Are Price Matching Guarantees Anti-Competitive?*

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Abstract

This paper examines the incentives for price-matching guarantees in markets where information about prices is costly. Under some conditions the conventional explanation of price-matching as facilitating collusion finds support, and is even strengthened, but our model provides an additional explanation for the practice. In many markets information about prices is difficult to obtain and assimilate, and the extent of price information varies across consumers. A price-matching guarantee may be a credible and easily understood means of communicating to otherwise uninformed consumers that a firm is low-priced. The credibility of the signal to uninformed consumers is assured by the behaviour of informed consumers.
1 Introduction

In many retail markets, sellers not only set prices but announce a guarantee that they will match the lowest advertised price that a customer can find in the market. Price-matching is observed in markets for sporting goods, personal computers, books, house wares, cell phones, office products, consumer electronics, luggage, furniture, tires, toys, gasoline, eyewear, prescription drugs, and grocery products, among others. Price-matching guarantees, or meeting-competition clauses as they are sometimes called, would appear to be pro-competitive. Customers do not complain about getting guaranteed low prices. Investment analysts have viewed announcements of price-matching as an increase in the intensity of competition.

In the economics and antitrust literatures, however, price-matching guarantees have a bad name. These announcements are seen as a way to collude. The argument is that price-matching guarantees facilitate cartel pricing by removing the incentive to undercut (Hay 1982, Salop 1982). The firm offering a price-matching commitment to buyers is in fact guaranteeing its competitors that any lower price from them would be matched immediately—eliminating the gains from the price cut. A second theory explains price-matching as a means of price discriminating among consumers (Png and Hirshleifer 1988). Firms offering price-matching guarantees provide discounts selectively to customers who shop for and are aware of lower prices in the market while charging a high list price for non-searchers. Edlin (1997) uses this argument to suggest that price matching policies be prosecuted as an unfair method of competition in violation of the FTC Act or the Robinson-Patman Act. In Edlin’s view, the market-wide impact of this practice is to limit the disciplining power of active shoppers on market pricing. Whereas price searchers usually provide a positive externality to non-searching customers by driving the price down for everyone, in a market with price-matching guarantees, the pro-competitive benefits of active price shopping are limited to

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1 Edlin (1997) and Arbatskaya, Hviid and Shaffer (1999). A well-publicized example of a price matching guarantee is Gateway’s announcement on May 30, 2001 that it would match key competitors’ prices on comparable PC’s. The Gateway Guarantee promises customers that if they “present a current ad from Compaq, Hewlett-Packard, Dell, IBM, Sony or Toshiba for a new PC or server with specifications at least equal to Gateway’s specifications,” then Gateway will sell them a comparable PC “for as much as $1 less than the advertised price of its rivals”. *The Wall Street Journal*, May 31, 2001. The press release accompanying the announcement notes that the guarantee will be launched “with broadcast and cable TV advertising, as well as a full-page ad in *USA Today* and dozens of local daily newspapers across the country.”

2 Investment analysts viewed Gateway’s announcement of price-matching as a step up in the P.C. price war, not a reduction in price competition (*Wall Street Journal, Ibid*).
the active shoppers themselves. The theory of price-matching as anti-competitive is thus extended to markets with large numbers of sellers.

Neither of the theories of anticompetitive price matching is compelling as an explanation of the wide range of markets in which the guarantees are observed. Prices do not appear to jump to monopoly levels when price-matching guarantees are offered, and the large number of firms in many markets where the practice is observed is also inconsistent with the basic cartel theory. The price discrimination theory accounts for the large number of firms and the fact that in most cases only some firms in a market offer the guarantees. But this theory also predicts that the price-matching firms set higher prices than non-price-matching firms. This prediction is inconsistent with the limited evidence available. Moreover, the price discrimination theory requires that a substantial number of consumers actually invoke their rights under the guarantee. If the theory were true, we would see in cashier lines many consumers bringing proof of lower prices in order to cash in on the guarantees, just as we see many consumers using product coupons (a bona fide price discrimination device). No evidence of a significant rate of cashing-in of the guarantees has been offered by the theory’s proponents.

This paper reexamines the incentives for price matching guarantees. Our theory is in the spirit of the industrial organization literature that explains observed business strategies as responses to specific transactions costs. Its central assumption is that price information is costly (Stigler (1961), Salop and Stiglitz (1977)). The costs are interpreted generally as the costs of obtaining, organizing and remembering information about prices offered at different retail stores. The costs include, for instance, the costs of obtaining and organizing newspaper ads, and memorizing the prices in them and even the costs of comparing the prices of the hundreds of personal computer configurations that are immediately available on the internet. The heterogeneity in these costs across consumers drives the main results.

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3 Arbatskaya, Hvid, and Shaffer (1999) examine advertised tire prices across the U.S., and do not find a statistically significant difference in the prices charged by price-matching firms and non-price-matching firms. If anything, price-matching firms seem to charge lower prices. [NTD: this claim needs substantiating.] The second type of evidence that casts doubt on the collusion effect is the simple finding that in experiments consumers believe that price-matching firms are lower priced than non-price-matching firms (Srivastava and Lurie 2001). Srivatava and Lurie exposed consumers to several simulated shopping environments in a controlled experiment and asked them questions about their perceptions of the price-matching and the non-price-matching stores. They find that subjects are more likely to stop searching, by as much as 25 percent, after they have been to a price-matching store than after they have been to a non-price-matching store. Consumers can be wrong, of course, but in general the observed behaviour of economic agents deserves some weight.

4 See, for example, Telser (1960), Katz (1986) and Bernheim and Whinston (xx).
of the theory. A firm’s pricing policy - to guarantee price matching or not - is relatively easily observed by consumers, however. Price matching guarantees emerge in our model as a credible way of advertising that “we are a low-priced outlet.” Such a signal is valuable because a price-matching announcement is much easier for busy consumers to assimilate than detailed price information on many products in a dynamic pricing environment. High time-cost customers choose to shop at an outlet because they are aware of its price matching policy and because this signals to them that the outlet is relatively low-priced. The credibility of the signal is ensured by the vigilance of the low time-cost customers, the customers who are aware of prices. Where optimal prices vary across firms, a high-priced store that offered a price-match guarantee would be forced to offer a low (and, for that firm, suboptimal) price to informed consumers. By directing busy consumers towards low-priced firms, price matching allows the low prices induced in the market by low-time-cost customers to be shared by busy customers. Thus price matching guarantees can facilitate the positive search externalities that active shoppers provide in markets with imperfect consumer information and transactions costs. This is the opposite of Edlin’s argument that price matching limits the extent of these externalities.

We start our analysis of price-matching guarantees by re-examining the cartel-facilitating theory of price matching in a traditional duopoly model with homogeneous products and zero transactions costs. We then add, in sequence: product differentiation (or travel costs), consumer heterogeneity in price information costs and firm heterogeneity in optimal pricing. The explanation of price-matching as a facilitating device is strengthened under some conditions along this path. The full set of assumptions, however, supports our theory of price-matching as conveying information about prices. We contrast the testable implications that emerge from our theory with those following from the two theories of price matching as anticompetitive. In the conclusion, we discuss a Grossman-Stiglitz (1980) paradox that emerges when one endogenizes consumers’ decisions to invest in information about prices rather than relying solely on announced price policies in decisions about where to shop.

2 The Model

2.1 Assumptions
We list at the outset the full set of assumptions of our model. This is the simplest set of assumptions that supports our theory of price-matching as information conveyance. In our initial reexamination of the traditional theory of price matching as a facilitating device and the extension of this theory to markets with various transactions costs, we invoke subsets of these assumptions.

1. Two firms, located at opposite ends of a unit line segment, compete in prices for the sale of a physically identical product.

2. Consumers are uniformly distributed along the line segment, with unit density. A consumer’s location is indexed by $s$.

3. Consumers bear a common travel cost, $t$, per unit distance, that is independent of the quantity purchased.

4. Consumers have a common, quasi-linear utility, $u(q) + e$ where $q$ is the amount of the product consumed and $e$ is expenditure on other goods. $u(\cdot)$ is strictly increasing and concave. Travel costs are independent of $q$, so the net surplus for a consumer at $s$ travelling to, say, firm 1 and purchasing at price $p$ is $v(p) - s\theta$ where $v(\cdot)$ is the indirect utility function corresponding to $u(\cdot)$. We assume that $v(0)$ is finite. A consumer’s demand function upon reaching a firm is $q(p) = -v'(p)$.

5. Firms face random, independent draws on unit costs of production: $c_L$ with probability $\lambda$ and $c_H$ with probability $(1 - \lambda)$; $c_L < c_H$.

6. After the simultaneous realization of costs, observed by both firms, the firms simultaneously decide whether to announce price-matching guarantees. A price-matching guarantee means that any consumer of a firm who has information as to the price charged by the other firm can obtain the same price at the firm where the purchase is being made. After the price-matching guarantee decisions, firms simultaneously decide on “list prices”.

7. A fraction $\alpha$ of the consumers at any location are uninformed about the list prices charged at the firms.\footnote{We emphasize that we are exploring the consequences of costly price information, but do not explain in the model why this information is costly. In reality, there are thousands of retail prices to keep track of at each outlet and price information costs are largely the time costs of organizing and retaining this information; in our model, however, each store sells a single product at a single price.} Price-matching guarantees, however, are observed by all con-
8. After prices are decided upon, all consumers each decide from which firm to purchase. Uninformed consumers condition their expectations as to the prices at the two firms on the firms’ decisions on whether or not to announce price-matching, and purchase where their expected consumer surplus net of transportation costs is higher. Uninformed consumers pay list prices. With respect to informed consumers, we must distinguish between list prices and transactions prices. The transactions price at a store that has announced price-matching is, for informed consumers, the minimum of its list price and the list price of its rival; the transactions price at a store that has not announced price matching is its list price.

9. The parameters of the model, under the condition that $\alpha = 0$, yields total profits that are concave in a common price charged by both firms, and individual profit functions that satisfy strategic complementarity and the contraction-mapping property.\(^7\)

2.2 Price-matching as a facilitating device

The theory of price-matching guarantees as supporting cartel pricing can be developed by considering two firms selling an identical product with identical costs, $c$, which decide simultaneously whether to announce price-matching guarantees prior to competing in prices.\(^8\) (In terms of the above set of assumptions, $t = 0$, $\alpha = 1$ and the distribution of costs is degenerate at $c$.) Let $m$ denote the monopoly price given demand $d(p)$ for the product,

\(^6\) In keeping with the assumption of bounded consumer rationality, we assume that consumers can remember only whether or not a firm has announced that it will at least match prices. Price beating policies, such as “we will refund 110 percent of any price difference” are therefore not considered.

\(^7\) This regularity condition on the demand functions is extended to the case of $\alpha > 0$ below, after the introduction of necessary concepts. Strategic complementarity means that each firm’s best response is a strictly increasing function of its rival’s price; the contraction mapping property is that the slope of the reaction function is strictly less than 1. The conditions on demand that are sufficient for these properties are the following: Given the parameters $t, c_L, and q(\cdot)$ for all $s_u \in (0, 1)$ and all $p_1, p_2 \in (c_L, 1)$, the demand $D_1$ facing Firm 1 satisfies: (1) $\frac{\partial^2 \ln D_1(p_1, p_2; s_u)}{\partial p_1 \partial p_2} > 0$, (2) $\left| \frac{\partial \ln D_1(p_1, p_2; s_u)}{\partial p_1} \right| > \frac{\partial \ln D_1(p_1, p_2; s_u)}{\partial p_2}$, and (3) $\left| \frac{\partial^2 \ln D_1(p_1, p_2; s_u)}{\partial p_1 \partial p_2} \right| > \frac{\partial^2 \ln D_1(p_1, p_2; s_u)}{\partial p_1 \partial p_2}$ and similarly for the demand facing Firm 2.

\(^8\) The set of Nash equilibrium under these conditions has been explained by a number of authors, first, we believe, by Chen (XX). Chen invokes a refinement of Nash equilibrium to support monopoly pricing as the only equilibrium, as we will do, but he uses a forward induction argument rather than our approach, which uses trembling-hand perfection. The elimination of equilibrium in Chen’s model requires both another transactions cost — that firms incur a positive cost to announce price matching — and that firms can implement price beating strategies as easily as price matching strategies.
and let “PM” and “noPM” refer to decisions to announce PM and not to announce PM, respectively.

**Proposition 1** If \( t = 0, \alpha = 0 \) and \( c_L = c_H \equiv c \), then in the sub-game following \{PM,PM\}, any \( p \in [c,m] \) can be supported as the Nash equilibrium transaction price for both firms. For the entire game, the set of subgame perfect Nash equilibrium actions includes PM adopted by both firms, PM adopted by only one firm or PM adopted by neither firm.

The first part of this proposition follows from the facts that if each firm chooses \( p \in [c,m] \) as its list price, following \{PM,PM\}, then neither has a positive incentive to increase its price since this will leave its transaction price unchanged; and either firm would lose by dropping its price because this would decrease the transactions prices of both firms, leave the price-cutting firm with half the profits of a monopolist that was charging less than the optimal price.\(^9\) The only equilibrium of the pricing subgame following \{no-PM, no-PM\} is clearly the Bertrand equilibrium \((c,c)\). Following PM by only one firm (say, Firm 1), the best response of Firm 2 to any \( p_1 \in [c,m] \) is to match \( p_1 \): above \( p_1 \), Firm 2 faces payoffs from \((p_1,p_2)\) identical to those of the unrestricted Bertrand game and will therefore not price higher than \( p_1 \) under Assumption 9, and Firm 2 will not undercut \( p_1 \) since it knows that any price drop would be matched automatically by its rival. Firm 1, however, will always undercut any price higher than \( c \) on the part of Firm 2. Therefore \((c,c)\) is the only equilibrium of this pricing subgame, as well. From this characterization of the equilibria in the subgames, it follows that \{PM,PM\} is part of a subgame perfect Nash equilibrium (e.g. the equilibrium in which \((m,m)\) follows \{PM,PM\}). The action pairs \{no-PM,PM\} and\{PM,no-PM\} are supported as actions of one subgame perfect Nash equilibrium by the selection of \((c,c)\) as the equilibrium of the pricing subgame following \{PM,PM\}. This selection leaves neither firm with the incentive to match a PM strategy. Finally, the pair \{no-PM,no-PM\} is part of a subgame perfect Nash equilibrium (whatever the equilibrium selected for the pricing subgame under \{PM,PM\}) since a unilateral move by one firm to PM has no impact on subsequent prices.

Thus, if we restrict ourselves to the conventional equilibrium concept, subgame perfect Nash equilibrium, the claim that cartel pricing can be supported by price-matching guar-

\(^9\) In addition, the pair of transactions prices \( \{p_m,p_m\} \) can be supported by a Nash equilibrium in which one firm sets a list price \( p_m \) and the other firm sets any list price above \( p_m \).
antees finds relatively weak formal support. It is one possible outcome of the appropriate game, but only one. Decisions on the part of both firms to refrain from price-matching is always an equilibrium. Moreover, even when price-matching is adopted by both firms, it may be followed by the competitive, Bertrand prices that would emerge without price matching.

2.3 Price Matching with Product Differentiation

The extension to product differentiation is captured by a single change in assumptions: let $t > 0$. Spatial models are often used to represent product differentiation in general (Eaton and Lipsey(1986)). In our context of retail markets, we have in mind a more literal interpretation of travel costs, with the location of a consumer representing the relative convenience to the consumer of one store versus the other to purchase an identical good. Retail shopping is not costless and it is natural to ask how these costs affect the use of price matching guarantees as a facilitating device.

**Proposition 2** If $t > 0$, $\alpha = 0$ and $c_L = c_H \equiv c$, then in the sub-game following \{no-PM, no-PM\} the unique Nash equilibrium has both firms setting the Bertrand price $p_B$, which satisfies $c < p_B < m$. In the subgame following \{PM, PM\}, any $p \in [c, m]$ can be supported as the Nash equilibrium transaction price for both firms. For the entire game, the set of subgame perfect Nash equilibrium actions includes PM adopted by both firms, PM adopted by only one firm or PM adopted by neither firm.

The proposition reads identically to Proposition 1, except that $t > 0$, and the proof is the same. But in this case of product differentiation, price matching carries the threat of making the market *more* competitive: the range of equilibrium prices in the sub-game following \{PM, PM\} includes $[c, m]$ which are less than the Bertrand price that prevails without price matching. The threat of greater competition can rationally – i.e. as part of a subgame perfect equilibrium – deter a firm from matching its rival’s PM strategy. In the sense that the recognition of product differentiation introduces the “strategic uncertainty” that PM can lead to more intense competition, the power of price matching as a facilitating device is weaker than previously understood in the literature – again, subject to the acceptance of subgame perfect Nash equilibrium solution as the appropriate solution concept.

To the extent, however, that one is willing to trust a refinement of this equilibrium concept, the theory of PM as a facilitating device is sustained. Suppose that in the
subgames under \{PM,PM\}, in either the traditional case or the product differentiation case, we assume that an individual player is unsure of which price its rival going to play. (Contrary to the assumptions of Nash equilibrium, the player does not know with certainty which action the rival is going to take but instead perceives the rival as having a “trembling hand”, setting each price with positive probability.) Then each player would adopt the monopoly price: whatever the realization of its rival’s strategy, the player is never worse off by adopting \(m\) rather than any other price \(\hat{p}\), since if the rival’s price is below \(\hat{p}\) the rival’s price determines the same transactions price for both firms whether \(m\) or \(\hat{p}\) is played whereas if the rival’s price is above \(\hat{p}\), then the play of \(m\) ensures a higher set of transactions prices (but not higher than \(m\)) and therefore yields a higher payoff. The requirement that a Nash equilibrium be robust in this sense is captured by the refinement of “normal form trembling hand perfection”.\(^{10}\) In a trembling hand perfect equilibrium, the \((m,m)\) price pair is ensured following price matching by both players since this is the only pair of strategies that are not weakly dominated.

Moving up the game tree to the price matching decisions requires another application of trembling hand perfection. The pair of actions in which neither player is adopting PM is part of a subgame perfect Nash equilibrium (even anticipating the \((m,m)\) price pair following \{PM,PM\}) since unilateral adoption of PM has no impact on payoffs. Again, however, the attribution to each player of the anticipation of a “tremble” on the part of the rival leads to \{PM,PM\} as the predicted outcome since no-PM is for each player weakly dominated by PM. In sum:

**Proposition 3** If \(\alpha = 0\) and \(c_L = c_H \equiv c\) (whether \(t > 0\) or \(t > 0\)), the only trembling hand perfect equilibrium in the pricing subgame following \{PM,PM\} is \((m,m)\). The normal form trembling hand perfect equilibrium for the entire game yields \{PM,PM\} and \((m,m)\).

### 2.4 Price Matching with Uninformed Consumers

The next transactions cost ingredient, or “market imperfection”, along the path towards our full set of assumptions is heterogeneous consumer information about prices. The

\(^{10}\) Define a totally-mixed strategy as a mixed strategy that puts positive probability on each element a strategy set. A normal form trembling-hand perfect equilibrium is a strategy pair \((\sigma_1, \sigma_2)\) that is the limit of some sequence \((\sigma_1^n, \sigma_2^n)\) of totally mixed strategies with \(\sigma_i\) being a best response to \(\sigma_j^n\), all \(n, i \neq j\) (Selten (1975)). Note that the Kreps-Wilson sequential equilibrium concept is generically equivalent to the trembling hand perfect equilibrium concept, but is inadequate to reduce the number of Nash equilibria here.
assumption of costly information about prices has a long tradition in industrial organization (Stiglitz (1961)). We adopt Salop-Stiglitz (1977) style assumption that some proportion, \( \alpha \), of consumers don’t shop at all, but just buy (in our model) at the nearest store.\(^{11}\)

Surprisingly, even an arbitrarily small number of uninformed consumers strengthens the facilitating-device theory of price-matching guarantees. Whereas the prediction of cartel pricing following price-matching previously required a refinement of the Nash equilibrium concept, with even a small number of uninformed consumers, this outcome follows as an equilibrium in strictly dominant strategies.

Given actual prices \((p_1, p_2)\), the demand facing Firm 1 is given by

\[
D_1(p_1, p_2, s_u) = [(1 - \alpha)s_I(p_1, p_2) + \alpha s_u] \cdot q(p_1) \tag{1}
\]

where \(s_I(p_1, p_2) \equiv \frac{1}{2} + \frac{[v(p_1) - v(p_2)]}{2t}\) is the marginal informed consumer, and \(s_u\), the marginal uninformed consumer, is equal to 1/2 following symmetric price-match decisions. Similarly for Firm 2. Note that the elasticity of the demand flowing from the uninformed consumers is the only elasticity of \(q(p_1)\), which is the market elasticity of demand. All consumers who purchase from a particular firm purchase the same amount.

We denote profits as \(\pi_i(p_1, p_2, s_u; c_i) = (p_i - c_i)D_i(p_1, p_2; s_u)\). It is convenient to denote \(\pi^I_1(p_1, p_2, c_1) = (p_1 - c_1)s_I(p_1, p_2)q(p_1)\) as Firm 1’s profits per unit density from informed consumers. Similarly \(\pi^U_1(p_1, s_u, c_1) = (p_1 - c_1)s_uq(p_1)\) so that \(\pi_i(p_1, p_2, s_u; c_i) = \alpha\pi^U_1(p_1, s_u, c_1) + (1 - \alpha)\pi^I_1(p_1, p_2, c_1)\). It is important to note that at the stage of the game when the two firms compete in prices, each is taking its endowment of uninformed customers over which it has monopoly power as exogenous.

**Proposition 4** If \(\alpha > 0\) and \(c_L = c_H \equiv c\) (whether \(t > 0\) or \(t > 0\)), then in the subgame following \{PM,PM\}, \((m,m)\) is a dominant strategy equilibrium.

Equilibrium in strictly dominant strategies is the strongest form of prediction in game theory, stronger in particular than Nash equilibrium in that it relies simply on the assumption that each player chooses a strategy that guarantees strictly higher payoffs than any other strategy whatever the strategy chosen by the player’s rival. With \(\alpha > 0\), each firm’s payoff now includes both the payoff from selling to informed consumers, which follows from the price-matching game described, as well as the payoff as a monopolist selling to its share

\(^{11}\) Under the full set assumptions, with firm heterogeneity, we will allow uninformed consumers to base their price expectations on information that they do have, the firms’ price-match policies.
of the $\alpha$ uninformed consumers. The price $m$ remains a weakly dominant strategy with respect to the game played for the demand of informed consumers, but is the strictly optimal monopoly price. Adding the payoffs from selling to the two groups of consumers, i.e. deriving profit from the demand given by equation (1) and the price-matching payoffs, yields $m$ as a strictly dominant strategy, for arbitrarily small $\alpha$, proving the proposition.

This result contrasts sharply with Hviid and Shaffer (1999) who argue that even an epsilon amount of transactions costs of a different kind – costs of redeeming a price-matching offer – moves a price equilibrium following price-matching from collusive pricing to marginal cost pricing. The mere presence of an epsilon of high-transactions cost consumers in our model serves to strengthen, not weaken, the cartel-facilitating role of price-matching in that it eliminates completely the coordination problem that arises when there is a continuum of equilibrium between marginal cost and monopoly price. As a general matter, the impact of even an arbitrarily small amount of transactions costs on market organization can be very sensitive to the nature of the transactions costs.

2.5 Price matching as information provision

The final ingredient in our transactions cost theory is firm heterogeneity. Any source of firm heterogeneity that leads to differences in optimal prices across firms will do. Possible sources of firm heterogeneity in reality include vertical differentiation, e.g. choice of an up-market location versus an inconvenient but low-rent location, a difference in the service levels provided by stores, or cost differences between firms. The key is that whatever the source of heterogeneity, a high-priced firm would find it costly to delegate its pricing decision to a low-cost firm because of the differences in optimal pricing. Price-matching inherently involves delegation of the decision on transactions prices to the firm that is, in equilibrium, lower priced. Market conditions giving rise to some cost to a high-priced store of such delegation means that a high-priced store will not mimic the price-matching behavior of a low-priced store, and thus provide some foundation for a theory of price-matching as

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12 When firms sell undifferentiated products even a penny of consumer transactions cost in redeeming a price-matching offer is enough to allow a firm profitably to undercut the prevailing price, making the entire collusive arrangement unravel. This is because consumer, having observed an undercutting firm, would prefer to buy from the undercutting firm rather than incur the transactions cost of invoking his or her rights under the price-matching guarantee at the higher priced store. This argument, however, depends upon firms being completely identical from the perspective of each consumer and hence is ruled out if one recognizes an additional transactions-cost based feature of retail markets, that a consumer finds some stores more convenient than others.
signaling low-prices. We adopt the simplest source of such market conditions, a random difference in the unit cost of the two firms.

While uninformed consumers do not observe prices, they can observe the price-matching policy of the firm. This assumption captures in extreme form the ease with which price-matching policies are observed relative to prices. We thus have the full set of assumptions laid out at the beginning of this section. We look for the perfect Bayesian equilibrium in the game described by these assumptions. The equilibrium consists of (1) a “price-match decision” (to announce a price-matching guarantee or not) contingent upon the pair of cost realizations, and a price on the part of each firm, contingent upon the history of cost realizations and policy decisions; (2) purchase decisions by each consumer; and (3) an expectational distribution on the part of each uninformed consumer, as to the price set by each firm, given the firm’s observable decision on price-matching, that satisfy: (i) rationality of each consumer’s purchase decision, given that consumer’s expectations if the consumer is uninformed; (ii) profit-maximization on the part of each firm given the mapping from its policy decision into consumer expectations and the strategy by its rival; and (iii) consumer expectations that are rational, i.e. that satisfy Bayes’ law (along the equilibrium path of the game) given the equilibrium policy decisions by firms and the probability $\lambda$.

The equilibrium that we have described cannot be solved via backwards induction, since there are no proper subgames (subgames not linked by consumers’ information sets). However, the simple demand structure of the model provides an approach to solving the game, which involves finding expectations that are self-realizing. Consider an arbitrary set of price expectations on the part of uninformed consumers, i.e. an expected price at each outlet for each combination of price-match decisions. Let $\hat{V} = (\hat{v}_{00}, \hat{v}_{01}, \hat{v}_{10}, \hat{v}_{11})$ represent the surplus expected from Firm 1 by each uninformed consumer, gross of transportation costs, in each of the consumer’s information sets: $v_{01}$, for example, is the consumer’s expected surplus following the consumer’s observation that Firm 1 has not announced price-matching ($i = 0$) and if Firm 2 has announced price-matching ($j = 1$). These expectations determine a partition of the set of uninformed consumers, which in turn determines for each firm a measure of “captive” uninformed consumers, each with demand $q(P)$, over which

\[\text{13} \text{ A consumer more easily remembers a price-matching policy, perhaps from shopping at a store for other items, than the specific prices of all items that the shopper may need to purchase. Alternatively, in the case of personal computers, the prices of each of the dozens of available configurations may be easily available, but costly to compare. The announcement of a price-matching guarantee is easily understood.} \]

\[\text{14} \text{ Expected surplus from Firm 2 is given symmetrically.} \]
the firm has monopoly power: uninformed consumers have rational price expectations in
equilibrium but do not respond, in their decisions of where to purchase, to (off-equilibrium)
changes in a firm’s price. The impact of the game’s history at the point of simultaneous
decisions on prices is summarized by these two amounts of captive consumers, as well as
by which of the two firms are competing under the constraint of a binding price-matching
agreement. We refer to the pricing game that is induced by an arbitrary set of expectations,
or an arbitrary allocation of uninformed consumers to the two firms, as an induced price
game.

We proceed by starting with an arbitrary set of expectations \( \hat{V} = (\hat{v}_{00}, \hat{v}_{01}, \hat{v}_{10}, \hat{v}_{11}) \). We consider the equilibrium in the pricing decisions induced by the expectations \( \hat{V} \) and each pair of price matching decisions. The payoffs from the set of subsequent induced
price games will determine optimal price-matching policy decisions at each cost pair drawn
by Nature. Finally, the optimal price-match decisions and the equilibrium prices of the
induced price games determine a set of “actual” expected surpluses conditional upon each
pair of policy decisions, \( \hat{V} = (v_{00}, v_{01}, v_{10}, v_{11}) \), which are determined by the equilibrium
policy and pricing decisions and the probability \( \lambda \). This procedure defines an operator \( \Phi \), via
\( \Phi(\hat{V}) = V \), on the possible set of surplus expectations in \( \mathbb{R}^4 \). A fixed point of \( \Phi \), \( V^* \), yields
a Bayesian Perfect equilibrium as the equilibria of the associated induced price games, and
the equilibrium policy decisions that follow from these induced price games. In fact, if the
game’s history at the point of the pricing decisions includes symmetric price-match decisions,
then the marginal uninformed consumer is at \( s = 1/2 \), and the induced pricing game includes
equal endowments of captive uninformed consumers. If the history includes asymmetric
price-match decisions, then the effect of expectations can be summarized by the marginal
uninformed consumer, \( s_u \). If the history includes price-matching by Firm 1 only, for
example, the marginal consumer given the expectations, satisfies \( v_{10} - s_u t = v_{01} - (1 - s_u) t \),
i.e. \( s_u = \frac{1}{2} + \frac{(v_{10} - v_{01})}{2t} \). The entire history of the game at the stage of price competition,
as it affects the outcome of the various induced pricing games, can thus be summarized by
a single expectations parameter, \( s_u \), as well as by which of the firms have announced price-
match guarantees.\(^{15}\)

Starting with an arbitrary parameter \( s_u \), we examine the price games induced by \( s_u \) (and

\(^{15}\) The summary of expectations by a single parameter, in the search for self-realizing expectations, allows
us to use the simplest of all fixed-point theorems, in applying the intermediate value theorem to show that
a particular function crosses the 45 degree line.
\( s = 1/2 \) for symmetric price-match decisions) following all possible histories of the game up to the pricing decisions. The payoffs from the induced price games then determine the payoffs from the price-match decisions. The task is to find price-matching decisions and pricing decisions that are individually rational given \( s_u \), and which in turn generate \( s_u \) as rational on the part of consumers. To this end, we refer to Figure 1, which is a substantially summarized depiction of the game tree. At the top of the tree, nature draws random costs for each firm from \( \{c_L, c_H\} \). The four possibilities are summarized in the diagram by the outcomes of symmetric costs (\( c_1 = c_2 \)), the asymmetric cost outcome \( c_1 < c_2 \); and following the asymmetric cost outcome \( c_1 < c_2 \) we have drawn only one branch. Following the cost realization, firms take price-match decisions from \( \{1, 0\} \) where 1 denotes a price-match announcement and 0 denotes a decision not to announce price-matching. After a symmetric cost realization, it is enough to keep track of three price-match histories: both choose 1, both choose 0, or only one firm (say, firm 1) chooses 1. After asymmetric cost realizations, however, we must keep track of both asymmetric price match decisions, \( (1,0) \) and \( (0,1) \). In sum, there are ten induced price games that must be solved for. Symmetry allows us to reduce these to the seven games labelled 1 through 7 in Figure 1, although we include in the figure one node or induced pricing game from the cost realization where \( c_1 > c_2 \).

The price games following price-match decisions \( (1,0) \) are grouped in an “information set”, which (again, in summary form) corresponds not to the information of players taking decisions at the nodes in the set but rather to the information of consumers. Consumers cannot distinguish among these three nodes. The price games in this information set are induced by the same \( s_u \), the single parameter summarizing consumer expectations; the remaining price games depicted in the diagram follow symmetric price-match choices and are induced by \( s = 1/2 \).

To characterize the induced price games, we first extend the regularity assumptions on demand (assumption 9) to the price games induced by arbitrary \( s_u \):

9A The demand functions (equation (1)) conditional upon arbitrary \( s_u \) yield total profits that are concave in a common price charged by both firms, and individual profit functions that satisfy strategic complementarity and the contraction-mapping property.\textsuperscript{16}

\textsuperscript{16} The conditions that must be satisfied by the demand functions are given in footnote XX. These have been verified for a wide range of numerical parameters for the model, but are violated in some ranges, where only mixed strategy equilibria exist. In considering the range of parameters where payoffs are well-behaved, we follow a long tradition in the economics of spatial models (see Eaton and Lipsey (19XX)).
**Equilibria in induced price games:** We discuss the equilibria in the induced price games in the following order: 1, 4, 2, 7, 3, 5, 6 and 8. The induced price game at node 1 is simply the Bertrand game with symmetric costs, with an equilibrium price between cost and the monopoly price; the equilibrium price reflects the endowment by each firm of half of the captive (uninformed) consumers. The equilibrium at node 4 is also a Bertrand equilibrium, conditional upon $s = 1/2$, but with asymmetric costs. The game at node 2 results in cartel pricing, $(m, m)$ – in fact as a dominant strategy equilibrium. The equilibrium at node 7 also yield monopoly prices, $(m_1, m_2)$. At this node, the low-cost firm, Firm 1, sets its monopoly price since this maximizes both its profits from informed consumers (for which this firm has been delegated the decision of which transactions price to set for both firms) and its profits from uninformed consumers. The high-cost firm, Firm 2, delegates its pricing for informed consumers and simply sets its own (higher) monopoly price as its list price for uninformed consumers. Firm 2 has no incentive to reduce its price within the range $(m_1, m_2)$ since this only lowers its profits from uninformed consumers, and has no incentive to lower its price below $m_1$ since this price drop would be automatically matched by Firm 1 with a consequent drop in Firm 2’s profits.

Returning now to node 3, we show first that a pure strategy equilibrium does not exist in this subgame. Note that Firm 2’s transaction price for all consumers is its list price. Its best response function is $BR_2(p) = p$ for all $p \in [p^B, m]$ where $p^B$ is the Bertrand equilibrium price that would set in a price game induced by the same $s_u$ but without price-matching. This is because (a) Firm 2 knows that any price cut below $p$ will be automatically matched for its informed consumers by Firm 1, and since $\pi_2(p, p)$ is decreasing in $p$ in this range such undercutting does not pay; and (b) under the regularity conditions on demand, $\pi_2(p, p_2)$ is decreasing in $p_2$ for $p_2 \geq p \geq p^B$ so responding with a price $p_2 > p$ would not be profitable. (To summarize (a) and (b), were it not for the price-match guarantee, it would pay Firm 2 to undercut any price $p \in (p^B, m]$ by Firm 1, but facing a price-match guarantee, the best that Firm 2 can do is match Firm 1.) Firm 1’s profits, however, are always higher by setting $m$ than by matching any price $p$ less than $m$ since by raising its price to $m$ Firm 1 collects maximum profits from the captive uninformed consumers without affecting its price $p$ (obtained under the price-matching guarantee) to informed consumers. It follows that the only possible pure strategy equilibrium is $(m, m)$. But this pair is not an equilibrium: $BR_1(m) < m$ because the elasticity of $D_1$ at $(m, m)$ exceeds the elasticity of the demand
curve \( q(p) \) (as seen from equation (1)); i.e. it pays Firm 1 to undercut Firm 2 at this price pair.

A mixed strategy equilibrium exists per Glicksberg’s (1952) theorem since the payoff functions of the firms are continuous. Using a conventional argument, we can show that under the regularity assumptions on demand, the strategy subset \([0, p^B]\) can be eliminated through iterated strict dominance.\(^{17}\) Moreover for Firm 2, \((m, \infty]\) is strictly dominated by \(m\) since \(\pi_2(p_1, p_2)\) is decreasing in \(p_2\) for any \(p^1\) and any \(p_2 > m\) and similarly for Firm 1. Thus only the strategy subset \([p^B, m]\) for each player survives iterated elimination of strictly dominant strategies. The supports of mixed strategy equilibrium strategies are always contained within strategy sets surviving the iterated elimination of strictly dominant strategies. In sum, the induced price game at node 3 yields a mixed strategy equilibrium with supports in \([p^B, m]\).

We arrive at node 5. There are two possibilities here, depending on model parameters. If a pure strategy equilibrium exists, it is the same as the asymmetric-cost Bertrand equilibrium, with the price-matching by the low-cost firm, Firm 1, having no impact on the equilibrium (conditional upon \(s_u\)). Firm 1’s best response to \(p^B_2\), however, may be to raise its list price to \(m_1\) thus charging the optimal price to its share of uninformed consumers and leaving the transactions price for its informed consumers at \(p^B_2\), which is higher than

\(^{17}\) To prove that the strategy subsets \([0, p^B_1]\) and \([0, p^B_2]\) can be eliminated through iterated strict dominance under the price game following price-matching by Firm 1 only, note first that these subsets can be eliminated through iterated strict dominance of the unconstrained pricing game because under the regularity conditions in assumption 9A, this game has a unique Bertrand equilibrium and satisfies strategic complementarity. The results of Milgrom and Roberts (1990) imply that in any strategic complementarity (more generally, supermodular) game with a unique equilibrium, the equilibrium can be solved via iterated elimination of strictly dominated strategies. Next, the same iterated elimination procedure eliminating the strategy subsets \([0, p^B_1]\) and \([0, p^B_2]\) in the unconstrained pricing game continue to hold in the game following price-matching by Firm 1 only. For Firm 2, if a particular interval \([0, P_2]\) is eliminated from Firm 2’s strategy set because any \(p \in [0, P_2]\) is dominated by some \(\tilde{p} > P_2\), then \(\tilde{p}\) continues to dominate \(p\) in the price-game following price-matching by Firm 1, because raising price from \(p\) to \(\tilde{p}\) now not only increase’s Firm 2’s own price but possibly its rival’s price as well. To make the analogous argument for Firm 1, let \(p \in [0, P_1]\) is dominated by some \(\tilde{p} > P_1\). Raising price from \(p\) to \(\tilde{p}\) is still dominant against any \(p_2 < p\) since this would increase price for the uninformed consumers while leaving the price for the informed consumers unchanged; if raising price to \(\tilde{p}\) were profitable in the unconstrained game, an increase to this price must be profitable for only the uninformed consumers. Raising price from \(p\) to \(\tilde{p}\) is dominant against any \(p_2 > \tilde{p}\) is profitable since over this range the profit of Firm 1 is unaffected by the price-match constraint. Finally, consider any \(p_2 \in [p, \tilde{p}]\). Raising price from \(p\) to \(p_2\) is profitable for Firm 1 in the unconstrained game because assumption 9A ensures the concavity of profits in price for Firm 1 in this game; the same increase is profitable in the price-match game since over this range Firm 1’s profits are unaffected by the constraint. Raising price further from \(p_2\) to \(\tilde{p}\) is profitable since this increase has no effect on the price paid by informed consumers but does increase the price paid by uninformed consumers. Thus \(p\) continues to dominated by \(\tilde{p}\) in the price-match game. Since the iteration of strictly dominant strategies eliminates \([0, p^B_1]\) and \([0, p^B_2]\) in the unconstrained game, it eliminates these sets in the pricing game following price-match by Firm 1 only.
The condition determining whether the pure strategy equilibrium will emerge is the inequality in
\[
\pi_1(p_1^B, p_2^B) = s_u \cdot \alpha \pi_U^1(p_1^B) + (1 - \alpha) \pi_I^1(p_1^B) \geq s_u \cdot \alpha \pi_U^1(m_1) + (1 - \alpha) \pi_I^1(p_2^B, p_2^B) \quad (2)
\]
The first term on the right hand side of this equality is greater than the first term on the left hand side; Firm 1 gains profits from the uninformed consumers by raising its price. But the second term decreases moving from the left hand side to the right hand side: the best response to \(p_2^B\) with respect to \(\pi_I^1\) is less than \(p_1^B\) (which is the best response with respect to \(\pi_1\)) since the demand from informed consumers alone is more elastic than the total demand. Increasing price from \(p_1^B\) to \(p_2^B\) is moving further away from the \(\pi_I^1\)-best response and therefore decreases \(\pi_I^1\) under the regularity conditions on demand. This condition is met if \(\alpha\) is sufficiently small or the cost difference, \(c_H - c_L\) sufficiently large. Since small \(\alpha\) and large cost differences will be required for our main proposition, we focus on the case where condition (2) is satisfied. (If condition (2) is violated, then only a mixed strategy equilibrium exists.)

Finally, node 6 and its symmetric equivalent node 8 may involve the pair of monopoly prices \((m_1, m_2)\) that resulted when both firms had announced price-matching. At these nodes, only the high-cost firm has announced price matching. At node 6, \(m_1\) is still a best response to \(m_2\) for the reasons given above, but under some parameters it may pay Firm 2 to undercut \(m_1\): Firm 2’s profit at its (Bertrand) best response to \(m_1\) may exceed its profit from accepting transactions prices \(m_1\) and \(m_2\) in response to \(m_1\). In this case one can show that only a mixed strategy equilibrium exists, following arguments similar to those above. Similarly for node 8. This completes the characterization of equilibria in the induced price games.

**Equilibrium price-match decisions:** We consider next the equilibrium price match decisions, and start with the temporary supposition that \(s_u = 1/2\) at the information set drawn in Figure 1. Given this value for \(s_u\), the only impact of changes in price-match decisions in the left-hand side of the game tree is on the equilibrium prices rather than the allocation of captive consumers (\(s_u\) being constant over the induced price games). Starting from the \((0,0)\) branch, the impact on Firm 1 of adopting price-matching is to move to an equilibrium (node 3) in which the prices of both players are random variables with supports on \([p^B, m]\). Because Firm 1’s transaction price to informed consumers is never undercut by Firm 2 in the latter equilibrium – Firm 1 has a price-match policy in force – Firm 1 is
guaranteed a higher payoff in the latter equilibrium whatever the realization of the mixed strategies (except for one realization: \( p^B \) for both firms). \((0,0)\) is therefore not on the equilibrium path, given the supposition of \( s_u = 1/2 \). But now price-matching by a single firm (say, Firm 1) is not an equilibrium under the supposition since Firm 2 can gain half the monopoly profits by matching Firm 1’s price matching announcement. Firm 2 earns at most \( \pi_2(p_2, p_2) \) under any realization \( p_2 \) of its own mixed strategies in the game at node 3 because it is never able to undercut Firm 1’s transaction price (Firm 1 having committed to price matching at this node). This payoff is less than \( \pi_2(m, m) \), which is half the monopoly profits, except for the realization \( p_2 = m \). In short, if equilibrium expectations elicit \( s_u = 1/2 \) at the information set drawn, then the information set will not be reached through any branches on the left hand side of the game tree. This result clearly extends to \( s_u > 1/2 \) since then adopting price matching (whether the rival has or not) carries the added benefit of increasing the set of captive consumers for either firm.

If \( s_u > 1/2 \) in equilibrium then the information set drawn is also not reached through node 8. Label as "node 9" the induced price game following \( c_2 < c_1 \) and \((1, 1)\); this induced price game yields equilibrium prices \((m_1, m_2)\) just as node 7 does, but at node 9, \( m_2 < m_1 \). Firm 2 has the option of matching Firm 1’s price-match announcement and ensuring the pair of equilibrium prices \((m_1, m_2)\) obtained in the induced price game at node 9. When faced with a rival that has committed to price-matching, as Firm 1 has at both nodes 8 and 9, the maximum profits that Firm 2 can attain over any pair of prices \((p_1, p_2) \in [c_1, m_1] \times [c_2, m_2] \) is achieved at \((m_1, m_2)\): at this pair, Firm 2 achieves maximum profits from uninformed consumers and half (the maximum fraction possible) of the profits from informed consumers that would be earned by a monopolist with cost \( c_1 \). When \( s_u > 1/2 \), Firm 2 gains by moving from the node 8 game to the node 9 game in ensuring the pair of prices that maximizes its profits (if \((m_1, m_2)\) is not also the equilibrium at node 8, which it may be) and by gaining a higher share of captive consumers. Node 8 is thus not reached in equilibrium if \( s_u > 1/2 \).

To find a Perfect Bayesian Nash equilibrium to the game, it remains to show that (a) at the single node, 5, remaining in the information set, self-fulfilling expectations on the part of the uninformed consumer can support a marginal uninformed consumer, \( s_u > 1/2 \); and (b) \((1,0)\) is the optimal price-match decisions following a cost realization in which Firm 1 alone has a low cost. To show (a), consider the marginal informed consumer, \( s_I \), that results from the price game at node 5 by an arbitrary \( s_u \), and define the functional relationship
by \( s_I = G(s_u) \). To find a self-fulfilling, it is sufficient find a fixed point \( s_u^* \) of \( G \), i.e. a marginal uniformed consumer that elicits an identical marginal informed consumer, since then assigning as expectations to the uninformed consumers the prices that actually result from \( s_u^* \) will result in prices that confirm these expectations.\(^{18}\) To this end, note that \( G \) is a strictly decreasing function, since a shift in the share of captive consumers from Firm 1 to Firm 2 will lower \( p_1 \) and raise \( p_2 \) in the induced price game, thus inducing more informed consumers to shop at Firm 1. Note further that \( G \) is continuous and, since \( c_1 < c_2 \), \( G(1/2) > 1/2 \). The three properties of \( G \) suffice, by the intermediate value theorem, to show that \( G \) has a fixed point \( s_u^* > 1/2 \).

The final ingredient is the demonstration that \((1,0)\) can be individually rational price-match decisions, following a cost realization \((c_L, c_H)\). Firm 1 is responding optimally to no-price-match on the part of Firm 2, since the only impact of its price-match announcement is to attract more captive consumers. The price-match announcement by a low-cost firm has no impact on the price game once the allocation of captive consumers is determined. Now, there are clearly parameters in the model for which Firm 2 will respond by matching Firm 1’s price-match announcement. In particular, if the possible cost difference between the firms is sufficiently small then the only equilibrium is the collusive equilibrium that obtains with identical costs. If the cost difference is large, however, and the proportion of informed consumers is large, then Firm 2 will only lose profits by matching Firm 1. To see this, select an extreme cost difference: suppose that the cost difference is so large that \( m_1 < c_2 \). In this case, by matching Firm 1’s price-match announcement, Firm 2 causes its transactions price to informed consumers to fall below costs. If the proportion of informed consumers is large, then Firm 2 clearly loses from this strategy. In sum:

**Proposition 5** Under assumptions 1 to 9A, if \( c_H - c_L \) is sufficiently large and \( \alpha \) sufficiently small, ceteris paribus, then a Perfect Bayesian Nash equilibrium exists in which under an asymmetric cost realization only the low-cost firm adopts price matching. In equilibrium, uninformed consumers rationally infer that if only one firm is adopting price matching, that firm has a lower price.

The critical parameter separating the case of PM emerging as a strategy signalling a low price from the role of PM as a cartel-facilitating device is the cost difference in the two

\(^{18}\) Here we take advantage of the assumption that informed and uninformed consumers have the same travel cost, \( t \).
firms. The logic of this proposition hinges on the delegation aspect of PM: when invoked by a high-cost firm, PM essentially delegates to the low-cost firm the decision of which price both firms should charge to the informed consumers. Delegation under PM of the prices for all firms to a single firm has the attraction that the price will be set closer to the cooperative level than the Bertrand price of the low-cost firm. When cost differences are large, however, this advantage is more than offset by the damage imposed on the high-cost firm by a policy of PM, arising from the delegation of its pricing decision to a firm whose costs and optimal price are very different from its own. In this case, uninformed – but rational – consumers know that the behaviour of informed consumers in invoking their PM rights would penalize the high-cost firm if the latter offered a PM guarantee. These consumers know, therefore, that the announcement of PM must therefore signal a relatively low-cost and low-price firm.

The proof of the proposition, as outlined, adopts an extreme cost difference, resulting in \( m_1 < c_2 \); a cost difference this large, however, is not necessary for the equilibrium described to emerge. Moreover, we have in mind that the group of firms (here, 2 firms) that are interacting strategically face some competition from possibly close substitutes outside the model, so that even a moderate cost difference may bring the “monopoly” price of the low-cost firm near the cost of the high-cost firm.

Now that we have established that price-matching can play the role of signalling a low price, the question is raised as to the impact of price-matching on the equilibrium in the market. The following proposition shows that, surprisingly, the impact of price-matching when it is used to signal a low-price is to increase the price of the firm adopting price-matching.

**Proposition 6** Compared to the equilibrium of the game in which price-matching is not allowed, the effect of price-matching, when it is adopted in equilibrium by the low-cost firm only (following an asymmetric cost realization) is to increase the price of the price-matching firm and to decrease the price of the non price-matching firm.

The proposition describes a second surprising effect of price-matching. The impact of adopting the practice is to decrease a rival’s price. In the conventional model of price-matching as a facilitating device the very point of a price-match announcement by a firm is to induce its competitors to maintain high prices. The proposition, follows from the reallocation of uninformed, captive consumers to the price-matching firm in the move from the non-price-matching game to the price-matching game. This leads to the convergence of
the two prices under price-matching relative to the non-price-matching equilibrium because of the direct effect of the respective changes in price elasticity of demand caused by changes in the quantities of captive consumers (see equation (1)). The direct effect of the change in the own-elasticity of demand for each firm is mitigated, but not completely offset, by the change in the rival’s price under strategic complementarity.

The allocative effects of price-matching in the market are two-fold: the effect of the information conveyed by the price-matching announcement on uninformed consumers’ decisions of where, and if, to buy; and the effect of the price-changes on the purchases of all consumers. The first of these impacts can only be a positive impact on overall welfare since consumers shop under full information. The second impact on welfare is mixed – but being a price impact on welfare is only of second order. As the parametric example in the following subsection illustrates, the overall welfare impact of price-matching in this model is positive for a wide range of parameters. We caution, however, that a third allocative effect of price matching, its impact on consumers’ incentive to invest in information about prices (i.e. to price shop) is missing in the simple model. This effect is discussed in the conclusion.

2.6 Example

In progress. This section has two aims: (1) to delineate the range of $a$ and cost differences $c_H - c_L$ that yield the signalling explanation; and (2) to investigate the overall impact on total surplus.

3 Empirical Implications

This section offers some guidance for the determination of which theory – collusive, price discrimination, or signalling - is most plausible in specific cases of price matching, by comparing the testable implications of the three theories. We discuss seven implications distinguishing the collusive theory, the price discrimination theory and the information-conveyance or signalling theory. These implications are summarized below.

- **Number of customers invoking rights**: If PM is used for the purpose of price discriminating, then a significant number of customers must exercise their rights under the guarantee to obtain lower prices from the price-matching firm.
for example, would not incur the expenses of an advertising campaign in order to offer selective discounts (via the price-matching program) to, say, 2 or 3 percent of its customers. On the other hand, if price-matching is a cartel coordinating device then the guarantee of matching discounts is a credible threat which the theory predicts is not exercised in equilibrium and if price-matching is a signal of low prices then its purpose is solely as a credible signal that is costly for higher-priced (and higher cost) firms to duplicate. Since it is offered by only the lowest-priced firms in the market, the rights under the guarantees are not exercised. In short, the observation that very few customers invoke the guarantee to obtain lower prices from the price-matching firm is consistent with the cartel theory and the signalling theory but not with the price discrimination theory.

- **Universality of price-matching within the market:** The cartel theory as it has been developed in the literature predicts that all firms in the market offer price-matching. In the absence of some asymmetries in the incentives for firms to cheat on a cartel price, there is no reason for the device to be adopted by only some firms within a given (product and geographic) market. An extension to the theory would appear to allow a single firm to act as a cartel ringmaster in announcing, via a price-matching agreement, to all other, smaller firms – smaller firms generally have more incentive to cheat on cartels – that it will automatically match any price cuts. In an oligopolistic market, the use of price-matching only by the rivals of a particularly aggressive firm would be consistent with the cartel theory. The signalling theory predicts that only some price firms adopt PM; and the price-discrimination theory is also inconsistent with all firms adopting PM since a firm can use PM as a price discrimination device only if some other firm charges a lower price in equilibrium. In sum, the observation of PM by all firms in a market is consistent only with the cartel theory.

- **Which firms, among a subset of firms in a market, adopt PM?** This evidence can distinguish the price discrimination theory from the signalling theory. The lowest-priced firms adopt PM under the signalling theory. These firms do not adopt PM under the price discrimination theory because that theory requires that consumers at a PM firm be able to locate lower-priced firms elsewhere in the market.

- **Impact of PM on prices of PM-adopting firms:** If one is examining prices in a
given product market across a variety of geographic markets or areas, or comparing
prices in a given region before and after PM is adopted, then the prediction of the
cartel theory is that PM causes the prices of the PM-adopting firms to increase. The
purpose of the instrument is to protect cartel pricing in this theory. Under the price
discrimination theory, the list prices of a firm are will also rise with the adoption of
PM as the firm avails itself of the opportunity to charge higher prices to consumers
with more inelastic demands. (The average transactions price, net of PM refunds,
may rise or fall.) In the signalling theory, where the purpose of PM is to signal
a low price, the impact of PM on the prices of the firms adopting the practice is,
ironically, to increase prices (Proposition 3). The direction of price change by PM
firms offers no test for distinguishing among the theories (although it does offer a test
of the theories collectively). The magnitude of the price increase, however, may offer
distinguishing test. Hess and Gerstner (1991) examine weekly supermarket prices in
the Raleigh, North Carolina market, before and after the adoption of a price-matching
guarantee by one of the supermarkets. They find a statistically significant increase
in the average price of a basket of goods (relative to a basket of goods not covered
by the price-matching policy) from before to after, but the price increase appears to
be of the order of 2 percent. This is too low to represent a plausible move from
competitive to cartel pricing.

- **Impact of PM on prices of rival firms:** The signalling theory predicts that in a
market where a single firm adopts price-matching, the impact is to lower the prices
of other firms (Proposition 3). On the other hand, in the cartel theory (if plausibly
extended to a model with asymmetries in incentives to invoke PM), the very purpose
of the instrument is to provide rivals with the incentive to set or maintain high prices.
The price discrimination theory would appear to offer only ambiguous predictions as
to the effect on non-PM rivals’ prices.

- **Profitability in a market with many firms:** Notwithstanding the theory that PM
facilitates cartel pricing, cartels are realistic only for markets with specific structure
features: a small number of firms, some barriers to entry, relatively stable costs, and
transparent prices. The price discrimination theory does not require a small number

\[19\] Moreover, even this finding is clouded by the possibility that cost and demand dynamics of the “covered”
and “not covered” goods may have been different during this period (store brands figured prominently in
the latter basket but not in the former).
of firms (Edlin (1997)). The signalling theory is developed in this paper in a model with only two firms, but this is not necessary for the theory. The explanation could plausibly be extended to the case of a large number of firms in a market with price dispersion, arising because of variation in costs or entirely as a response to variation in consumer search costs or in tastes with respect to the trade-off between lower prices and higher quality or service. Firms at the lower end of the price distribution could offer PM as a signal of low prices.

- **Impact of PM on consumer search:** In the price discrimination theory, the discovery by a consumer that a store has a PM policy is evidence to the consumer that other stores are charging even lower prices. This evidence should, if anything, encourage the consumer to search further. In the cartel theory, a consumer might search further in response to the discovery of a PM policy if the consumer believed that the practice was being invoked by a “pocket” of colluding firms selling close substitutes within a broader, differentiated product market; or a consumer having read the literature might infer that all prices are cartelized and that further search would be futile. The impact on consumer search is ambiguous. In the signalling model, generalized to a market in which even information about price-matching policies is costly to obtain, a PM announcement would tell the consumer that the firm was relatively low-priced and that further search was unlikely to be optimal. Srivastava and Lurie (2001) found experimental evidence that consumer’s incentive to continue searching was, as predicted by this model, reduced by a PM policy. Srivatava and Lurie exposed consumers to several simulated shopping environments in a controlled experiment and asked them questions about their perceptions of the price-matching and the non-price-matching stores. They find that subjects are more likely to stop searching, by as much as 25 percent, after they have been to a price-matching store than after they have been to a non-price-matching store.

- **Adoption of PM only by firms with small market shares:** If one observed PM being adopted only by a firm with, say, a 5 percent share of a market in which there were large rivals, one could be confident that the cartel theory, even generalized to the idea that PM is invoked to inhibit price cutting by rivals, were not at work. A large firm will not be significantly deterred by a guaranteed match, on the part of a small rival, of its own price cuts because the fraction of its demand that is diverted
by the small rival’s price match is unlikely to be significant. On the other hand, this observation is consistent with either of the other two theories.

These empirical implications are summarized in Table 1. A literal reading of our model would yield another prediction: that PM is adopted for signalling purposes only by firms that have been endowed by nature with lower costs in the market. In many if not most retail markets, firms have access to very similar technologies. This prediction, however, is an artifact of our simplifying assumption that the only variation among firms that could be reflected in price differences is cost variation. In reality, firms may choose to adopt a low-cost distribution strategy or sell a product at the low-price, low-quality end of the market in order to attract customers with particular preferences. Many models with consumer heterogeneity predict vertical product differentiation even where firms face identical costs.\(^20\) We believe that the theory of price-matching policies as signals of low prices would extend to such models.

4 Conclusion

In a model of differentiated retail competition that incorporates consumer heterogeneity in information, location, and travel costs, we investigate price matching policies. We show that two types of equilibria can arise with respect to price-matching policies. Under symmetric cost structures, price-matching by both firms is an equilibrium, and it leads to collusive pricing by both firms. Under large asymmetries, however, we find that only the low-cost firm would use a price-matching policy in equilibrium, and the resulting pricing is not collusive. Instead, it involves Bertrand pricing with the low-cost firm setting a lower price than the high-cost firm.

Our results simultaneously strengthen and weaken the traditional view that price-matching are collusive devices. On the one hand, the collusive pricing result under symmetric and somewhat asymmetric cost structures arises not just as a Nash equilibrium, but as a dominant strategy equilibrium. We find that the mere presence of uninformed consumers, strengthens the collusion in the sense that instead of a multiplicity of equilibria ranging from Bertrand pricing to monopoly pricing—which poses the inevitable coordination issue—we get a unique dominant strategy equilibrium involving monopoly pricing.

\(^{20}\) E.g., Iyer (2000).
These results strengthen the theoretical basis for price-matching as a facilitating device.

On the other hand, the result that only a low-cost firm would use price-matching under conditions of significant cost disparities, and that the resulting pricing is more competitive than collusive, weakens the collusion argument. It accords more with business person’s view of price-matching as a way to compete. It also agrees with the empirical literature that says that consumers view price-matching stores as more competitive than non-price-matching stores.

This result shows that price-matching policies do not offer unalloyed positive benefits to the firms that adopt them. For a firm with a cost disadvantage, adopting a price-matching policy amounts to delegating the pricing decision to its low cost competitor. Such delegation cannot be advantageous in the presence of a cost disadvantage. By not offering a price-matching policy a high cost firm keeps control of its pricing.

The presence of both uninformed and informed consumers is crucial to our result. Without uninformed consumers, there would be no positive incentive for the low cost firm to adopt a price-matching policy. It is the possibility that these consumers may take price-matching as a signal of lower costs that allows the low cost firm to adopt price matching. Of course, this same possibility might motivate a high cost firm not to cooperate in providing the signal. With a large enough cost difference, however, the disadvantage of delegating the pricing decision to the low-cost firm—a disadvantage that has to borne both in the informed segment of the market and in the uninformed segment—is greater than the share penalty in the uninformed segment from the adverse signal.

We will offer, in the next version of this paper, an extension to a model in which consumers decide endogenously whether to become informed about prices (and become “active shoppers”) or to shop on the basis of inferences drawn from stores’ price-matching policies (thus remaining “inference shoppers”). The extension reveals a Grossman-Stiglitz paradox. If inference shopping is less costly, no consumers will want to become active shoppers; but the presence of some active shoppers is necessary for inference shopping to be possible in equilibrium. This paradox can be resolved in a “noisy rational expectations” framework, in which the price-matching policy conveys some but not all information about prices.21 The resolution, however, reveals a qualification to the efficiency of price-matching

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21 Specifically, we will assume that price-matching is decided after the realization of “long-term” costs, but a short-term cost shock (such as the amount of excess inventory) is realized after the price-match decision but before prices are set.
in directing consumers towards low-cost firms: the adoption of price matching policies by low-priced firms encourages high time-cost consumers to shop on the basis of inference rather than direct price comparison or active shopping. Since only active shopping disciplines prices in a market, the effect of price matching can be to reduce the competitive discipline on prices.
References


Price Match Decisions:  
“1,0” : price-matching by Firm 1 only  
“1,1” : price-matching by both firms, etc. 

Induced Price Game:  

FIGURE 1: SUMMARY OF PRICE-MATCHING GAME
**TABLE 1: SUMMARY OF TESTABLE IMPLICATIONS**

<table>
<thead>
<tr>
<th>Implication</th>
<th>Collusion Theory</th>
<th>Price Discrimination</th>
<th>Price-matching As signal</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Significant percentage of customers invoke PM rights</td>
<td>X</td>
<td>✓</td>
<td>X</td>
</tr>
<tr>
<td>2 PM adopted by all firms in market</td>
<td>✓</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>3 PM firms are lowest priced in market</td>
<td>X</td>
<td>X</td>
<td>✓</td>
</tr>
<tr>
<td>4 PM increases prices of PM-adopting firms</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>5 PM increases prices of non-PM-adopting firms</td>
<td>✓</td>
<td>?</td>
<td>X</td>
</tr>
<tr>
<td>6 PM profitable with large number of firms</td>
<td>X</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>7 PM policy terminates consumer search</td>
<td>?</td>
<td>X</td>
<td>✓</td>
</tr>
<tr>
<td>8 PM adopted only by firms with small market shares</td>
<td>X</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>