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The Welfare Losses from Price Matching Policies

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Abstract WP 97-257

Several recent papers argue that price matching policies raise equilibrium prices. We add to this literature by considering potential welfare losses, which have two sources: Harberger triangles from high prices and Posner rectangles from over-entry. We compare markets with price matching and free entry to the traditional concerns of antitrust law, monopoly or cartel markets without entry. Price matching with entry leads to greater welfare losses than both monopoly and cartel in markets with a low ratio of fixed to marginal cost and low demand elasticity. We illustrate these general results using parameters from the wholesale gasoline and air travel markets, and relate our model to price matching on NASDAQ.

1. Introduction

Sellers increasingly "guarantee" their prices by promising to match any lower price a buyer finds elsewhere.[2] Ironically, though, adopting a guaranteed-low-price policy is a good substitute for actually having low prices, and a number of recent papers have argued that such "price-matching" policies raise equilibrium prices (see, e.g., Salop [1986], Belton [1987], and Doyle [1988]).[3] This paper considers the welfare effects of price matching in a model with entry, thereby extending the existing price matching literature, which has focused on price effects.[4]

Industrial organization economists and antitrust authorities concerned about supra-competitive pricing have traditionally focused their attention on oligopoly markets where entry is difficult or impossible. Limited entry is often seen as a necessary condition for high prices, because, as Kleidon and Willig [1995, p. 6] argue

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[2]These practices are commonly associated with resellers, however, they are also seen in other sectors, including construction (Blain [1995]), funeral homes (Milkman [1994]), wholesale gasoline (Crocker and Lyon [1994]), electronic component manufacturers (Jorgenson [1993]) and among NAS-DAQ market makers, as we will discuss in Section 6. Their roots are traceable at least as far back as International Salt Co. v. United States 332 U.S. 131 (1947).

[3]There is also some experimental and empirical evidence that these policies raise prices (see Grether and Plott [1984] and Hess and Gerstner [1991]). On the other hand, two recent papers have argued that if firms can promise to *beat* as well as match posted prices, then the competitive outcome re-emerges (Corts [1995] and Hviid and Shaffer [1994]). These models restore the Bertrand intuition because firms can offer final prices that are unmatchable, and can only match or beat posted prices. As Doyle [1988] and Edlin [1998] explain, however, monopoly pricing is restored in a model where both final and posted prices can be matched or beaten. Matching final prices perhaps better accords with the spirit of guaranteed low prices, which is to create genuinely unbeatable prices by willingly matching any legitmate offer.

Hviid and Shaffer [1997] present a more compelling argument that the anticompetitive power of price matching is limited. They argue that price-matching offers can be weakened or undone completely by the "hassle costs" buyers incur in taking advantage of the offer. We discuss this argument in Section 2.

[4]Hirshleifer and Png [1987] also consider a model with entry and show, interestingly, that under price matching, entry causes prices to rise. Their paper, however, does not directly compare price matching to non-price matching prices, or calculate welfare losses created by these policies.

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When entry is easy, cooperative efforts by incumbents to maintain excessive prices simply attract entrants who undercut collusive prices and restore competitive outcomes.

We will argue, however, that when firms are price matchers, as were the NASDAQ market makers that Kleidon and Willig discussed, then supracompetitive prices can persist in the face of widespread entry. One straightforward reason that we should be concerned about price matching, then, is that it allows supracompetitive pricing to occur in a much larger set of industries than are susceptible to monopoly or collusive agreement.

The more subtle danger of price matching, which we explore in this paper, is that welfare losses arise not just due to the allocative inefficiency of high prices but also due to the productive inefficiency of higher industry-wide average costs. When a high price is locked in by price matching, entry occurs until firms' average costs rise to equal the high price, and all producer surplus is eliminated. The total welfare loss thus includes both the traditional Harberger deadweight loss triangle from the price distortion and the Posner rectangle from increased average costs due to over-entry.[5]

We compare this welfare loss to welfare losses under monopoly and under a structure we label "cartel," in which the firms in a competitive equilibrium manage to raise price to a collusive level without attracting entry. Our cartel is just our price matching scenario without entry, and is useful as a way of separating the price and entry effects of price matching. We first make these comparisons analytically, then numerically for a variety of demand elasticities and ratios of fixed to variable cost.

When fixed costs are high, monopoly produces the largest welfare loss, because it has the largest price distortion. To see this, note that a monopoly typically will have

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[5] Our model represents a specific instance of the tendency, explained by Mankiw and Whinston [1986], Spence [1976] and others, for entry to be excessive in homogeneous product markets with fixed costs. The "business stealing" effect in post-entry competition – that is, the extent to which new entry results in incumbent firms having a lower volume of sales – means that the private benefits from entry exceed the social benefits. As we will see, this effect is particularly strong under price matching.

no excess capacity, since it will build just sufficient plants to satisfy demand at the price it charges. If satisfying industry demand requires many plants, as we assume, the monopolist will incorporate the construction cost as part of the true shadow cost of additional output and so charge a monopoly markup on the minimum of average cost. In contrast, high prices in our price matching model attract entry, which leads to excess capacity and high average costs. This excess capacity means that, for a price matching firm, producing an additional unit does not entail building an additional plant. Thus the optimal markup for a price matching firm is based solely on marginal production cost and is not affected by the plant construction cost.

When fixed costs are large, therefore, a monopoly charges a significantly higher price than a price matching firm. In this case, the larger Harberger triangle from the additional price distortion under monopoly outweighs the Posner rectangle from over-entry under price-matching. In contrast, in industries where fixed costs are small relative to variable costs, price matching produces larger welfare losses than either cartel or monopoly.[6] In these industries, marginal cost is close to the minimum average cost, so that markups are similar across the three scenarios. Excessive entry creates large Posner rectangles under price matching, however, which eliminates producer surplus and leads to greater welfare losses under price matching than under either monopoly or cartel.

To get a sense of the magnitude of these welfare effects under a realistic set of parameter values, we calibrate our model using data from the U.S. wholesale gasoline and air travel markets, two markets that might in principle be susceptible to matching since the goods are fairly homogenous. Assuming that these markets are currently competitive, we ask what would happen if competition were replaced by monopoly,

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[6]This result may seem surprising. For instance, in Mankiw and Whinston's [1986] model of entry, welfare losses go to zero as fixed costs become smaller. The difference lies in the effect of entry on price. Their result depends on the assumption that price approaches marginal cost as the number of firms grows infinitely large, whereas in our price matching model the number of firms has no effect on price.

price matching, or cartel. We find that monopoly or cartel would lead to welfare losses of approximately $12 billion, compared to total U.S. sales of approximately $70 billion, in each market. Price matching yields somewhat higher losses (at $16 billion) than monopoly or cartel in the air travel market. In contrast, losses soar to $30 billion under price matching in the wholesale gasoline market. The difference results from the fact that fixed costs are much smaller in the wholesale gasoline market, where the largest production cost is a marginal fuel cost, than in the air travel market, where most costs are fixed.

Welfare losses are highest in markets that combine price matching, entry, and low fixed cost relative to marginal cost. Thus, industries that appear competitive under traditional market structure criteria can actually be subject to higher welfare losses than pure monopoly. Antitrust enforcers and lawmakers should therefore be prepared to broaden their focus beyond traditional Sherman Act Section 1 and 2 concerns, subject to the following caveats.

While our analysis illustrates the tremendous anti-competitive *potential* of price matching, we do not contend that this potential will be realized in every case, or even that it will be *fully* realized in any case. It is extreme to suppose that the Posner rectangles will be wholly wasted. If firms cannot lower price to attract business, they may compete along other dimensions, such as quality. This could reduce waste, and in extreme cases could eliminate it entirely.[7] Alternatively, firms may find another

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[7]Another avenue by which losses from price matching may be mitigated in a retail context has been offered by David Butz [1993]. He argues that price matching is a *legal* substitute for resale price maintenance. Hence, if resale price maintenance is efficient, retail price matching might also be efficient, at least if price matching happened to achieve the same price as the manufacturer would set under resale price maintenance. This argument undoubtedly has some merit, and we will not opine here on whether resale price maintenance is efficient, or whether price matching in retail markets serves as a close substitute. Instead, we limit the application of our welfare calculations to manufacturers or other primary sellers.

Crocker and Lyon [1994] propose a different efficiency rationale. They hypothesize that price matching offers (what they term "third party most-favored-nation clauses") may be included in long-term contracts to allow for efficient adjustment of prices over time. They test this hypothesis in the natural gas industry against the null hypothesis that price matching clauses are used to facilitate implicit collusion.

avenue, such as coupons, by which to lower price.[8] As Corts [1995] and Hviid and Shaffer [1994] suggest, the key is to find a way to raise value or lower price that is not matchable.

Similarly, the anti-competitive power of price matching may be reduced if a "matched" price is not equivalent to a posted price in buyers' eyes. Hviid and Shaffer [1997] have recently argued that the "hassle costs" buyers must pay to take advantage of a price matching offer can significantly constrain supracompetitive pricing.[9] Their duopoly model assumes that buyers incur identical hassle costs in using a price matching offer, and that firms cannot compensate buyers for these hassle costs. Where their model applies, the effects of price matching will indeed be reduced, though entry, which they do not consider, may exacerbate welfare costs beyond the price distortion.[10] Their model does not apply, however, in markets such as NASDAQ where firms assume the cost of price matching.[11] Also, to the extent that firms can com-

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Running a probit, Crocker and Lyon find the frequency of adoption of price matching clauses to be positively related to the number of independent firms in a particular regional market. They interpret this result as supporting their efficiency rationale, since collusion becomes more difficult to sustain with an increasing number of firms. However, this result is also consistent with our model, in which adoption of price matching clauses raises equilibrium prices, and causes new firms to enter until average costs rise to meet the high price. Which is the correct interpretation depends in part upon which variable is "more" exogenous, the number of firms or the adoption of price matching clauses.

[8] Observe, though, that coupons are often matched (see, e.g., Hess and Gerstner [1991]).

[9] These "hassle costs" represent the time and energy a buyer must expend to bring a matchable price to a firm's attention and verify that it fulfills the requirements of a price matching guarantee. In a retail context, for example, this could be the effort expended clipping a price from a competitor's advertisement, finding the store's manager, and waiting for the guarantee to be verified and the price adjusted.

As discussed in footnote 7, however, this paper focuses on wholesale markets. In these markets, hassle costs are likely smaller relative to the price paid than in retail markets.

[10] Hviid and Shaffer's [1997] model does not consider the effect of entry on prices. If entry has no effect on prices, as in our model, or actually causes prices to rise, as in Hirshleifer and Png's [1987] model, then entry will exacerbate the welfare costs of price matching. In models where entry lowers prices, the price effects of entry must be weighed against welfare losses due to inefficient replication of fixed costs.

[11] Other examples in which the seller rather than the buyer incurs the cost of matching include the grocery stores discussed in Hess and Gerstner [1991], the U.K. retail gasoline market discussed in Hviid and Shaffer [1997] and Corzine [1996], and Tweeter, etc., a consumer electronics firm in New England that checks the prices of other sellers after a purchase and sends refunds if others offer lower prices.

pensate buyers for hassle costs, the tendency of hassle costs to drive prices down may be moderated.

The recent SEC and DOJ investigations into the NASDAQ stock market, which we discuss in Section 6, have uncovered good illustrations of many of the issues discussed in this paper. Price matching by NASDAQ market makers may have raised bid-ask spreads, despite the fact that there were numerous competitors and that entry was easy. We argue, however, that because supply and demand for a given security are highly elastic, spreads increased only slightly over competitive levels. Also, there were avenues other than inefficient entry – not all of them wasteful – through which revenues from supracompetitive spreads could have been dissipated. Nonetheless, the NASDAQ case illustrates how price matching and price matching-like phenomena can be facilitated by computerized trading systems. Since these systems are becoming more pervasive, the potential for significant welfare losses from price matching merits attention.

This paper is organized as follows. Section 2 calculates the equilibrium under price matching. Sections 3 and 4 make analytic and numeric comparisons of the welfare losses of price matching to those of monopoly and cartel. Section 5 calculates these potential welfare losses in two industries, air travel and wholesale gasoline. Finally, Section 6 discusses the implications of our analysis for antitrust policy, with particular focus on computerized trading systems such as NASDAQ.

2. Price-Matching Equilibrium

This section defines a price-matching equilibrium and calculates equilibrium prices for a market with a homogeneous good. Our model has an unlimited number of firms, each of which can build a plant for a fixed cost $F > 0$ that allows it to produce any quantity q up to some capacity Q at a marginal cost of c. Hence each firm's average

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cost is $AC(q) = \frac{F}{q} + c$ for $q \in (0, Q]$. Each firm i decides (1) whether to enter the market, (2) what price p_i to post, and (3) whether to match prices. For simplicity, we assume that firms cannot expand capacity by building additional plants.[12]

In our model, all buyers are fully informed of available prices. This assumption is admittedly unrealistic, but Appendix A considers an explicit model of search and finds identical results. Since the purpose of our paper is not to prove that price matching leads to high prices, but rather to study the consequences *when* price matching leads to high prices, we choose to present the simplest model, instead of the most realistic one, in the main text. The interested reader should refer to Appendix A, which presents price matching under a Salop-Stiglitz search model and a generalization of that model.

Since buyers are fully informed in our model, none is willing to pay a price above $p_{\min} \equiv \min_i p_i$. A firm that promises to match prices will sell at $p_{\min}$ even if it posts a higher price, so that buyers can purchase at this price either from a firm actually posting $p_{\min}$ or from a matcher (regardless of the matcher's posted price). We assume there is no transaction cost of obtaining a "match," so that demand $D(p_{\min})$ is divided evenly among firms that either post the lowest price in the market or promise to match prices, as assumed in Corts [1995], Doyle [1988], Belton [1987], and Salop [1986]. Our assumption is probably realistic for the NASDAQ market, which we discuss in Section 6, and for other settings where the firm assumes the cost of price matching – for example, by checking the prices of other sellers after a purchase and sending refunds to buyers if others offer lower prices.[13] We suspect that such attempts to eliminate the buyer's transaction cost from matching will become increasingly common in the future.[14] Although our demand assumption facilitates the extreme anticompetitive

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[12] We explain in Appendix B why this possibility complicates our derivations but does not affect the equilibrium.

[13] Tweeter, etc., a consumer electronics firm in New England, has this practice.

[14] There are other ways in which this transaction cost could be reduced in addition to the strategy described above. For example, Rasputin Records in Berkeley, which accepts competitors' discount

results this paper presents, it turns out not to be as critical as one might think. In fact, one finding of Hviid and Shaffer [1997] is that in an asymmetric model of duopoly, supracompetitive prices can persist even with hassle costs, though prices will then not rise as high as they do here.[15]

Let demand be some monotonically decreasing function $D(p)$, for which a unique price p maximizes $D(p)(p - c)$, and let

$$p^{pm} \equiv \max \left\{ \frac{F}{Q} + c, \arg \max D(p)(p - c) \right\}.$$

Thus, p^{pm} is the greater of the minimum of $AC(\cdot)$ and the monopoly markup on c. Observe that the inverse of average cost, $AC^{-1}(\cdot)$, has domain $[\frac{F}{Q} + c, \infty)$ and range $(0, Q]$, so we can define $q^{pm} \equiv AC^{-1}(p^{pm})$. We assume that $N^{pm} \equiv \frac{D(p^{pm})}{q^{pm}}$ is an integer. This assumption avoids standard integer problems and is justified as an approximation when N^{pm} is large, which is the primary interest of this paper.

Proposition 2.1. *It is a Nash equilibrium for N^{pm} firms to enter the market, post price p^{pm}, and match prices. Each firm sells quantity q^{pm} and breaks even.*

Proof: In the proposed equilibrium, the N^{pm} entering firms split the demand, so

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coupons, recently began compensating its customers for transaction costs by offering a free slice of pizza at nearby Blondie's Pizza for anyone taking advantage of the offer.

Attempts at reducing transaction costs will likely become more common as commercial exchange moves onto computer networks, such as the World Wide Web. Firms, for example, could send search agents crawling around the Web to check prices for a customer, and promise to charge the lowest price found or refund the difference of any lower price later found. Taking advantage of such an offer entails little or no additional cost for the consumer.

[15]In the Hviid and Shaffer [1997] model with hassle costs, a combination of price matching and a significant degree of asymmetry between duopoly firms supports a price above the Bertrand equilibrium, but below the range of prices supported by price matching in the absence of hassle costs. On the other hand, when firms are symmetric or only slightly asymmetric, the presence of hassle costs nullifies the ability of price matching offers to raise industry prices above the Bertrand equilibrium. Intuitively, hassle costs give a firm "room" to undercut its rival, and move closer to its best response function even in the presence of a matching offer. If the hassle costs are larger than the difference in Bertrand equilibrium prices, instituting price matching policies will not raise prices. In this case, at any price above the Bertrand equilibrium each firm will want to undercut the other, and the presence of hassle costs means that a price matching offer cannot prevent this undercutting.

each firm sells $\frac{D(p^{pm})}{N^{pm}} = q^{pm}$. Since $p^{pm} = AC(q^{pm})$, the entering firms break even. Hence, they cannot increase profits by exiting. They also cannot increase their profits by raising prices, since if they continue to match, their effective price remains p^{pm}, and if they don't, they lose all of their business.

To complete the proof, we must show that no additional firms enter and that lowering price cannot increase a firm's profits. Since all N^{pm} firms match prices, even if one deviates by posting a price $p < p^{pm}$, the N^{pm} firms will still split the market, selling at p, regardless of the deviator's matching policy. Note that if all firms charge $\hat{p} \equiv D^{-1}(N^{pm} Q)$, then they each sell their capacity Q, so there is no point in a deviator lowering price below $\hat{p}$. Hence, a deviator's pricing problem reduces to solving $\max\limits_{p \in [\hat{p}, p^{pm}]} \frac{D(p)}{N^{pm}}(p - c)$.[16] When $q^{pm} < Q$, $p^{pm} = \arg\max \frac{D(p)}{N^{pm}}(p - c)$ by construction, so cutting price is not profitable. When $q^{pm} = Q$, pricing below p^{pm} cannot increase a firm's profits because the firm cannot increase production.

The same argument (but substituting $N^{pm} + 1$ for N^{pm} in the pricing problem) shows that new entrants also cannot do better than to post p^{pm}. They won't enter because $p^{pm} < AC\left(\frac{D(p^{pm})}{N^{pm}+1}\right)$. ∎

This price matching equilibrium is illustrated in Figure 2.1. Firms will continue to enter the market as long as there are profits to be earned, so in equilibrium market demand is sufficiently fragmented that each firm's demand touches its average cost curve. By the construction of p^{pm}, $\frac{D(p)}{N^{pm}}$ lies below the average cost curve except at $\left(\frac{D(p)}{N^{pm}}, p^{pm}\right)$.

This proposition is essentially similar to ones in Salop [1986], Belton [1987], Hirshleifer and Png [1987], Doyle [1988], Corts [1995], and Edlin [1998]. As in these analyses, the high-price equilibrium described in Proposition 2.1 is not unique. There is also a low-price Nash equilibrium at the competitive price $p^{co} \equiv \frac{F}{Q} + c$, with each of $N^{co} \equiv \frac{D(p^{co})}{q^{co}}$ firms selling $q^{co} \equiv AC^{-1}(p^{co})$ and earning zero profits. To see this,

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[16]Note that $\hat{p} \leq p^{pm}$ since $q^{pm} \leq Q$, $\hat{p} = D^{-1}\left(\frac{D(p^{pm})Q}{q^{pm}}\right)$, and $D(\cdot)$ is downward sloping.
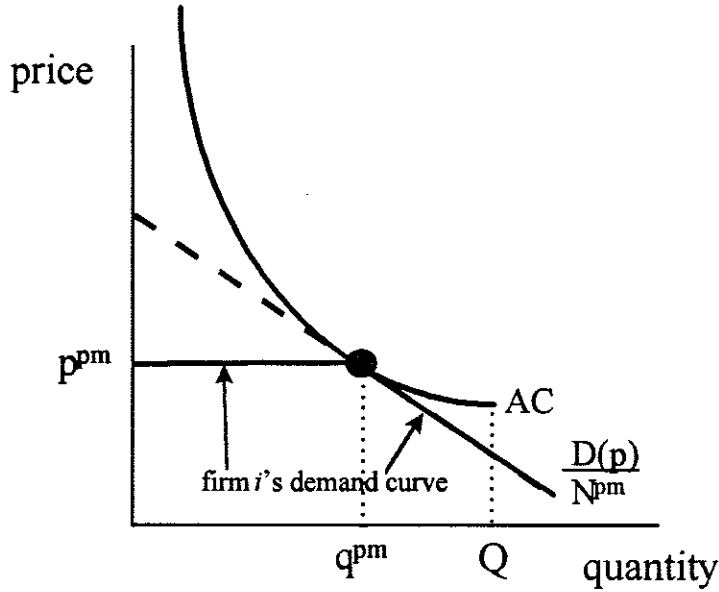
Figure 2.1: **A price matching equilibrium at p^{pm}.**

note that as in the proof of Proposition 2.1, a firm cannot increase profits by raising its price, since if it matches, its effective price remains p^{co} and if it does not, it loses all of its business. Since $p^{co} = \min\limits_{q \in (0,Q]} AC(q)$, deviating from the proposed equilibrium by choosing any price $p < p^{co}$ also would not be profitable, either with or without a matching policy. Similarly, new firms will not enter the market since they cannot make any sales at $p > p^{co}$, and sales at $p \le p^{co}$ are unprofitable since $p^{co} < AC(\frac{D(p^{co})}{N^{co}+1})$.

Any intermediate price between $\frac{F}{Q} + c$ and p^{pm} may also support a Nash equilibrium, depending on the shape of the demand curve. In particular, if $D(p)(p - c)$ is quasi-concave within $p \in [\frac{F}{Q} + c,\ p^{pm}]$, then the logic of Proposition 2.1 can be used to show that any $\tilde{p} \in \left(\frac{F}{Q} + c,\ p^{pm}\right)$ is part of an equilibrium with each of $\tilde{N} \equiv \frac{D(\tilde{p})}{\tilde{q}}$ firms selling $\tilde{q} \equiv AC^{-1}(\tilde{p})$, matching, and earning zero profits.

There are several reasons, however, to favor the high-price equilibrium at p^{pm}. In Belton's [1987] duopoly model, the high price equilibrium emerges because of subgame perfection: one firm moves first, and so chooses the collusive price and a matching policy, anticipating that this choice will induce the other firm to choose the collusive

price. It may be possible to extend such arguments beyond duopoly, though they hinge on timing.

Another argument for p^{pm} emerging involves iteratively striking weakly dominated strategies (see, e.g., Doyle [1988]). Observe first that posting $\frac{F}{Q} + c$ and not matching dominates posting any price less than $\frac{F}{Q} + c$, with or without matching. Once these strategies are eliminated, the strategy of posting any price p and matching weakly dominates posting p and not matching (profits rise if $p_{min} < p$, but otherwise remain unchanged). Finally, observe that in the remaining game where all firms match, posting p^{pm} weakly dominates posting any other price if $D(p)(p-c)$ is quasi-concave.

Perhaps the strongest reason to favor the equilibrium of Proposition 2.1 is that it is the only equilibrium robust to having some poorly informed buyers. In particular, consider the Salop and Stiglitz [1977] model of bargains and ripoffs, in which some buyers choose not to become informed and instead buy at random. Even if there are only a few buyers who will pay high posted prices when lower prices are available, a price matching firm can price discriminate by charging high posted prices to poorly informed buyers without driving away savvy buyers, who get low prices because of the matching offer. In this way a price matcher can have the best of both worlds by offering bargains and ripoffs at the same time. Once other firms in the industry duplicate this behavior, there are no bargains left for even the savviest shopper to find. That p^{pm} is the unique equilibrium in such a model is proven formally and generalized for more complex search in Appendix A.

3. Analytic Welfare Comparisons

This section compares the welfare properties of the price matching equilibrium developed in Section 2 with equilibria under competition, monopoly, and cartel. In doing these comparisons, we assume a constant elasticity demand function $D(p) = p^{-\varepsilon}$,

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with $\varepsilon > 1$. The constant elasticity demand function simplifies some of the welfare calculations, but it is not essential to the results in Propositions 3.1 and 3.2. These relationships also hold, for example, under linear demand.[17]

When the market price is p, consumer surplus is

$$CS(p) = \int_p^\infty t^{-\varepsilon} dt = \frac{1}{\varepsilon - 1} p^{1-\varepsilon}.$$

In both the competitive and the price matching equilibria, firms make no profits, so total welfare equals consumer surplus. Hence, competitive welfare is given by

$$W^{co} = \frac{1}{\varepsilon - 1} \left(p^{co}\right)^{1-\varepsilon}, \text{ where } p^{co} = \frac{F}{Q} + c.$$

In contrast, welfare under price matching is

$$W^{pm} = \frac{1}{\varepsilon - 1} \left(p^{pm}\right)^{1-\varepsilon}, \text{ where } p^{pm} = \max\left\{\frac{F}{Q} + c, \arg\max D(p)(p - c)\right\}.$$

Price matching causes a loss of welfare with respect to competitive welfare whenever the markup on c, $c\left(\frac{\varepsilon}{\varepsilon-1}\right)$, exceeds $\frac{F}{Q} + c$. There are two reasons for this welfare loss. First, there is a price distortion relative to the competitive equilibrium. Second, average cost is higher under price matching because all firms have excess capacity, and thus $AC(q)$ is not minimized as it is under competition.

If the market were monopolized instead, the monopoly would solve

$$\max_{p,N} (p - c)D(p) - NF, \qquad \text{s.t. } N \geq \frac{D(p)}{Q}, \ N \in \mathbf{Z}^+.$$

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[17]A direct comparison between constant elasticity and linear demand is complicated by the fact that elasticity varies along a linear demand curve. A constant elasticity = 2 demand curve yields much higher welfare losses across the board than a linear demand curve with an elasticity of 2 at the *competitive* price, but sometimes yields lower welfare losses than a linear demand curve with an elasticity of 2 at the *monopoly* price.
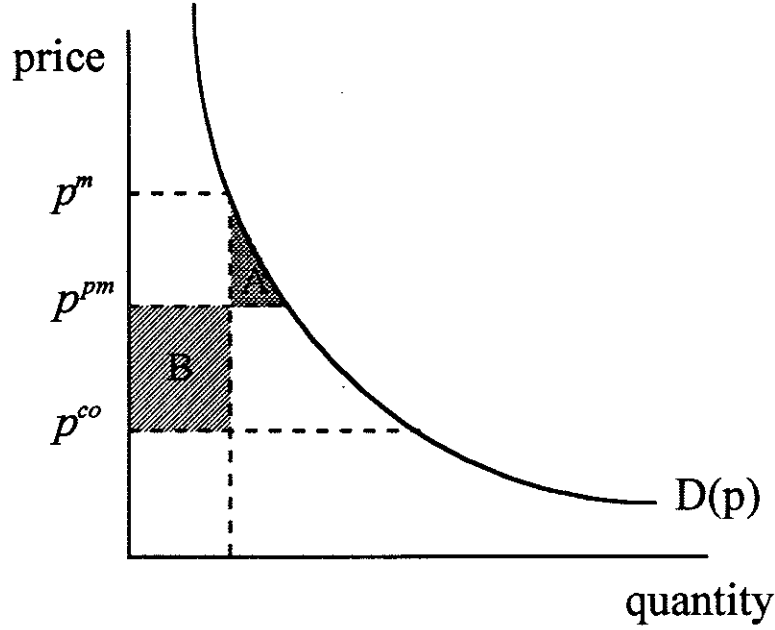
Figure 3.1: **Welfare losses from price matching are greater than those from monopoly if rectangle B is larger than triangle A; otherwise, they are smaller.**

to find the optimal price p^m and number of plants N^m. When N^m is large, as we assume, the monopoly will essentially markup the cost $\frac{F}{Q} + c$ and charge approximately $\left(\frac{F}{Q} + c\right)\left(\frac{\varepsilon}{\varepsilon-1}\right)$. Hence, consumer plus producer surplus is

$$W^m = \frac{1}{\varepsilon-1}(p^m)^{1-\varepsilon} + D(p^m)\left(\frac{F}{Q} + c\right)\left(\frac{1}{\varepsilon-1}\right), \text{ where } p^m = \left(\frac{F}{Q} + c\right)\frac{\varepsilon}{\varepsilon-1}.$$

Since the monopoly treats $\frac{F}{Q}$ as a marginal cost, it always charges a higher price than is charged under price matching. On the other hand, the monopoly produces efficiently and does not needlessly replicate fixed costs. Hence, whether monopoly or price matching is more efficient depends on $\frac{F}{Q}, c$, and ε. The question is whether the shaded triangle (A) is bigger than the rectangle (B) in Figure 3.1. We summarize these observations in the proposition below.

Proposition 3.1. *The welfare losses from price matching are greater (smaller) than*

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those from monopoly if

$$(p^{pm} - p^{co}) \, D(p^m) > (<) \frac{1}{\varepsilon - 1} \left[(p^{pm})^{1-\varepsilon} - (p^m)^{1-\varepsilon} \right] - (p^m - p^{pm}) \, D(p^m),$$

or, equivalently, if

$$(p^m - p^{co}) \, D(p^m) > (<) \frac{1}{\varepsilon - 1} \left[(p^{pm})^{1-\varepsilon} - (p^m)^{1-\varepsilon} \right].$$

Proof: Compare W^{pm} to W^m, as defined above. ∎

Finally, we want to determine how much of the welfare losses under price matching are due to entry. To do so, we consider the consequences if the firms in a competitive equilibrium successfully agree to fix prices (perhaps using price matching), but entry does not occur. We call this no-entry case the "cartel" case. This cartel would maximize joint profits by shutting down the production of some members, but the requisite side payments would probably attract the notice of the antitrust authorities, so we assume this doesn't happen.[18] Without side payments, the cartel will charge p^{pm} and so welfare will be

$$W^{ct} = \frac{1}{\varepsilon - 1} \, (p^{pm})^{1-\varepsilon} + (p^{pm} - c) \, D(p^{pm}) - N^{co} F, \text{ where } N^{co} = \frac{D(p^{co})}{Q}.$$

The following proposition summarizes the relationship between welfare losses from cartel and price matching.

Proposition 3.2. *When $p^{pm} > \frac{F}{Q} + c$, the welfare losses from price matching exceed those from a cartel. Otherwise, there are no welfare losses from either.*

Proof: Compare W^{pm} with W^{ct}, as defined above. ∎

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[18] If the cartel were able to make side payments, we would again get the monopoly outcome.

The equivalence of price matching, cartel, and competition when demand elasticity is large enough ($\varepsilon \geq \frac{Qc}{F}+1$), is caused by the kink in the average cost curve at Q, which makes it possible for an individual firm's demand, $\frac{D(p)}{N^{co}}$, to be flatter than average cost at the minimum of the average cost curve. If this kink were smoothed out, then price matching firms and cartels would price above $AC_{\min}$ even when demand is very elastic, so that $W^{pm} < W^{ct} < W^{co}$. But these welfares would be almost equal since price would rise only slightly above competitive levels.

The welfare differences among price matching, monopoly, and cartel reflect variations in both price and cost. Though monopoly always has the highest price ($p^m > p^{ct} = p^{pm}$), price matching has the highest average costs ($AC^{pm} \geq AC^{ct} \geq AC^m$). While our monopoly and cartel models assume restricted entry, the fact that there is free entry in our price matching model does not drive prices down. Entry simply means that fixed costs are needlessly replicated, which gives price matching the potential to be more harmful than both monopoly and cartel. Whether the higher price of monopoly causes more harm than the higher cost of price matching in a particular industry depends on its demand and cost parameters.

4. Numeric Welfare Comparisons

In this section, we use the formulas derived in Section 3 to calculate welfare losses under price matching, monopoly, and cartel for a variety of demand and cost parameters. This allows us to quantify the impact of these structures, as well as gain more insight into the types of industries that are particularly sensitive to each. Below, we calculate losses in an industry as a percentage of sales at the competitive price in that industry. There are only two relevant parameters in this metric: ratio of fixed to marginal cost $\frac{F}{cQ}$, and demand elasticity ε. As in Section 3, we assume a constant elasticity demand function.
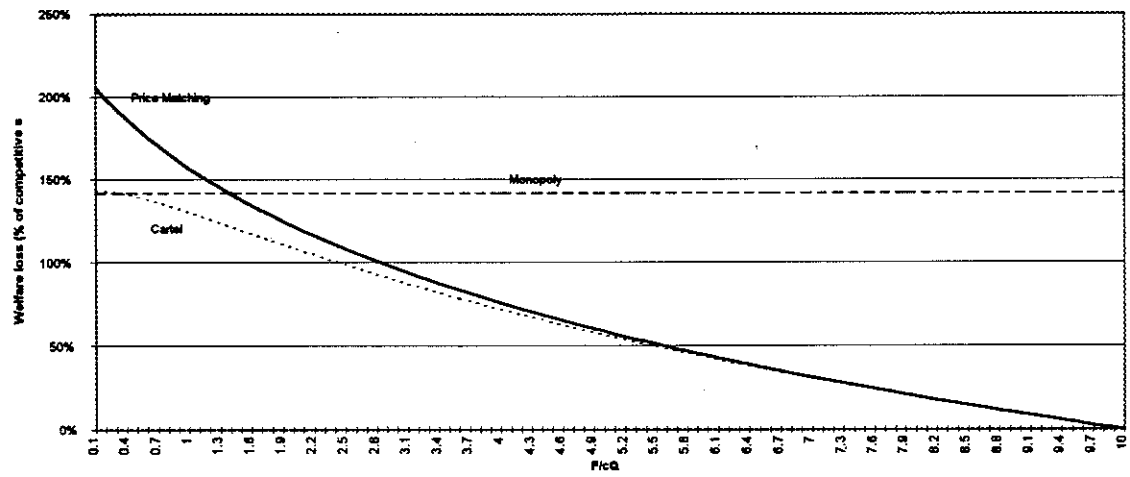
Figure 4.1: **Welfare losses under price matching, cartel and monopoly when** $\varepsilon = 1.1$.
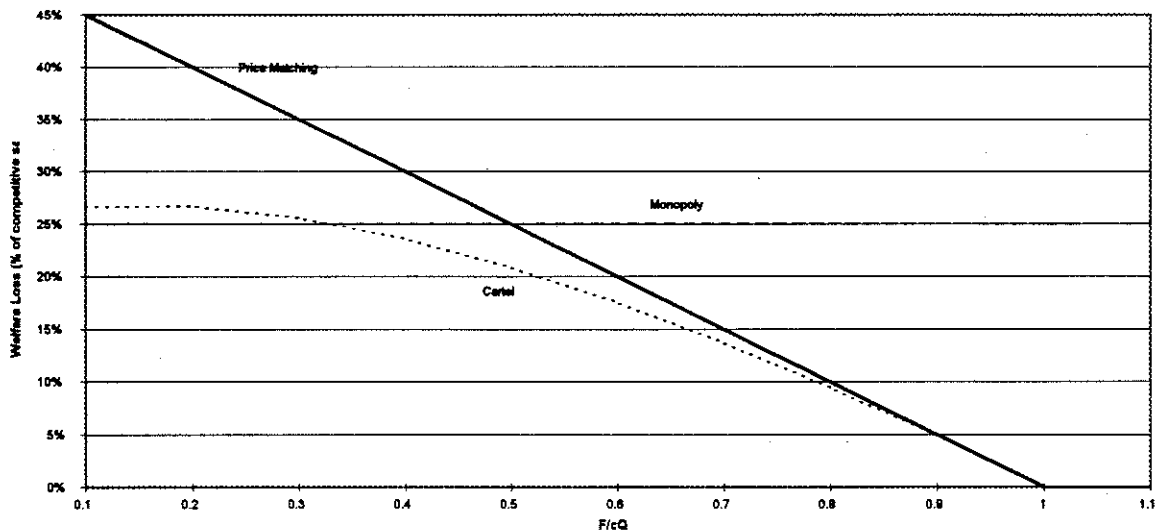
Figure 4.2: **Welfare losses under price matching, monopoly, and cartel when** $\varepsilon = 2$.

In industries with high marginal costs relative to fixed costs (i.e., low $\frac{F}{cQ}$), price matching yields high welfare losses, and higher losses than either monopoly or cartel. Figure 4.1 demonstrates this pattern. It shows welfare losses when $\varepsilon = 1.1$ across a variety of industries with different values of $\frac{F}{cQ}$. Losses from price matching increase as $\frac{F}{cQ}$ decreases, to more than 200% of competitive sales when $\frac{F}{cQ} = \frac{1}{10}$. Figure 4.2 shows the same pattern at a higher elasticity, $\varepsilon = 2$. At this higher elasticity, however, welfare losses are significantly lower across all three scenarios, and the range of $\frac{F}{cQ}$ over which price matching is worst of the three is reduced.

Figures 4.1 and 4.2 also demonstrate the flip side of this result. Price matching is *not* very costly when fixed costs are high relative to marginal costs. In these situations, monopoly is much more costly than either price matching or cartel. When

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$\varepsilon = 1.1$, for example, price matching and cartel replicate the competitive outcome for all $\frac{F}{cQ} \geq 10$, while monopoly yields a constant welfare loss of 145% of competitive sales. This is illustrated in Figure 4.1. When $\varepsilon = 2$, as shown in Figure 4.2, price matching and cartel mimic the competitive outcome whenever c is less than $\frac{F}{Q}$, while monopoly causes a constant welfare loss of 25% of competitive sales across all values of $\frac{F}{cQ}$.

The fact that losses from price matching fall as fixed costs rise may seem counter-intuitive – after all, the particular harm of price matching comes from the inefficient replication of fixed costs. But the magnitude of this harm is determined entirely by the price markup above $\frac{F}{Q} + c$, and this markup rises when c rises relative to $\frac{F}{Q}$. The monopoly markup, in contrast, depends on the sum of c and $\frac{F}{Q}$ and not on the size of each component; this explains the fact that monopoly welfare losses are represented by a horizontal line in figures 4.1 and 4.2. The monopoly markup is always larger than the markup under price matching, but the price matching markup brings the additional harm of higher average costs, which makes it more costly when $\frac{F}{cQ}$ is low.

Figure 4.3 shows welfare losses in a series of industries with $\frac{F}{cQ} = 1$ and varying elasticities of demand. For a given $\frac{F}{cQ}$, price matching is most damaging relative to monopoly at low elasticities, though losses under all three scenarios become higher as ε decreases. At $\varepsilon = 1.1$, $\frac{F}{cQ} = 1$, for example, price matching yields a welfare loss of more than 150% of competitive sales at $\varepsilon = 1.1$, compared to monopoly and cartel losses of 140% and 130%, respectively. At elasticities greater than 1.3, however, price matching is less costly than monopoly, and by $\varepsilon = 2$, price matching and cartel do not reduce welfare. A rise in elasticity lowers price by the same percentage in all three scenarios; under price matching, however, average cost decreases along with price.

Our cartel model represents, in a broad sense, an intermediate case between monopoly and price matching. When $\frac{F}{cQ}$ is low, cartel resembles monopoly; when $\frac{F}{cQ}$ is high, it resembles price matching. This is most clearly shown in Figure 4.1.
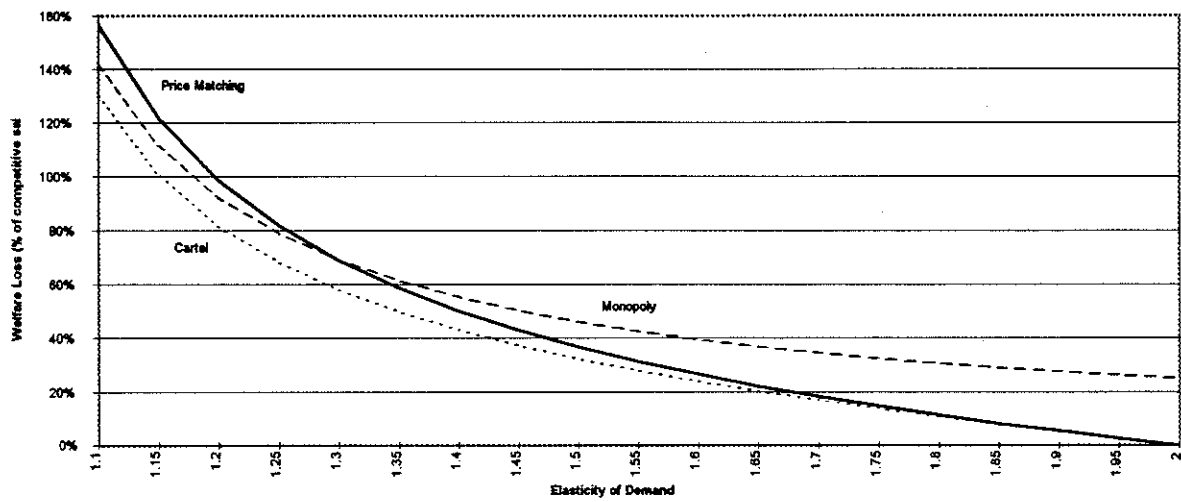
Figure 4.3: **Welfare losses under price matching, cartel, and monopoly when** $\frac{F}{cQ} = 1$.

Since prices are identical under cartel and price matching, the two regimes differ only to the extent that new entry increases average costs under price matching. When $\frac{F}{cQ}$ is low, price matching and cartel firms set a high price relative to the competitive price, causing a high level of entry and thus more difference in average cost between the two scenarios. When $\frac{F}{cQ}$ is high, markup over the competitive price is small and thus there is less entry and less difference in average cost.

As discussed in the introduction, our model of cartel is equivalent to price matching *without* entry, and is useful for isolating the distinct welfare losses from entry and from high prices under price matching. The cartel model is not intended to represent all of the industry structures that are commonly grouped together under the heading of "cartel." If a cartel could have more than the competitive number of firms and still maintain high prices, cartel welfare would more closely resemble price matching welfare. A cartel in an oligopoly industry with only a few firms, each with many plants, might yield welfare closer to that of monopoly, and if cartel firms could avoid building extra capacity, the two would be identical. On the other hand, if cartelized firms did build extra capacity in order to deter entry, oligopoly welfare might look more like our model of cartel.

5. Calibration

To get a sense of the size of these welfare effects under realistic sets of parameter values, in this section we calculate welfare losses from our three scenarios using data from the U.S. wholesale gasoline and air travel markets. Products are fairly homogenous in these two industries, making them good candidates for our model. We assume in each case that the current market structure is competitive, and determine the losses that would be incurred by switching to a regime of monopoly, cartel, or price matching. This calculation requires estimating the ratio of fixed to marginal cost in each

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	Air travel	Wholesale gasoline
F/cQ	6.5	0.2
ε	0.7	0.86
Competitive sales	$64 billion	$79 billion
Losses under price matching	$16.2 billion	$30.2 billion
Losses under monopoly	$11.4 billion	$11.5 billion
Losses under cartel	$12.7 billion	$13.3 billion

Figure 5.1: **Potential welfare losses in the air travel and wholesale gasoline markets in the United States.**

industry, and then incorporating published estimates of demand elasticity in order to perform welfare calculations of the type described in Sections 3 and 4.

Air travel is an example of an industry with a high $\frac{F}{cQ}$ and a relatively low elasticity of demand – we find values of 6.5 and .7, respectively.[19] Under linear demand, and assuming that the 1993 average price of $.13 per passenger mile is competitive, a price matching regime causes welfare losses of 25% of sales.[20] Given 1993 total U.S.

[19] The "rule of thumb" in the airline industry is that short-run demand elasticity is .7 (Morrison and Winston [1995, p. 119]). The majority of costs are fixed. The marginal cost of an extra passenger primarily consists of ticketing commissions paid to travel agents and owners of the computerized reservation system used to book the flight, and in-flight food (we ignore extra fuel costs due to the weight of an additional passenger). These total about 13.4 percent of costs, yielding an $\frac{F}{cQ}$ of 6.5, since we assume price is equal to average cost.

Cost data are from U.S. Bureau of the Census [1995, p. 656]. Passenger ticketing costs and passenger food were 10.8 and 3.4 percent of operating expenses plus interest less depreciation and amortization in 1993. Since depreciation and amortization are about 6% of total operating expenses in a typical airline, these figures translate to 10.2 and 3.2 percent of total operating expenses plus interest.

[20] We assume linear demand, as opposed to constant elasticity demand – given the observed elasticities in each market, the markup under a constant elasticity demand curve is not defined. The 1993 average price and total passenger revenue are from Morrison and Whinston [1995, p. 7].

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passenger revenues of \$64 billion, this translates to welfare losses of \$16.2 billion under price matching, compared to losses of \$11.4 billion under monopoly and \$12.7 billion under cartel. Note that, even though $\frac{F}{cQ}$ is high, welfare losses are still greater under price matching than under monopoly due to the low elasticity of demand.[21]

Wholesale gasoline represents, in contrast, an industry with *low* $\frac{F}{cQ}$ and a low elasticity of demand, with values of .2 and .86, respectively.[22] Given 1993 U.S. market size of \$79 billion dollars,[23] we find losses of \$30.2 billion under price matching, compared to \$11.5 billion under monopoly and \$13.3 billion under cartel. In this industry, potential welfare losses from price matching are nearly triple those under monopoly and cartel.

The U.S. wholesale gasoline market is roughly the same size as the air travel market

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[21] Some might argue that current air travel prices are supracompetitive, and that matching-like phenomena are already evident in the way airlines choose prices. Indeed, airlines have been accused of using their computerized reservation system to coordinate collusion. Plaintiffs in *In Re: Domestic Air Transportation Antitrust Litigation 1993-1 Trade Cas. (CCH) (N.D. Ga. 1993)* accused the major airlines of coordinating price rises by announcing them in advance via their computerized reservation system, then withdrawing them if all others did not signal acceptance. Though this is not equivalent to our price-matching model, the price effects could be similar.

We do not think that the market is currently in a price-matching equilibrium, however, since that would imply an excess capacity that does not seem to be in evidence today. If prices are indeed too high, it's possible that they do not attract entry because potential entrants anticipate that incumbents will slash prices in response to any entry. This kind of dynamic story is beyond the scope of our price matching model, which is static in nature. The equilibrium under such a scenario might more closely resemble our model of cartel, in which entry barriers prevent some of the excess capacity that is present under price matching.

[22] The most significant marginal cost in producing wholesale gasoline at a refinery is the cost of the crude oil used to produce it. The November 19, 1996 *Wall Street Journal* (p. C18) reports prices of \$24.48 for a 42-gallon barrel of West Texas intermediate crude oil and \$0.69 a gallon for New York wholesale unleaded regular gasoline. The figure $\frac{F}{cQ} \approx .2$ results from assuming that the oil fuel cost of a gallon of gasoline is $\frac{\$24.48}{42}$; although a gallon of crude oil only yields approximiately $\frac{1}{2}$ gallon of gasoline, this calculation is appropriate because the other oil products, such as kerosene, have roughly comparable value. This calculation represents an upper bound on $\frac{F}{cQ}$; the true figure is slightly lower because ours assumes that all costs other than fuel costs are fixed, ignoring other marginal costs, such as transportation costs, which are approximately \$.02 per gallon.

In a recent survey article, estimates of the long-run elasticity of demand for gasoline range from .23 to 1.05; we use the mean figure of .86 (Dahl and Sterner [1991, pp. 206, 210]).

[23] In 1993, the average retail price of regular grade unleaded gasoline was \$0.754 (American Petroleum Institute [1995, Section VI, Table 5]). Of this, approximately \$.07 represents retail markup over costs (using the most recent estimate from Borenstein [1991, p. 360]). Total U.S. demand for gasoline was 7,456,000 (42-gallon) barrels per day (American Petroleum Institute [1995, Section VII, Table 3d]). Total wholesale market size thus equals approximately $.684 \times 7,456,000 \times 42 \times 365 = \$79$ billion. Note that $\frac{F}{cQ}$ is calculated from current data while market size data are from 1993.

– about $70 billion. Potential welfare losses when there is no entry – i.e., the cartel and monopoly cases – are approximately $12 billion in each market. Price matching with entry, however, yields potential welfare losses of $30 billion in the wholesale gasoline market, compared to $16 billion in the air travel market. The reason losses from price matching are so much higher in the wholesale gasoline market is that fixed costs are so low. Correspondingly, marginal cost is a large portion of price, and since price matchers mark up marginal cost, potential welfare losses are much larger.

6. Implications

In comparing our monopoly, cartel and price matching models, one fact stands out. Welfare losses are highest in markets where fixed costs are low relative to marginal costs, firms match prices, and entry is possible. In these situations, price matching yields a particularly large markup over the competitive price, which attracts a great deal of inefficient entry. This observation suggests that government attention should focus on these markets.

It is more traditional, of course, to worry about supracompetitive pricing in industries with large fixed costs. Posner [1976, pp. 39-78], for example, argues that authorities should focus their attention on these industries because they will be more susceptible to collusion and consequently experience more frequent and substantial price distortions. Price matching, however, does not require concerted effort, and thus may be possible in many more industries than is oligopoly coordination. As we have demonstrated above, it may also be more costly. An essential difference between our view and Posner's is the extent to which entry depresses prices. If entry has little or no effect on price, as in our price matching model, then welfare losses may be large in markets with plentiful entry, since entry only serves to increase industry-wide average costs.

Since our model captures a worst-case scenario, our analysis should not be viewed as a definitive guide for U.S. antitrust policy. It suggests, however, that unconcentrated markets should not be immune from public scrutiny. It also suggests that we should be concerned that unconcentrated industries with relatively unfettered entry have witnessed a proliferation of price matching policies and related strategies in recent years.[24]

Another concern is that price-matching and related strategies are facilitated by computerized sales and trading systems, which are becoming more pervasive with the growth of a variety of computer networks, including the Internet. When prices are posted to a common computer system, it becomes cheap for firms to monitor each others prices. This may facilitate quick response equilibria, as in Anderson [1985], or explicit price matching policies, where firms pay the transaction cost of matching by searching for the lowest price themselves. One example is the NASDAQ stock exchange, where a computerized matching system may be an important factor in explaining recent findings that bid-ask spreads have been above competitive levels.[25]

Retail trades on NASDAQ are generally placed with brokers, who then direct them to market makers for execution, although most of the 512 NASDAQ market makers offer brokerage services as well.[26] A market maker is required to execute a customer

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[24]These policies initially appeared in the consumer electronics industry (Schwadel [1989]), but have since spread to such diverse industries as homebuilding, consumer loans, and even funeral homes. For example, Sundial Homes offered a guaranteed lowest price policy on 118 newly built homes in the Toronto area, promising to match offers on comparably sized homes with similar features and lot size (Blain [1995]). Also, Bank of the West has offered an interest-rate-matching policy in San Francisco Bay area radio advertisements. For a story of price matching in the funeral home industry, see Milkman [1994].

[25]Both the SEC [1996b] and the Department of Justice [1996] have recently concluded that bid-ask spreads on NASDAQ were higher than competitive levels. Huang and Stoll [1996] find NASDAQ spreads to be significantly higher than spreads on the New York Stock Exchange, and conclude that the difference cannot be explained by traditional economic determinants of the bid-ask spread.

[26]Market makers buy, sell, and hold inventory of NASDAQ stocks. There were an average of 11 market makers per NASDAQ stock in 1995 (SEC [1996b, p. 14]). The bid and ask prices posted by market makers define the "quoted spread" for a stock. Smaller trades are usually conducted at the quoted spread, while large traders with more bargaining power can often negotiate a trade "inside the spread." See Schwartz [1991, pp. 136-164] for a more complete description of the operation of NASDAQ market makers.

order at the most favorable terms available, which has been interpreted to mean that market orders are executed at best price posted on the NASDAQ computer system. (SEC [1996b, p. 14]). When a broker receives an order for a stock for which it is a market maker, it will generally match the best posted price, rather than passing sales to the low-price market maker. As the SEC notes in its recent review of NASDAQ,

> It is also a general practice for a NASDAQ market maker receiving a retail customer order to execute the order itself rather than send it to another market maker, even if that market maker is posting the best price (i.e., the best inside bid or offer) and the executing market maker is not. The executing market maker will provide the customer with the price displayed in the inside quotes, whether or not it is quoting those prices itself. (SEC [1996b, p. 15]).

When a broker does not execute an order itself, it is typically "preferenced" to a market maker who has agreed in advance to match the inside spread, even when that market maker is not quoting the best price. This preferencing may reflect a long-term business relationship, or it may be in return for payment under a "payment for order flow" agreement.[27] Since most or all market makers will trade at the inside spread, posting the best price is not what brings in trades: A market maker gets trades from its own brokerage services or from brokers with which it has an arrangement.

Christie and Schultz [1994] and Christie, Harris and Schultz [1994] were the first to call attention to the wide bid-ask spreads of many stocks traded on NASDAQ. They argued that the dearth of odd-eighth quotes among heavily-traded stocks could not be explained by economic fundamentals, and may have resulted from an implicit agreement among market makers. This assertion has been controversial. Kleidon and Willig [1995], for example, compared NASDAQ to the New York Stock Exchange and

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[27]These "payment for order flow" agreements resemble travel agent commission override programs (TACOs) in the air travel market. In both cases, the upstream seller pays downstream retailers for an increased share of downstream sales. In both industries, upstream sellers have been accused of using computerized sales systems to support supracompetitive pricing, though the NASDAQ market fits more closely with our model of price matching than does the air travel market.

argued that differences in spreads could be explained without resorting to collusion.[28] In addition, they argued that with up to 50 or more market makers trading in each stock, and low entry and exit barriers, collusion was *a priori* impossible (Kleidon and Willig [1995, p. 6]).

Although price matching policies may not reflect collusion, we have argued that the danger of price matching is precisely that it can lead to high, cartel-like prices in industries where traditional market structure analysis predicts competitive outcomes. The price matching on NASDAQ makes the findings of Christie and Schultz plausible, despite the large number of market makers.[29] The existence of payment for order flow contracts bolsters this conclusion, since such contracts would cause market makers to lose money if spreads were competitive.

The papers by Christie and Schultz and Huang and Stoll [1996] find that spreads are generally larger for trades under 1,000 shares than for those over 1,000, though in both cases larger than comparable spreads on the NYSE.[30] This volume difference may reflect the fact that small orders were directly subject to the price matching forces described above, while large orders were often traded inside the quoted spread.[31]

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[28] The bulk of the economics literature, as well as reports by the Department of Justice and the SEC, runs contrary to Kleidon and Willig's assertion that NASDAQ spreads were competitive. See footnote 29 below for a discussion of this literature.

[29] Huang and Stoll [1996] have concluded that price matching via internalization and preferencing of order flow is the most likely explanation for wide bid-ask spreads on NASDAQ, as did Godek [1996]. Kandel and Marx [1996] argue, on the other hand, that supra-competitive spreads are a direct consequence of having a minimum price increment (tick size), though they concede that preferencing of order flow may also play a role.

In addition, Christie and Huang [1994] find that trading costs fall for stocks that voluntarily switch from NASDAQ to the New York Stock Exchange or the American Stock Exchange. Affleck-Graves, et. al. [1994], using 1985 data, find that spreads are the same in NASDAQ and the NYSE for comparable companies. This result may conform with Kothare and Laux [1995] and Huang and Stoll [1996], who found that NASDAQ spreads increased between 1984 and 1992. Kothare and Laux attribute this rise to an increase in institutional trading activity, however, and not price matching. Huang and Stoll [1996, pp. 347-348] reject this explanation, and note that the increase occurred "during a period in which trading technologies have become more automated and more efficient," while NYSE spreads declined over the same period.

[30] See also Randall [1994], which notes that before May 1994, 23 percent of NASDAQ trades of at least 1,000 shares were priced in eighths, while only 6 percent of trades of less than 1,000 shares traded in eighths.

[31] One way this can occur is via Instinet, a computer system on which large investors can anony-

We therefore applaud the SEC for insisting on new rules that make it easier for small traders to use limit orders to trade at prices inside the spread.[32] This has the potential to break the power of price matching by allowing customers to quote their own prices.

Our model predicts that the welfare losses from price matching on NASDAQ must be small as a fraction of sales if, as we presume, demand elasticity is high and fixed costs are high relative to marginal costs.[33] The attention of the DOJ and SEC may have been justified, however, by the huge market size. In 1995, 101.2 billion shares were traded on NASDAQ,[34] which means that if prices averaged 1/8 point over competitive levels, welfare losses could have exceeded $12 billion in that year.

This figure represents an upper bound on welfare losses, however, since revenues earned from high spreads were probably not entirely dissipated by over-entry, as in our model. Some could have been dissipated on service-based competition for retail customers, which may have been only partially wasteful. More directly, we might expect revenues from supracompetitive spreads to be simply funneled back to customers via lower retail commissions.[35] If the brokerage market were perfectly competitive, in fact, we would expect to see commission schedules with a fixed fee paid by the customer, accompanied by an order flow payment from the broker to the customer to compensate for the supracompetitive spread. We are not convinced, however, that the market for brokerage services is perfectly competitive.[36]

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mously conduct trades and thus bypass NASDAQ intermediaries. See Smith [1994] for some discussion of Instinet.

[32] A limit order is a customer's order to buy or sell a stock at a particular price, while a market order is an order to execute the trade at the current market price. The spread on market orders is defined by market makers, while the spread on limit orders is defined by the customers themselves. For a description of recent SEC rule changes, see SEC [1996a].

[33] Demand to buy or sell a given security should be fairly elastic because there are other securities, on NASDAQ or elsewhere, that when bundled are good substitutes. We are less certain of our technological presumption, but we suspect there are significant fixed costs in buying computers for trading or hiring a licensed broker to be a market maker for a given security.

[34] SEC [1996a, p.11].

[35] Large transactions on NASDAQ are sometimes conducted "net," that is, without commission, but smaller customers usually pay a commission to the retail broker executing the trade.

[36] In fact, instead of brokers paying customers for order flow, their commissions have traditionally *increased* with volume. This tendency has been mitigated recently as some brokers have begun

More generally, in markets where avenues of non-price competition are available, high prices may not attract as much entry as they would otherwise, and thus price matching's full competitive potential may not be realized. In some other markets, as Hviid and Shaffer [1997] argue, the hassle costs of taking advantage of a price matching offer may mean that prices do not rise all the way to p^{pm}, or fail to rise at all above the competitive price. Ultimately, determining the price effects of matching policies in different types of markets is an empirical exercise – one whose pursuit we recommend with enthusiasm.

Even without the sort of explicit matching policies envisioned in our model, computerized trading may present problems quite similar to the matching we discuss. A firm's incentive to undercut a price that exceeds cost naturally depends on how that firm expects rivals to react. In our price matching model, customers demand that rivals who adopt a matching policy instantaneously track a price cutter's price. It has long been observed that when rivals' reaction times decrease sufficiently, undercutting becomes unprofitable. One feature of computerized trading systems is that reaction times may be very short, even if they are not immediate as under the NASDAQ system. Although quick-response price matching may not solve the problem of coordinating on a price hike, the potential for downward price stickiness could become increasingly important as more business gets conducted on the Internet or on proprietary computer systems such as NASDAQ or the airlines' reservation systems. In some cases, near-frictionless price "competition" may lead to higher welfare losses than if there were no competition at all. This possibility warrants more study and attention.

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to offer flat fee trades. Still, we have yet to see any brokers pass along a payment for order flow, suggesting that the market may not be perfectly competitive.

7. Appendix A

Here we modify the Salop and Stiglitz [1977] model of bargains and ripoffs to allow firms to offer price matching pledges. Buyers are aware of the equilibrium price distribution, but must pay some individual cost s to know which sellers post which prices. The cost s has a cumulative distribution function given by $G(s)$. A buyer who buys at price p has consumer surplus of $CS(p) = \int_p^\infty d(\bar{p})d\bar{p}$. Individual demands are identical so that with L buyers, $D(p) \equiv Ld(p)$.

An uninformed buyer buys from store i at price p_i with probability $\frac{1}{N}$, where N is the equilibrium number of stores, and so has expected consumer surplus equal to $\sum_{i=1}^N \frac{CS(p_i)}{N}$. A buyer will pay s to become informed if $s < \hat{s}$, where $\hat{s} = CS(p_{\min}) - \sum_{i=1}^N \frac{CS(p_i)}{N}$. Then, $G(\hat{s})$ is the fraction of buyers who become informed. Salop and Stiglitz show (in a model with no price matching) that the unique equilibrium typically involves two prices. Low-priced firms sell at "bargains" for $p = \frac{F}{Q} + c$, and high-priced firms sell at "ripoffs" for p^{pm}.[37]

Price matching breaks the Salop-Stiglitz two-price equilibrium. As shown below, low-priced firms will adopt price matching polices and raise prices to price discriminate. In equilibrium, there are no low prices left, and all buyers pay p^{pm}.

Buyers' search strategies depend on the equilibrium price dispersion and do not take into account deviations by firms.[38] In an equilibrium, a fraction $G(\hat{s})$ buyers are informed, where $\hat{s}$ is determined by the equilibrium price dispersion. Let $p_{\min} \equiv \min_j \{p_j\}$ and M = number of firms either posting $p_{\min}$ or agreeing to match. Then, firm i's profits are:

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[37]Technically, this result requires that $G(0)$ be sufficiently low and that ε is low enough so that $p^{pm} > \frac{F}{Q} + c$.

[38]Essentially, Salop-Stiglitz have a simultaneous game with a Nash equilibrium concept. Another view of this assumption is that it represents an approximation which captures the idea that with many firms, one firm's price has a negligible effect on the price distribution, and so should not affect search appreciably.

$$\pi_i = \begin{cases} \frac{D(p_i)(1-G(\hat{s}))}{N}(p_i - c) - F & \text{if } p_i > p_{\min} \text{ and the firm doesn't match,} \\[2ex] \frac{D(p_i)(1-G(\hat{s}))}{N}(p_i - c) + \frac{D(p_{\min})G(\hat{s})}{M}(p_{\min} - c) - F & \text{if } p_i = p_{\min} \text{ or the firm matches.} \end{cases}$$

There is no equilibrium in which some firm i charges $p_i < p^{pm}$, since firms' incentives to price discriminate would undo such an outcome. This result is summarized as follows:

Proposition 7.1. *If matching is possible in the Salop-Stiglitz model, then all firms post p^{pm} in any equilibrium with some uninformed buyers.*

Proof: Observe first that in equilibrium, no firm will post $p_i > p^{pm}$ since such a firm could increase profits by posting p^{pm}, whether or not it matches prices. Suppose, then, that some firm posts $p_i < p^{pm}$. Note that there can be no firm charging an intermediate price $p \in (p_{\min}, p^{pm})$, since this firm could increase profits by matching and posting p^{pm}. Profits increase by $\frac{(1-G(\hat{s}))}{N}((p^{pm} - c)D(p^{pm}) - (p_i - c)D(p_i))$ if the firm was initially a matcher and by $\frac{(1-G(\hat{s}))}{N}((p^{pm} - c)D(p^{pm}) - (p_i - c)D(p_i))$ $+ \frac{D(p_{\min})G(\hat{s})}{M}(p_{\min} - c)$ if it was not. Note also that $1 - G(\hat{s})$ is positive since we assume there are some uninformed buyers, and that $p_{\min} > c$ in equilibrium, since if $p_{\min} \leq c$, firms charging $p_{\min}$ cannot cover their fixed costs.

Any firm charging $p_{\min}$ can increase profits by raising price to p^{pm} and matching, unless $p_{\min} = p^{pm}$. This is straightforward when there are other firms charging $p_{\min}$, because then profits increase by $\frac{(1-G(\hat{s}))}{N}((p^{pm} - c)D(p^{pm}) - (p_{\min} - c)D(p_{\min}))$. If there is only one firm charging $p_{\min}$ and all buyers are uninformed ($G(\hat{s}) = 0$), then the firm can raise its profits by $\frac{1}{N}((p^{pm} - c)D(p^{pm}) - (p_{\min} - c)D(p_{\min}))$ by posting p^{pm}. If, finally, there is only one firm charging $p_{\min}$ and some buyers are informed, then all firms charging p^{pm} must be matching,[39] and so the single firm charging $p_{\min}$ can raise its profits by $\frac{1}{N}((p^{pm} - c)D(p^{pm}) - (p_{\min} - c)D(p_{\min}))$ by posting a price of p^{pm}. ∎

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[39] Every firm charging p^{pm} prefers to match, since this will capture a share of the informed market and increase profits by $\frac{D(p_{\min})G(\hat{s})}{M}(p_{\min} - c)$. Recall, also, that $p_{\min} > c$ in equilibrium – otherwise, firms charging $p_{\min}$ could not cover their fixed costs.

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As in Proposition 2.1, in which all buyers were informed, it is an equilibrium for N^{pm} firms to enter, post p^{pm}, and match prices. With some uninformed buyers, however, it is typically the only equilibrium. If *all* buyers are uninformed, this result is straightforward. If there are both informed and uninformed customers, as Proposition 7.1 shows, firms pricing below p^{pm} will generally have an incentive to price discriminate by raising their posted price to p^{pm} while offering a matching policy. This maximizes profits on uninformed customers while retaining an equal share of informed customers.[40] In equilibrium, only p^{pm} survives.

In the Salop-Stiglitz model, buyers choose either to search all firms or take their chances and canvas only one seller. The proof given above can be extended to the case where buyer k chooses to search some number of firms n and has total search costs of $s^k(n)$. A firm charging $p_{\min}$ would still be better off matching and charging p^{pm}, as long as this did not make it less likely to be among the sets of firms from which any buyer chooses. With this proviso, raising price to p^{pm} will increase profits from buyers who do not draw a $p_{\min}$ from the n firms they choose to search, while the firm is protected by the price matching pledge from losing customers who do.

8. Appendix B

For simplicity, we assumed in Proposition 2.1 that a firm cannot build multiple plants. In this appendix, we show that Proposition 2.1 would still hold if we relaxed this assumption. To see this, suppose that building multiple plants is possible, and that when firms charge the same price, the market is divided evenly among *plants*. (The proof would be easier if we assumed that demand were divided among *firms*.) Consider the equilibrium proposed in the proposition. If a firm deviated by building n

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[40]Strictly speaking, for this intuition to be correct, all firms must be price matchers (otherwise, a low-price firm might decrease its share of the informed customers when it posts a higher price, which could lower profits). However, even when not all other firms match, a low-price firm will want to match and raise p somewhat to price discriminate, as long as $D(p)(p-c)$ is quasi-concave.

additional plants and posting price $p < p^{pm}$, then the demand curve for each plant would be $\frac{D(p)}{N^{pm}+n}$, and each plant's sales would be $\min\{Q, \frac{D(p)}{N^{pm}+n}\}$. The profits of a deviator would then be

$$(n+1)\min\left\{Q, \frac{D(p)}{N^{pm}+n}\right\}(p-c) - (n+1)F.$$

Let n^* and p^* maximize profits for the deviator. Then,

$$p^* \in \max_p \left[(n^*+1)\min\{Q, \tfrac{D(p)}{N^{pm}+n^*}\}(p-c) - (n^*+1)F\right],$$

which implies that

$$p^* \in \max_p \min\{Q, \tfrac{D(p)}{N^{pm}+n^*}\}(p-c).$$

Observe that

1. $\min\left\{Q, \frac{D(p^{pm})}{N^{pm}+n^*}\right\}(p^{pm}-c) = \frac{D(p^{pm})}{N^{pm}+n^*}(p^{pm}-c)$, since $\frac{D(p^{pm})}{N^{pm}+n^*} < Q$; and

2. $\min\left\{Q, \frac{D(p)}{N^{pm}+n^*}\right\}(p-c) \leq \frac{D(p)}{N^{pm}+n^*}(p-c) \; \forall p.$

Since p^{pm} maximizes $\frac{D(p)}{N^{pm}+n^*}(p-c)$, observations (1) and (2) imply that p^{pm} also maximizes profits for the deviator.

9. References

Anderson, Robert. 1985. "Quick Response Equilibrium," unpublished manuscript, February 1985.

Affleck-Graves, J., S. Hedge, and R. Miller. 1994. "Trading Mechanisms and the Components of the Bid-Ask Spread," *Journal of Finance* 49(4), 1471-1488.

American Petroleum Institute. 1995. *Basic Petroleum Data Book: Petroleum Industry Statistics.* Volume 15, No. 2. Washington, DC: American Petroleum Institute.

Belton, Terrence M. 1987. "A Model of Duopoly and Meeting or Beating Competition," *International Journal of Industrial Organization* 5(4), 399-417.

Blain, Vincent. 1995. "18-Hole Links Proposed for Community," *Toronto Star*, May 6, 1995, at F1.

Borenstein, Severin. 1991. "Selling Costs and Switching Costs: Explaining Retail Gasoline Margins," *RAND Journal of Economics* 22(3), 354-369.

Butz, David. 1993. "Meeting-the-Competition, Guaranteed Retailer Margins, and Vertical Price-Fixing," UCLA Working Paper #688, April 1993.

Christie, William and Roger Huang. 1994. "Market Structures and Liquidity: A Transactions Data Study of Exchange Listings," *Journal of Financial Intermediation* 3(3), 300-326.

Christie, William and Paul Schultz. 1995. "Policy Watch: Did NASDAQ Market Makers Implicitly Collude?" *Journal of Economic Perspectives* 9(3), 199-208.

Christie, William, and Paul Schultz. 1994. "Why do NASDAQ Market Makers Avoid Odd-Eighth Quotes?," *Journal of Finance* 49(5), 1813-1839.

Christie, William, Jeffrey Harris and Paul Schultz. 1994. "Why did NASDAQ Market Makers Stop Avoiding Odd-Eighth Quotes?," *Journal of Finance* 49(5), 1841-1859.

Corts, Kenneth. 1995. "On the Robustness of the Argument that Price Matching is Anticompetitive," *Economics Letters* 47(4), 417-421.

Corzine, Robert. 1996. "Petrol Rivals on Price-War Footing," *Financial Times*, January 18, 1996, p. 8.

Crocker, Keith J. and Thomas P. Lyon. 1994. "What do 'Facilitating Practices' Facilitate? An Empirical Investigation of Most-Favored-Nation Clauses in Natural Gas Contracts," *Journal of Law and Economics* 34, 297-322.

Dahl, Carol and Thomas Sterner. 1991. "Analyzing Gasoline Demand Elasticities: A Survey," *Energy Economics* July 1991, 203-210.

Department of Justice. 1996. *Competitive Impact Statement of the U.S. Department of Justice Antitrust Division, U.S. v. Alex. Brown & Sons, et al.* (S.D.N.Y. July

17, 1996).

Doyle, Christopher. 1988. "Different Selling Strategies in Bertrand Oligopoly," *Economics Letters* 28(4), 387-390.

Edlin, Aaron. 1998. "Do Guaranteed-Low-Price Policies Guarantee High Prices, and Can Antitrust Rise to the Challenge?," forthcoming, *Harvard Law Review.*

Grether, David M. and Charles R. Plott. 1984. "The Effects of Market Practices in Oligopolistic Markets: An Experimental Examination of the Ethyl Case," *Economic Inquiry* 22(4), pp. 479-507.

Godek, Paul E. 1996. "Why NASDAQ Market Makers Avoid Odd-Eighth Quotes," *Journal of Financial Economics* 41, 465-474.

Hess, James and Eitan Gerstner. "Price Matching Policies: An Empirical Case," *Managerial and Decision Economics* 12, 305-315 (1991).

Hirshleifer, David and I.P.L. Png. 1987. "Price Discrimination Through Offers to Match Price," *Journal of Business* 60(3), 365-383.

Huang, Roger D. and Hans R. Stoll. 1996. "Dealer versus Auction Markets: A Paired Comparison of Execution Costs and NASDAQ and the NYSE," *Journal of Financial Economics* 41, 313-357.

Hviid, Morton and Greg Shaffer. 1994. "Do Low Price Guarantees Facilitate Collusion?" Warwick Economic Research Papers, No. 422.

Hviid, Morton and Greg Shaffer. 1997. "Hassle Costs: The Achilles' Heel of Price Matching Guarantees," unpublished manuscript, January 1997.

Jorgenson, Barbara. 1993. "AMP Diversifies to Continue Growing," *Electronic Business Buyer* 19(10), p. 78.

Kandel, Eugene and Leslie M. Marx. 1996. "NASDAQ Market Structure and Spread Patterns," unpublished manuscript, September 19, 1996.

Kleidon, Allan, and Robert Willig. 1995. "Why Do Christie and Schultz Infer Collusion From Their Data?" Report (Cornerstone Research, Menlo Park, CA).

Kothare, Meeta and Paul Laux. 1995. "Trading Costs and the Trading System for NASDAQ Stocks," *Financial Analysts Journal* 51(2), 42-53.

Mankiw, N. Gregory and Michael Whinston. 1986. "Free Entry and Social Inefficiency," *RAND Journal of Economics* 17(1), 49-58.

Milkman, Nancy. 1994. "Price Wars Spreading to Once-Sacred Funeral Industry; Skokie Discounter Leads Attack on Establishment," *Chicago Tribune*, March 21, 1994, at C1.

Morrison, Steven A. and Clifford Winston. 1995. *The Evolution of the Airline Industry*. Washington, DC: The Brookings Institution.

Posner, Richard. 1976. *Antitrust Law: An Economic Perspective*. Chicago: University of Chicago Press.

Randall, Eric. 1994. "Street Talk: Justice Dept. Probes NASDAQ Price Spread," *USA Today*, October 20, 1994, at 3D.

Salop, Steven. 1986. "Practices that Facilitate Oligopoly Coordination," in J. Stiglitz and G.F. Mathewson, eds. *New Developments in the Analysis of Market Structure*. Cambridge, MA: MIT Press.

Salop, Steven and Joseph Stiglitz. 1977. "Bargains and Ripoffs: A Model of Monopolistically Competitive Price Dispersion," *Review of Economic Studies* 44, 493-518.

Schwadel, F. 1989. "Who Wins with Price Matching Plans?" *Wall Street Journal*, March 16, 1989, at B1.

Schwartz, Robert. 1991. *Reshaping the Equity Markets: A Guide for the 1990s*. New York: Harper Business.

Securities and Exchange Commission. 1996a. Release No. 34-37619A, September 1996.

Securities and Exchange Commission. 1996b. *Report Pursuant to Section 21(a) of the Securities Exchange Act of 1934 Regarding the NASD and the NASDAQ Market*, August 8, 1996.

Smith, Carrie. 1994. "NASDAQ Under Fire," *Wall Street & Technology* 12(9), 25-30.

Spence, Michael. 1976. "Product Selection, Fixed Costs, and Monopolistic Competition," *Review of Economic Studies* 43(2). pp. 217-235.

U.S. Bureau of the Census. 1995. *Statistical Abstract of the United States: 1995* (115th edition). Washington, DC: U.S. Government Printing Office.

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