Figure 3. Because of the symmetry between the firms, the same applies to firm 2, and the prices of the two firms in period 0 are equal. This means that prices when firms respond to relative thinking are higher than when they do not. Because prices are equal and by assumption every consumer buys one unit, each firm sells to one half of the consumers (the half that is closer to the firm). This means that when responding to relative thinking the firms sell the same quantity but at a higher price, and therefore their profits are higher, and consumer surplus is lower. Total welfare (firms' profits + consumer surplus) is identical in period 0 with or without response to relative thinking, because the good's price does not affect total welfare (because it is a transfer from the consumers to the firms, so a price increase reduces consumer welfare by exactly the same amount that it increases firms' profits), and other than the good's price everything else is the same (quantity sold, the division of consumers to the firms, and transportation costs). *Q.E.D.*

[Figure 3 here]

As Proposition 2 shows, the response of firms to relative thinking, and in particular the understanding that their prices can affect the perceived transportation cost in the second stage, results in higher prices. The intuition is that the firms have an incentive to raise prices so that in the second stage the perceived transportation cost becomes higher, softening the competition between the firms and allowing higher profits. Knowing that response to relative thinking increases prices in period 0, we can look again at period 1 and analyze the effects of firms' response to relative thinking there. Proposition 3 describes the results of this analysis.

Proposition 3. Because of the higher prices in period 0, firms' response to relative thinking has the following effects in period 1: it increases prices and profits and reduces consumer surplus. Total welfare is unchanged if we use T as the transportation cost. However, if we compute total welfare using the perceived transportation cost, $t(p_1^0, p_2^0, T)$, then total welfare is reduced.

Proof. Proposition 1 shows that $p_1^1 = p_2^1 = t(p_1^0, p_2^0, T) + c$, and $\pi_1^1 = \pi_2^1 = t(p_1^0, p_2^0, T)/2$. Because firms' response to relative thinking results in higher period-0 prices, it also results in a higher transportation cost in period 1 (recall that $t(p_1^0, p_2^0, T)$ is increasing in p_1^0 and p_2^0). Therefore, Proposition 1 implies that prices and profits in period 1 are higher when firms respond to relative thinking. When we come to analyze consumer surplus and total welfare, we need to deduct the transportation costs, but there are two alternatives to consider.

One alternative is to take the objective transportation costs, consisting of the value of time, the cost of gasoline, etc. These are captured in *T* and do not change as a function of the good's price, and therefore they are the same regardless of whether the firms respond to relative thinking. Consumer surplus in period 1 is reduced as a result of the firms' response to relative thinking because of the higher period-1 prices. Total welfare is unchanged, because the higher prices do not affect total welfare (they increase the firms' profits and reduce consumer surplus by the same amount), and transportation costs are unchanged as explained above.

A second alternative is to take the perceived (subjective) transportation costs, $t(p_1^0, p_2^0, T)$, when computing consumer surplus and total welfare. Under this approach, transportation costs are higher when firms respond to relative thinking. Consequently, consumer surplus is reduced not only because of the higher period-1 prices, but also because of the higher transportation costs. The higher transportation costs, however, do not increase firms' profits, and therefore under this approach the total welfare is reduced when firms respond to relative thinking. *Q.E.D.*

It should be emphasized that while the effect of firm response to relative thinking seems to be similar in the two periods, the reasons for the higher prices are different. In period 0 the higher prices result from the firms' desire to increase the perceived transportation costs (in order to make more profits in period 1). In period 1, the higher prices (when firms respond to relative thinking) result from the higher prices in period 0 and the subsequent increase in transportation costs; the higher prices are no longer strategic means to achieve something in the future, as the higher prices in period 0 are.

4. Conclusion

Relative thinking is a phenomenon that has been addressed in several experimental studies, but with one exception (Azar, 2005c), its implications on firm strategy and market outcomes have not been explored before. This article examines how response of firms to relative thinking and their awareness that prices influence perceived transportation costs affect pricing strategy and market outcomes. The main finding is that the response of firms to relative thinking increases prices. Relative thinking causes firms to raise prices because this increases the perceived transportation costs, thus softening competition and allowing higher profits. Consumer surplus is reduced because of the higher prices, and under a certain interpretation, also because of the higher perceived transportation costs. Total welfare is unchanged if the objective transportation costs are used in the computation, but is reduced (in the second stage) if the subjective perceived transportation costs are used.

While this article focuses on the case of location differentiation and transportation costs, it seems reasonable that in the context of search the main findings (that response to relative thinking leads to higher prices and reduced consumer surplus) will also hold. When the consumer does not know the prices offered by various stores (for an identical good) and has to incur a search cost to find the price in each additional store, this can allow price dispersion in equilibrium (see for example Dana, 1994). The firms' pricing decisions are determined by a trade-off: increasing the price raises profits per sale, but decreases the number of sales because it increases the chances that the consumer will continue to search for a lower price and will buy elsewhere. Relative thinking implies that people make more effort to save a constant amount when the good's price is lower (and therefore the relative savings are higher). In terms of search models this implies that people behave as if their search costs are higher when the good's price is higher (because in search models what leads to less effort to search is higher search costs). Firms generally benefit from higher search costs, because it softens competition and increases their ability to charge higher prices without losing customers. Therefore, if firms take into account that their prices can affect the perceived search costs of the consumers (because of relative thinking), it gives the firms an additional incentive to raise prices. Consequently, it seems plausible that also in the search context, firms' response to relative thinking will increase prices and reduce consumer surplus. Showing this in a formal search model is beyond the scope of this article and is left as an idea for future research.

Analyzing how deviations of decision makers (consumers, workers, etc.) from rationality can be exploited by firms, and how these deviations and their exploitation can affect market outcomes, is an intriguing research direction that calls for more research, both in general and specifically about the bias of relative thinking. I hope that this article will encourage others to contribute to this literature.

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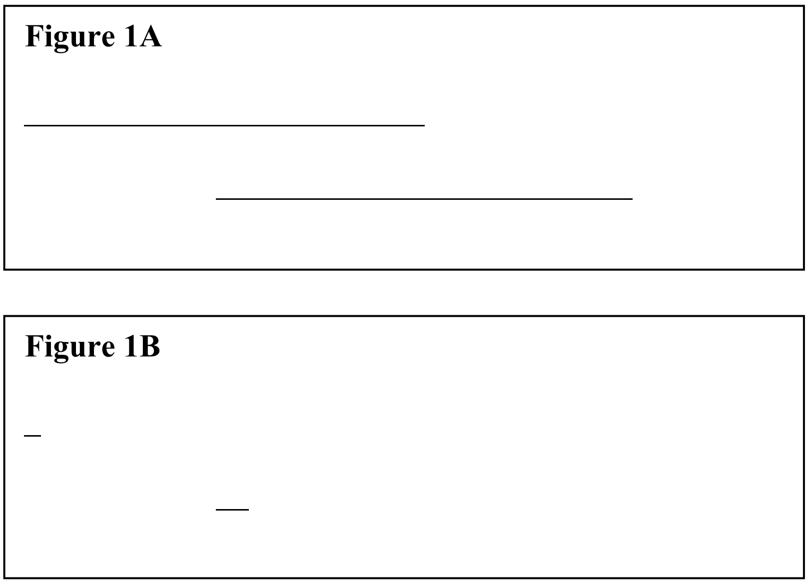
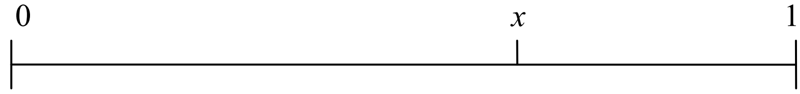
Figure 1. An illustration of the Weber-Fechner Law



Try to determine which line is longer in the two figures. In Figure 1B it is obvious that the lower line is longer. In Figure 1A the two lines seem to be of equal length. However, the bottom line in Figure 1A is also longer than the top one, and by the exact same magnitude of the difference in Figure 1B. This magnitude, however, is 4% of the top line in Figure 1A, and 100% of the top line in Figure 1B. Because the relative difference between the two lines is higher in Figure 1B, we can easily detect a difference in Figure 1B but not in Figure 1A, even though the absolute difference between the two lines is the same in both figures. This illustrates the Weber-Fechner Law, according to which our ability to distinguish between stimuli depends on their relative difference.

Figure 2: The linear city

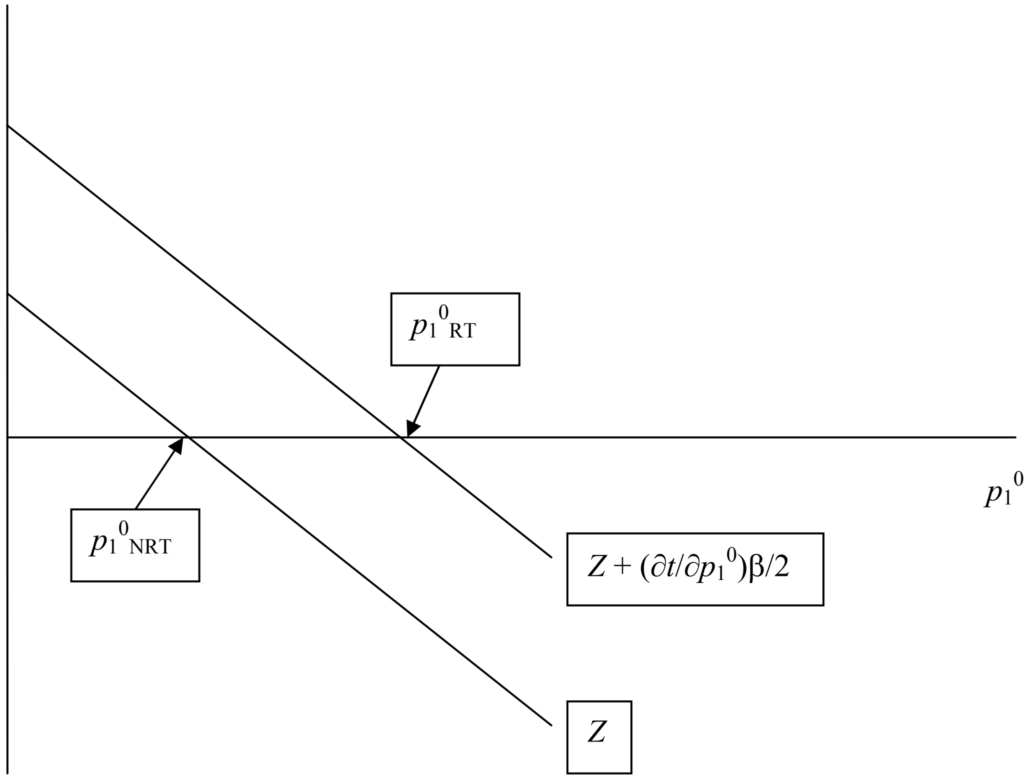


Firm 1
Price: p_1
Transportation cost: tx^2
Total cost: $p_1 + tx^2$

Firm 2
Price: p_2
Transportation cost: $t(1\text{-}x)^2$
Total cost: $p_1 + t(1\text{-}x)^2$

The figure depicts the structure of the linear city and the two firms, and the costs that a consumer located at some point x has to incur in order to purchase from each of the two firms.

Figure 3: Optimal value of p_1^0 with and without firm response to relative thinking



The figure shows how the value of p_1^0 is determined with and without firm response to relative thinking of consumers. Without such response, equation (3) implies that p_1^0 is determined by the equation $Z = 0$. The corresponding price is marked as $p_1^0{}_{NRT}$ (NRT stands for "no relative thinking"). With response to relative thinking, equation (4) suggests that p_1^0 is determined by the equation $Z + (\partial t/\partial p_1^0)\beta/2 = 0$. The corresponding price is marked as $p_1^0{}_{RT}$. As the figure shows, because Z is negative-sloping and $(\partial t/\partial p_1^0)\beta/2 > 0$, it must be the case that $p_1^0{}_{NRT} < p_1^0{}_{RT}$. The same analysis applies to p_2^0. Thus, firm response to relative thinking raises equilibrium prices in period 0.