Higher Prices from Entry: Pricing of Brand-Name Drugs

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Abstract

When a new firm enters a market and starts selling a spatially-differentiated product, the prices of existing products may rise due to a better match between consumers and products. Entry may have three unusual effects. First, the new price is above the monopoly price if the two firms collude and may be above the monopoly price even if the firms play Bertrand. Second, the Bertrand and collusive price may be identical. Third, prices, combined profits, and consumer surplus may all rise with entry. Consistent with our theory, the real prices of some anti-ulcer drugs rose as new products entered the market.

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When a new firm starts marketing a product that is spatially differentiated from existing products, the price of existing products may rise whether or not the firms collude. We assume that a brand's location in product space is exogenously determined, and the firm's only choice variable is price. Using a spatial model, we show that the effect of entry on price depends on how close together products are located in characteristic space.

To illustrate this logic, we suppose that a firm enters a market that previously had one firm. If the new product is located at the same point in characteristic space as the original one, the two goods are perfect substitutes so that price must fall if the firms act noncooperatively. If the new product is located so far from the original one that no consumer is interested in buying both products, entry does not affect the original product's price.

Suppose, however, that the two products are located near enough each other that they compete for the same customers but are not perfect substitutes. The original monopoly kept its price down to attract consumers who are located relatively far from its product in characteristic space. Some of these distant customers prefer the new product, which has characteristics closer to their ideal than does the original product. After entry, the original firm has less of an incentive to lower its price to attract consumers for whom its product is a relatively poor match, so it raises its price and sells to only consumers located near its product in characteristic space whose demand is relatively inelastic.

Entry may have three unusual effects. First, the new price is *above* the monopoly price if the two firms collude and may be above the monopoly price *even if* the firms play Bertrand. Second, the Bertrand and collusive price may be identical. Third, prices, combined profits, and consumer surplus may *all* rise with entry. Consumers are located closer on average to their ideal product in the new equilibrium than in the original one, which compensates for the higher price.

We examine the implications of our model for pricing of brand-name prescription drugs, a market that has been subjected recently to much media and regulatory scrutiny. For example, President Clinton, observing that an index of drug prices rose nearly six times faster than general inflation over roughly the last decade called for a National Health Board to investigate "unreasonable" drug prices.[1] Apparently many politicians believe that the rapid prescription drug price increases reflect increasing monopoly or collusive behavior.

Our model offers an alternative explanation, which is consistent with either collusive or noncollusive behavior by firms.[2] As assumed in our model, location of brand-name drugs in characteristic space is exogenous because it is very difficult for the firm to develop a drug with specific properties. Drugs may have unattended side-effects or must be taken more frequently than patients prefer. We examine the largest prescription pharmaceutical market,

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[1] "Clinton's Health Plan; Drug Companies Feeling Pressure of Clinton's Plan to Keep Their Prices Down," *New York Times*, September 30, 1993, p.22.

[2] Our explanation is only part of the explanation for these rapid price increases. Some other explanations for the relatively rapid rise in the indexes of pharmaceutical prices concern changes in quality or biases in the sampling procedures for new goods. See Berndt, Griliches, and Rosett (1993), Griliches and Cockburn (1994), and Suslow (1995).

anti-ulcer drugs. We show that unexpected price increases occur when new drugs enter that are dissimilar from original drugs.

Our explanation for price increases upon entry is different from the familiar story in the pharmaceutical literature (e. g., Caves, Hurwitz, and Whinston, 1991) that contends that brand-name manufacturers raise their prices to price discriminate when generics enter the market. In that explanation, when manufacturers of generic pharmaceuticals are allowed to sell a clone of a previously proprietary drug, they sell at a price far below that of the original. Although price-sensitive consumers switch to the generics, the brand-conscious consumers who continue to buy the brand-name drug are charged a higher price than they paid originally. Despite this price discrimination, the average market price (across name brands and generics) is likely to fall (Frank and Salkever, 1992, p. 24). In any case, the price of the generics is below the original monopoly price. In contrast, in our model of competition between differentiated proprietary drugs, the prices of *all* products may rise with entry.

Section I presents the basic spatial differentiation model. We then compare equilibria under various market structures. Section II covers monopoly, and Section III examines duopoly Bertrand and collusive equilibria. In Section IV, we present empirical evidence from the anti-ulcer drug market that illustrates that prices can rise with entry, consistent with our theory. A brief concluding section follows.

I. The Basic Model

Our analysis and presentation of the basic spatial-differentiation model is based on Salop (1979). For simplicity, suppose that products differ in only one characteristic (e. g., soft drinks range from not sweet to sweet). Products are located in this one-dimensional

characteristic space, which is represented as a line (Hotelling, 1939) or a circle (Salop, 1979) of unit length.[3] A firm cannot change its location, t, but it can set its price. Customers are located uniformly along the line segment. For simplicity, each consumer buys one unit.

The ideal product of a customer located at $\hat{t}$ is a product located at the same point along the line. The utility a consumer located at $\hat{t}$ gets from a product located at t is

$$U(\hat{t}, t) = u - c|\hat{t} - t|, \tag{1}$$

where u is the utility from the consumer's preferred product, $|\hat{t} - t|$ is the distance product t is from the customer's preferred product $\hat{t}$, and c is the rate (transportation cost) at which a deviation from the optimal location lowers the consumer's pleasure. Because this utility function reflects constant marginal disutility as one moves away from $\hat{t}$ in this metric, the utility function is symmetric around $\hat{t}$. A consumer has zero utility if the product is located at $t = \hat{t} \pm u/c$.

Each consumer maximizes consumer surplus, $U(\hat{t}, t) - p$, which is the difference between the consumer's utility from consuming a product located at t and the price. The consumer purchases the best buy, which is the product with the greatest surplus (the best combination of price and location).

Instead of buying one of the products in this market, a consumer buys an outside good if it is a *better buy* in the sense that it gives more pleasure for a given amount of money. If the product is a prescription anti-ulcer drug, then antacids, surgery, antibiotics, or stress-

[3] If product space is a line, firms are located so far from the end points that end-point considerations can be ignored.

reduction therapies are outside goods. Let the best outside good give the consumer a surplus of u_o. The consumer only buys a unit of the best-buy product *i*, if its surplus exceeds u_o:

$$\max_i \left[U(\hat{t}, t_i) - p_i\right] \geq u_o, \tag{2}$$

where the left side of the equation is the surplus from the best-buy product (found by maximizing the surplus over the choice of product *i*).

A consumer is only willing to buy the best-buy brand if the surplus from that brand, $u - p_i$, is greater than that from the outside good: $u - p_i \geq u_o$, or, rearranging terms, $u - u_o \geq p_i$. Thus, the consumer has a reservation price, $v = u - u_o$, which is the highest price that the consumer is willing to pay for this drug. Alternatively stated, a consumer buys the best-buy brand only if the net surplus from that brand — the surplus from the best-buy brand minus the surplus from the outside good — is positive:

$$\max_i \left(v - c\,|\hat{t} - t_i| - p_i\right) \geq 0. \tag{3}$$

(For simplicity, we could assume that $u_o \equiv 0$ so that $u \equiv v$, because the outside good does not play an important role in the following analysis.)

We start by describing a market with only one firm. Then we examine the impact of a second firm entering close enough to the first firm that they compete for some customers. We consider various duopoly market structures, including Bertrand and collusive.

II. Monopoly

If there is only one brand, the monopoly sells to all consumers located close enough to its brand in characteristic space that their net surplus is positive. Salop (1979) calls this range of characteristic space the *monopoly region*. That is, the monopoly sells only to consumers who receive more surplus from that brand than they get from the outside good.

Consider a consumer located at $\hat{t}$, who is $x \equiv |\hat{t} - t_A|$ distance from the monopoly located at t_A. If the monopoly charges price p, the consumer is willing to buy that brand only if the consumer's net surplus is positive: $v - cx - p \geq 0$. By rearranging this expression, the maximum distance, x_m, a consumer can be located from the monopoly brand and still be willing to buy it is

$$x_m = \frac{v - p}{c}. \tag{4}$$

This distance, x_m, is shown in Figure 1. The vertical axis in the figure is the net surplus from that brand. The greater the distance, x, a brand is from the consumer's most preferred product (shown on the horizontal axis), the lower the consumer's net surplus. When the brand is x_m distance from the consumer's most preferred location, the consumer's net surplus from that brand equals zero (where the net surplus line hits the x-axis) so that the consumer is indifferent between buying and not buying.

The monopoly captures all the consumers who are no further than x_m distance on each side of its location, or all the consumers in a $2x_m$ segment. The total number of consumers in this range is $q_m = 2x_m L$, where L is the number of consumers in the market (located uniformly along the line of unit length). Substituting for x_m from Equation 4,

$$q_m = \frac{2L}{c}(v - p). \tag{5}$$

As shown in Equation 5, the change in quantity demanded with respect to a change in price is $-2L/c$ for the monopoly. If the firm sets its price equal to the reservation price of the customer who most prefers this product, v, its sales fall to zero.

We assume that the firm has a constant marginal cost, m, and no fixed costs. Adding positive fixed costs would not change any of our main results and would only complicate the presentation. Its fixed cost affects whether the second firm enters but not post-entry prices.

The monopolist's profit-maximizing price is

$$p_m = \frac{v + m}{2}. \tag{6}$$

Consequently, the distance x_m equals $(v - m)/(2c)$.

Consumer surplus for a monopoly is

$$CS_m = \left(u - \frac{v + m}{2}\right)\left(\frac{v - m}{2c}\right)L. \tag{7}$$

If there is no outside good ($u_o = 0$) so that $u = v$, consumer surplus for a monopoly is

$$CS_m = \frac{(v - m)^2}{4c}L. \tag{8}$$

For example, if $v = 10$, $c = L = 1$, and $m = 2$, then $p_m = 6$, $q_m = 8$, $x_m = 4$, $\pi_m = 32$, and $CS_m = 16$. This example is used throughout the paper to illustrate our analytic results.

III. Duopoly

A second product enters and locates at t_B, which is $z = |t_A - t_B|$ distance from the first firm in characteristic space. If the firms are at least twice the monopoly distance, $\bar{z} = 2x_m = (v - m)/c$, apart, no consumer receives positive surplus from both brands. As a result, each firm maximizes its profit by charging the monopoly price, p_m. Here, entry causes consumer surplus to double because the firms do not compete for the same consumers (there are two local monopolies).

Now suppose that $z < \bar{z}$ so that a duopolist cannot ignore its rival's price when setting its own. Assume that price discrimination is not possible. At low enough prices (such as p_0 in Figure 2), the firms compete for some of the same customers in the sense that some customers would receive positive surplus from both brands. Those customers located in the potential market of each of the two brands buy from the one offering the highest net surplus. As a result, a firm does not capture all customers who prefer its brand to the outside good: It loses some to its rival.

In a symmetric equilibrium, both firms charge the same price. The incumbent firm is selling product *A* located at t_A. If each firm charges the relatively low price p_0, then product *A* captures the consumers to its right up to a distance $x_d(p_0)$. Just as x_m was the maximum distance that a consumer could be from the monopolist's brand and still buy, x_d is the maximum distance that a consumer could be from a duopolist's brand, when the brands are competing, and still buy. A consumer located exactly $x_d(p_0)$ distance from one duopolist is indifferent between buying from either firm. As shown in Figure 2, there are other consumers located slightly further than $x_d(p_0)$ from brand *A* who would obtain positive surplus if

they bought from that firm but they buy product *B*, from which they get a greater surplus. That is, the firms are actively competing for some consumers. Product *A*, however, captures all the customers to its left within its monopoly region because it is not competing with another firm for those customers.

At the moderate price p_1 in Figure 2, the marginal customer is indifferent between buying from either brand or the outside good. This marginal consumer is $x_d(p_1) = x_m(p_1) = (v - p_1)/c$ distance from either firm (as shown in Equation 4).

If the firms charge a higher price, such as p_2 in Figure 2, some consumers located between the firms would buy from neither. That is, both firms are local monopolies.

A. Demand Curve as a Function of Rival's Price

Whether a duopolist is affected by its rival's price depends on the price that is set and the distance between the two firms. We now show how the quantity of output demanded of product *A* changes if the firm raises price *p*, given the price of product *B* is fixed at $\underline{p}$.

We first determine demand when *p* is low enough that at least some customers receive positive surplus from both brands. The firms compete for at least some customers if the sum of their monopoly regions, *X*, evaluated at the appropriate prices, is greater than *z* (the distance between the two firms in characteristic space):

$$X(p, \underline{p}) \equiv x_m(p) + x_m(\underline{p}) = \frac{v - p}{c} + \frac{v - \underline{p}}{c} > z . \tag{9}$$

For the marginal consumer, the net utility from Product *A* equals the net utility from the rival brand or

$$v - cx_d - p = v - c\left(z - x_d\right) - \underline{p}, \tag{10}$$

because the consumer who is x_d from the first brand is z - x_d distance from the second brand. Solving Equation 10 for x_d, we find that

$$x_d = \frac{z}{2} + \frac{\underline{p} - p}{2c}. \tag{11}$$

The entry of a rival affects the original firm in two ways. First, the incumbent must compete for some customers that it originally had to itself. Second, because its elasticity of demand changes and it cannot price discriminate, the incumbent changes its price, which affects its monopoly region (to the left of its location t_A in Figure 2) as well as its competitive region.

For a relatively low p, where $X > z$, the demand facing the incumbent is, $q_d = (x_m + x_d)L$ or

$$q_d = \frac{L}{2c}\left(2v + cz + \underline{p} - 3p\right). \tag{12}$$

If p increases by \$1 (holding $\underline{p}$ constant), the quantity demanded falls by -1.5L/c. For an equal price increase, the change in the quantity demanded from a pure monopoly was -2L/c. That is, the duopoly demand curve is less elastic than the monopoly demand curve.

If p is high enough that no customer is willing to buy from either firm, so that $X(p, \underline{p}) < z$, the relevant demand curve is the monopoly demand curve (Equation 5). Thus, the demand facing the original firm is kinked:

$$q_d = \begin{cases} \frac{L}{2c}(2v + cz + \underline{p} - 3p) & \text{if } X \geq z \\ \frac{2L}{c}(v - p) & \text{if } X < z. \end{cases} \tag{13}$$

If $p = \underline{p}$, the kink occurs at $p = v - cz/2$, which can be shown by equating the two demand expressions in Equation 13. Figure 3 shows such a kinked demand curve for the parameters given above ($v = 10$, $L = c = 1$) and $z = 7$. In the "monopoly" or non-competitive duopoly region (prices above the kink at $v - cz/2$), the demand curve is relatively flat; whereas, in the competitive duopoly region (prices below the kink), where some customers receive positive surplus from both firms, the demand curve is relatively steep.[4]

Where $p = \underline{p}$, call the smallest z such that a firm is operating at the kink on its demand curve $\hat{z}$. For $z < \hat{z}$, the firms compete for some of the same customers. Assuming there is no outside good, consumer surplus with a duopoly is

$$CS_d = 2\left(\frac{(v - p)^2}{c} + (v - p)z - \frac{cz^2}{4}\right)L. \tag{14}$$

As z goes to zero, this expression collapses to the monopoly formula, though it is evaluated at the duopoly price. If z is large enough so that p is set at the kink in the demand curve ($z > \hat{z}$), the consumer surplus equals twice the monopoly expression evaluated at the appropriate price.

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[4] We ignore the possibility Salop (1979) notes of supracompetitive prices where one firm's price is so low that it can even sell to a consumer located on the other side of its rival.

B. Bertrand Equilibrium

Suppose the two firms play Nash in prices (Bertrand). To find the equilibrium, we need to examine both parts of the demand curve.

If the equilibrium price is below the kink in the demand curve, we have a standard interior solution. The first-order condition for profit maximization for the first firm is $p = (2v + cz + \underline{p} + 3m)/6$. Assuming symmetry (identical costs), the equilibrium Bertrand price is[5]

$$p_b = \frac{2v + cz + 3m}{5}. \tag{15}$$

As Equation 15 shows, in the interior, the smaller z (the closer the two firms to each other), the lower the Bertrand price. As z approaches zero (the product become nearly homogeneous), the Bertrand price is below the monopoly price: p_b approaches $(2v + 3m)/5$, which is less than $(v + m)/2 = p_m$. The Bertrand price, p_b, equals p_m at a z equal to $(v - m)/(2c) = x_m = \bar{z}/2$ and exceeds p_m for larger z. That is, if the brands are differentiated

[5] Where the brands are located at the same point in product space (the products are homogeneous), the usual Bertrand result holds that price equals marginal cost. Henceforth, we assume that the brands are located far enough apart that they use this marginal condition to determine their behavior. This assumption is reasonable in the pharmaceutical market because proprietary pharmaceuticals *must* be differentiated to avoid patent problems.

enough ($z > \bar{z}/2$) and there is an interior equilibrium, the Bertrand price is greater than the monopoly price.[6]

The surprising result that $p_b > p_m$ for some z occurs because Bertrand duopolists face *less elastic* demands than does a monopoly. If the second brand enters far from the original monopoly, some consumers will greatly prefer the new brand to the old one (and vice versa). Each firm finds it profitable to concentrate on selling to those consumers with relatively inelastic demands. That is, the incumbent monopoly kept its price down to sell to some consumers who were close to indifferent between buying and not buying. When a second brand enters that is a better match for some consumers, the original firm gives up on those consumers and sells its product at a higher price to only those consumers who really like its product.

If the Bertrand equilibrium is not on the lower portion of the demand curve and the two firms are not local monopolies, the equilibrium must be at the kink in the demand curve.[7] Assuming symmetry, $p_b = v - \frac{1}{2}cz$, which is above the monopoly price.[8] In the

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[6] As readers of a previous draft of this paper pointed out, there is an earlier spatial competition literature that derives a similar result. That literature, however, uses Löschian competition (where a firm presumes that its rivals will react identically to any proposed price change) rather than the Hotelling-type Bertrand-Nash model that we use. Also unlike our paper, those papers don't look explicitly at the role of distance and the effects of entry on welfare.

[7] Above the kink in the demand curve, the derivative of profit with respect to p_b, $2(v - 2p_b + m)L/c$, is strictly negative because $p_b > p_m = (v + m)/c$.

[8] Because the firms are operating at a kink in their demand curves, there is a range of Nash solutions (Perloff, 1995). As is traditional, we assume that the firms choose an identical price because they are symmetric. Salop (1979) notes that the monopolistic competition kink price can be above the monopoly price.

kink region, as z increases, the Bertrand price falls. Our findings about the Bertrand equilibrium are summarized in:

Result 1. Bertrand Pricing:

- In the interior (for small z), as z increases, the Bertrand price rises.
- In the interior, the Bertrand price is greater than the monopoly price if $z > x_m$!
- For z large enough that the equilibrium is at the kink in the demand curve, the Bertrand price falls as z increases.
- Thus, the Bertrand price reaches its peak at the smallest z, $(6/7)(v - m)/c$, such that the equilibrium is at the kink.[9]
- As z approaches $\bar{z}$ the Bertrand price approaches the monopoly price.

Figure 4 illustrates how the Bertrand price varies with z (for $v = 10$, $c = L = 1$, $m = 2$). As the brands become more homogeneous ($z \to 0$), the Bertrand price approaches 5.2, which is below the monopoly price, $p_m = 6$. If $z > x_m = 4$, however, the Bertrand price is greater than the monopoly price. For $z > 6.86 = \hat{z}_b$, the Bertrand price is set at the kink in the demand curve. As z increases beyond this point, p_b falls but remains above p_m. For $z \geq \bar{z} = 8$, the firms are "local" monopolies and charge p_m.

Intuitively, in the symmetric equilibrium, the duopolist chooses p_b if $2x_d < z$. If this condition is violated, there are customers not being served between the firms and $p_b > p_m$. Each firm finds it in its best interest to lower its price to capture some of these customers (as

[9] Using Equation 13, we know that at the kink $p = v - cz/2$. Equating that expression to the Bertrand price given in Equation 15, we obtain this condition.

well as more customers on the other side of its location). The price is lowered to the point where, if it were lowered further, the marginal consumer would be indifferent between the two brands. If both firms lower the price further, each firm loses because it does not gain any more customers (in the contested region) and it receives a lower price.

C. Collusive Equilibrium

If the firms collude, on the lower part of the demand curve ($X \geq z$) the cartel price is

$$p_c = \frac{v + m}{2} + \frac{cz}{4} = p_m + \frac{cz}{4}. \tag{16}$$

Thus, so long as the products are differentiated ($z > 0$), the cartel price is *above* the monopoly price by $cz/4$. If both firms are located at the same location, the best they can do is split the monopoly profit. If the brands are differentiated, the cartel is operating as a two-location monopoly. By adding a differentiated brand, the cartel has more customers who are willing to pay very high prices than before because more customers are located very near a brand than with a single-location monopoly. The cartel takes advantage of these customers' high reservation prices.

By the same reasoning as before, if the cartel does not set the price p_c at the interior solution in Equation 16, it sets it at the kink in the demand curve, $p_c = v - \frac{1}{2}cz$. Our findings about collusion are:

Result 2. Collusive Pricing:

- At $z = 0$ or $\bar{z}$, the collusive price (or two-location monopoly price), p_c, equals the monopoly price, p_m.

- For z between 0 and $\bar{z}$, p_c is strictly greater than the single-location monopoly price, p_m!
- In the interior, as z increases, the collusive price rises.
- In the kink region, as z increases, the price falls.
- Thus, the maximum collusive price occurs at the smallest z, $(2/3)(v - m)/c$, such that the equilibrium is in the kink region.

In the example in Figure 4, as z approaches 0, the cartel price approaches the monopoly price, $p_c = p_m = 6$, and each firm sells half the monopoly quantity. For $z \in (0, 8)$, $p_c > p_m$. The cartel sets its price at the kink in the demand curve if $z \geq 5.33$.

D. Comparison of the Bertrand and Collusive Equilibria

We have four results from comparing the Bertrand and collusive equilibria. First, the Bertrand price may be as high as the cartel price if the brands are sufficiently differentiated:

> *Result 3. Bertrand Pricing Relative to Collusive Pricing*: If z is large enough that both the Bertrand equilibrium and the collusive equilibrium are in the kink region, the Bertrand price and the collusive price are equal! For smaller z (less differentiated products), the Bertrand price is less than the collusive price.

That is, the cartel price and the Bertrand price are identical if $z > (6/7)(v - m)/c$ (= 6.86 in our example), the smallest z such that the Bertrand firms price at the kink. Beyond $\hat{z}_b$, as z approaches $\bar{z}$, the Bertrand and collusive prices are equal and approach the monopoly price: $p_b = p_c \rightarrow p_m$.

We now examine profits and consumer surplus. The key results concerning profits are:

Result 4. Profits:

- Regardless of the market structure, each duopoly firm earns less than a monopoly.
- Compared to monopoly, the duopoly firms' combined profits, however, are always greater under cartel, and are sometimes greater under Bertrand (for $z \geq 1/3$ in our example).
- Regardless of market structure, a firm's profit is strictly increasing in the distance between the firms for $z < \bar{z}$.

These results are illustrated in Figure 5, which is based on our usual numerical example.

Figure 5 also shows how Bertrand consumer surplus, CS_b, varies with z. If z is so large that the two firms do not compete, consumer surplus doubles over the monopoly level (there are two monopolies): In our example, the monopoly consumer surplus is 16 and the consumer surplus is 32 when the two firms are located 8 units apart. If z is very small, consumers benefit from lower prices and better matching, so consumer surplus is again unambiguously higher than CS_m. It can be shown that, in intermediate ranges where $p_b > p_m$, the better matching effect dominates the adverse price effect. That is, consumers are always better off with two Bertrand firms than with a single monopoly.

If the firms charge the cartel price, consumer surplus is:

$$CS_c = \left(\frac{(v - m)^2}{4c} + \frac{(v - m)z}{4} - \frac{7cz^2}{16} \right) L . \tag{17}$$

At z equals zero, this expression is the same as consumer surplus under monopoly at the monopoly price, CS_m. As z increases from zero, CS_c is greater than CS_m until $z \geq (4/7)(v - m)/c$ (= 4.57 in our example).[10] At a larger z (and any z where the collusive firms operate at the kink in the demand curve) CS_c is again greater than CS_m, as shown in Figure 5. The reason for this pattern in CS_c is that there are two off-setting effects for $z < \hat{z}_c$. First, as z increases, the cartel price rises, which lowers consumer surplus. Second, as z increases, more consumers benefit from entry due to better matching, which raises consumer surplus. Our results on consumer surplus are summarized in:

Result 5. Consumer Surplus:

- Consumer surplus is always greater under Bertrand duopoly than under monopoly.
- Consumer surplus is greater under cartel than under monopoly except for an intermediate range of z.

In our example, for $z \geq 1/3$, both consumer surplus and combined profits are greater after entry if the firms play Bertrand. For $z > 4$, the Bertrand price, combined profits, and consumer surplus are all higher after entry. Similarly, entry may raise prices, combined profits, and welfare under cartel (especially for large z, as shown in Figure 5):

Result 6. Overall Effect of Entry: Under Bertrand competition or collusion, for some values of z, entry raises prices, combined profits, and consumer surplus.

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[10] The smallest z such that the firms stop competing for the same customers is $z = (2/3)(v - m)/c > (4/7)(v - m)/c$. Thus, $CS_c < CS_m$ for some values in the "interior" range.

E. Other Market Structures

Because the cartel price is above the monopoly price, which is above the Bertrand price, prices in other duopoly games may be either above or below the monopoly price. For all plausible games, however, there must be a range where "competitive" prices are higher than the monopoly price because they are always greater than or equal to the Bertrand price.

For example, we can describe the outcome of any other game as some weighted average of the Bertrand and the collusive price: $(1 - \lambda)p_b + \lambda p_c$,
where $\lambda = 1$ yields the collusive price and $\lambda = 0$ yields the Bertrand price.[11]

Market power alone does not explain why price may increase after entry. A single firm sets the monopoly price. If a second firm that produces a homogeneous product enters, price stays constant if the firms collude and otherwise falls. Even with more firms in the initial equilibrium, it is difficult to tell a story where entry would lead to a new market structure with a higher price. In contrast, product differentiation, by itself, can explain a price increase after entry for any given market structure (including Bertrand, collusive, or any intermediate game).

The actual observed price, of course, depends on both the degree of differentiation, z, and the market structure, λ. Thus, to explain price movements, a reduced-form price equation needs to capture the change in differentiation (entry, changes in perceptions about the product, and reformulations) and any changes in market structure (possibly correlated with entry).

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[11] Alternatively, if one uses a model for empirical work where firms use a conjectural variation of Λ, the resulting symmetric equilibrium price is $[2v + cz + (3 - \Lambda)m]/[5 - \Lambda]$. This price is a different weighted average of the Bertrand and collusive equilibrium values than the one described in the text.

IV. Empirical Evidence

Information on how prices change may allow us to reject certain theories of how firms compete. In particular, we can contrast our spatial-competition model to a nonspatial oligopoly model, such as a Chamberlinian, representative-consumer model.

In a typical Chamberlinian, oligopoly model — where all brands compete with each other and there is no spatial competition — entry causes prices to fall unless demand curves have very peculiar properties. If Chamberlinian firms collude, entry may not affect prices if new (identical) firms join the cartel, or may cause the cartel price to fall if the entrants do not join the cartel. Thus, in oligopoly models without spatial competition, entry causes prices to remain constant or fall.

In contrast, in our spatial-competition model, if the firms collude, prices rise unless brands are extremely differentiated or perfect substitutes. If the firms play Nash in prices, the incumbent's price falls if the products are very close substitutes, the price rises if the products are moderately differentiated, and the price is unaffected if the products are extremely different so that the brands do not compete for the same customers.

Thus, if we find that prices rise with entry, we can reject the Chamberlinian noncooperative oligopoly and collusion models. Indeed, if prices stay constant (do not fall), we can reject the Chamberlinian noncooperative oligopoly model. Prices falling with entry are consistent with any model but the Chamberlinian collusion model where all entrants join the cartel.

A. Anti-Ulcer Drugs

We illustrate our theory using data on the anti-ulcer drug market. Starting in 1977, a revolutionary class of anti-ulcer drugs entered the market. These drugs are H_2-receptor antagonists, which block the formation of acid. The first of these drugs, Tagamet, rapidly captured the majority of the market for anti-ulcer drugs. Compared to the older generation of anti-ulcer drugs, Tagamet is highly effective in stopping acid formation and has fewer side-effects. Tagamet was the only new-generation anti-ulcer drug in the United States from 1977 until 1983, when Zantac was introduced by Glaxo. Zantac was heavily promoted as having fewer side-effects and fewer potentially serious drug interactions than Tagamet. Doctors were well-aware of these side effects because of extensive media attention.[12] By the late 1980's, more Zantac was sold than Tagamet.[13]

Within a few years other firms entered, including two new H_2-receptor antagonists, Pepcid in 1986 and Axid in 1988. Carafate entered in 1981 and Cytotec in 1988 — both of which coat the ulcer area but do not inhibit acid production.[14] The newest generation of anti-ulcer drugs are the proton-pump inhibitors. The first of these, Prilosec, entered the

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[12] For example, see "SmithKline's Ulcer Medicine 'Holy War'," *Fortune*, September 19, 1983:129-136; *Marketing and Media Decisions*, Vol. 19, April, 1984:32f; "Agitation in a Crowded Anti-Ulcer Drug Market," *Chemicalweek*, January 25, 1989:8-9.

[13] When it first entered, Zantac's share was about one-fourth that of Tagamet. Zantac's share steadily grew and, by 1986, overtook Tagamet's. Many industry observers attribute Zantac's larger share more to superior marketing than to its slightly superior side-effects profile.

[14] It is conceivable that these two drugs could be used simultaneously with an H_2-antagonist or could be used as a substitute. However, Cytotec is approved only for the prevention of those ulcers caused by nonsteroidal anti-inflammatory drugs (such as Ibuprofen).

market in 1989. It may be more potent than the H_2-receptor antagonists but may also be carcinogenic. It is approved for short-term treatment only, as opposed to maintenance therapy.[15] A second proton-pump inhibitor, Prevacid, was approved for marketing in May, 1995. These products vary in several dimensions such as frequency with which one must ingest a pill, number and seriousness of side-effects, and effectiveness for various groups of patients.

All these products sell at prices that are substantially above the marginal cost of manufacturing. For example, a 100-tablet bottle of Zantac sold for $170 in the United States, but only $103 in Canada and $39 in Mexico.[16]

Firms in the anti-ulcer drug market engage in spatial competition, and their products cannot be easily relocated in space.[17] In a general discussion of drug development, Spilker (1989, pp. 402-408) mentions a number of obstacles to changing the attributes of a drug once it has been developed and marketed. First, drug formulas specify ingredients to four significant figures. The FDA must approve any change in the formula for a marketed drug. Second, there are issues of chemical stability and packaging to consider when changing the

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[15] When Prilosec entered the market in September 1989, it was approved to treat only gastroesophageal reflux disease (GERD); however, in June 1991, it was approved by the FDA to treat duodenal ulcers. In March of 1995, an FDA advisory committee voted to revise the Prilosec labeling to delete the prominent warning on gastric carcinoid and move the information to the "precautions" section (*The Pink Sheet*, May 15, 1995).

[16] "Worth Noting," *Business Week*, No. 3317, May 3, 1993:162.

[17] The one exception is that SmithKine, within 18 months of Zantac's entry, was able to change the frequency with which patients must take Tagamet from four times to two times a day when it discovered that consumers preferred Zantac's lower daily frequency of use. Tagamet's side-effect profile and drug-interaction profile, however, remained the same (Suslow, 1995).

dosage form. We therefore feel safe in our assumption that — except perhaps for occasional changes in dosage form — the physical characteristics of marketed drugs are exogenous. Drug companies may still try to convince doctors, through their marketing agents ("detailing") that their pharmaceuticals are superior to rivals' because they differ in characteristics (location). Although we acknowledge this possibility, controlling for such changes in perceived location is beyond the scope of this paper.

According to our theory, the price effect of entry depends on how close in product space is the entrant drug to the existing product. These four H_2-antagonists are roughly equal in terms of their average healing rate (and far superior to the older generation of drugs), but differ in other respects. In particular, Pepcid and Axid both came on the market with a once-a-day dosage, and they have fewer drug interactions and fewer side-effects than Tagamet and Zantac, as shown in Table 1.[18]

We believe that the major split in the H_2-antagonists submarket is between the two early entrants, Tagamet and Zantac, and the later entrants with superior side-effects profiles, Pepcid and Axid. In the sample period, the first two entrants, Tagamet and Zantac, had much larger market shares than the later entrants. For example, in January 1991, Tagamet's share was 25%, Zantac's was 57%, Pepcid's was 14%, and Axid's was 5%. Berndt et al. (1995)

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[18] The drug interaction count for 1989 reported in Table 1 differs from that reported in Berndt et al. (1996) for two reasons. First, our table is based on the U. S. Pharmacopeial Convention, Dispensing Information, which lists "significant" drug interactions; whereas Berndt et al. list "number of adverse drug indications" from the *Physician's Desk Reference*. Second, our data are for 1989, in the middle of our sample period, whereas Berndt et al. report data for 1993. (It is odd that the number of adverse drug interactions falls for Zantac between 1989 and 1993. As we would expect more interactions to be reported over time, we are unable to explain why the count for Zantac fell.)

report that there is a strong first-mover effect in their estimated demand equations for these drugs and that the between-drug price elasticity is -0.7.

So as to keep an open mind about the relationships between these drugs, we use two approaches to categorizing events. In one approach, we treat all six drug events in the same manner. In the other approach, we divide the set of new drug entry events into two subsets: similar and dissimilar. The similar set consists of the two events where a relatively undifferentiated drug (one that is located close to the incumbent in product space) was introduced: the price reaction of Tagamet to the introduction of Zantac, and the price reaction of Pepcid to the introduction of Axid. Because the entrants are similar to the incumbents, we expect their entry to cause a decline in the price of the incumbents. The dissimilar set contains the remaining four events where a differentiated drug was introduced: the price reactions of Tagamet and Zantac to Pepcid and to Axid. Because the entrants are differentiated from the incumbents, the incumbents' prices may increase if our theory holds.

B. Effects of Entry

To determine the effects of entry on prices of anti-ulcer drugs, we use a time-series methodology that explicitly accommodates the high degree of persistence in the price series. This methodology is analogous to the "event study" methods used in the finance literature (e. g., Plosser and Schwert, 1978). Our analysis is based on monthly price series for Tagamet, Zantac, and Pepcid from 1977 through 1993.

As explained in more detail in the Appendix, we use data from IMS America, Ltd. These data reflect only sales through drug stores, which did not receive discounts from the manufacturers. As a result, these price series do not reflect changes in the average price due

to selective discounting to health maintenance organizations, hospitals, and other non-pharmacies.

The following results are based on an analysis of the series of natural logs of prices. We obtain the same results and conclusions, however, if we use nominal prices or the log of nominal prices deflated by the Consumer Price Index.

Realizing that the price series are highly autocorrelated, we dichotomize the price levels into two components: an expected or anticipated component, which is highly auto-correlated; and a residual, unexpected, or price-shock component, which is conditionally uncorrelated over time by construction. We limit our inference to the uncorrelated residuals.

We start by determining whether a series is nonstationary (contains a unit root), so as to partition the log-price series into expected and unexpected components. We calculate Dickey-Fuller and modified (5-lag) Dickey-Fuller test statistics for the presence of unit roots in the log-price series.[19] Using all available data, we fail to reject the existence of a unit root for each of the four log-price series. We reject the unit-root hypothesis, however, for each of the first-differenced log-price series. Thus, we conclude that our model would be better specified using changes in log prices (henceforth, when we say "price" we mean "log price"). An added benefit of this transformation is that these series can be interpreted as the

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[19] To conduct the Dickey-Fuller test of whether the time series of p is non-stationary (or equivalently, contains a unit root), we use ordinary least squares to estimate $\Delta p_t \equiv p_t - p_{t-1} = \mu + \beta p_{t-1} + u_t$. If the ratio of the estimate of β to its standard error is less than the test-statistic reported in Fuller (1976), then we reject the null hypothesis that there exists a unit root. The modified Dickey-Fuller test (see Fuller, 1976) uses the regression

$$\Delta p_t = \mu + \beta p_{t-1} + \sum_{j=1}^{5} \Delta p_{t-j} + u_t.$$

percentage changes in price, thereby eliminating comparison problems due to different price levels.

Next, using standard Box-Jenkins identification techniques, we chose an ARIMA model with an intercept for each of the four series, using all available data. Our model selection criteria is to maximize the Akiake Information Criteria (AIC) subject to each AR or MA term being significant at the 5% (two-tailed) level.[20]

For the complete, similar, and dissimilar sets, we compute a series of monthly price change forecasts conditional on past prices for all six entry events:

$$E\{\Delta p_{j,t} \mid p_{j,t-1}, p_{j,t-2}, \ldots, p_{j,0}\},$$

for j = 1,..., 6 events, and all t. Thus, these forecasts of future prices are conditional on information up to the month before an entry event.

Next, these forecasts are subtracted from the actual prices, yielding a series of residuals, which we view as abnormal prices or price shocks:

$$\hat{e}_{j,t} = \Delta p_{j,t} - E\{\Delta p_{j,t} \mid p_{j,t-1}, p_{j,t-2}, \ldots, p_{j,0}\},$$

for j = 1,..., 6 and all t. These deviations of prices from their expected values reflect many macroeconomic, industry, and firm specific factors including the entry of a competing product.

Using these transformed series, we can study the unexpected price effects for each event individually and collectively. In an effort to minimize the confounding effects of factors other than the entry of a competing product, we follow the finance "event study"

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[20] Our results and conclusions are unchanged if, instead, we follow Bessembinder and Seguin (1993) and choose *a priori* an arbitrarily high AR process for every series.

literature and average the residuals across events in each of our sets of events yielding series of average abnormal prices:

$$\bar{e}_\tau = \sum_{j=1}^{J} \frac{\hat{e}_{j\tau}}{J},$$

where the τ subscripts are relative to an event or entry month of zero, and $J = 2$ for the similar set, 4 for the dissimilar set, and 6 for the complete set. Thus, for example, $\bar{e}_0$ is the cross-sectional average for one set of all abnormal price shocks when $\tau = 0$, the month that a new anti-ulcer drug entered. Similarly, $\bar{e}_{-1}$ is the cross-sectional average of all abnormal price shocks for the month before the new firm entered. If the effect of the entry of a new product on the price of an existing drug is systematic and confounding factors vary randomly from event to event, then mean abnormal price responses should be dominated by the systematic product-entry effect.[21]

In Table 2, for months $\tau = -1$ and $\tau = 0$ (the month before an entry and the month of an entry), we present abnormal price responses for each of the six events and the cross-sectional average abnormal price response for each of our two sets of events. The right-most column shows the abnormal price responses aggregated over months -1 and 0.

Are these results different than what might be produced by accident? Calculating the statistical significance of these results is hampered by the non-normality of the abnormal price

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[21] As an illustration, suppose that the measured abnormal price response is the sum of the systematic product entry effect μ and a random effect attributable to both measurement error and firm, sector, or macro factors ν_{jt}. If the ν_{jt}'s are independently and identically distributed with a mean of zero and a constant variance of σ_ν^2, then the $\bar{e}$'s calculated as the average across J events are unbiased with a mean of μ and a variance of σ_ν^2/J.

responses and cross-sectional correlation. To deal with these two problems, we calculate bootstrapped *p*-values.

Following Efron and Gong (1983) and Efron and Tibshirani (1986), we begin with the series of $\hat{e}_{jt}$ or abnormal price movements. In the case of the response of a single drug *A* to the entry of another drug *B*, we simulate 1,000 events with replacement, where an event is defined as the price reaction of the price of drug *A* to the simulated introduction of the competing drug. This procedure yields the empirical distribution of abnormal price responses of *A*. Next, the actual abnormal price response is compared to this simulated empirical distribution. The bootstrapped *p*-value reported in Table 2 is the portion of the empirical distribution that exceeds the actual abnormal price response.

To derive an empirical distribution of cross-sectional average responses, we again simulate 1000 events with replacement, where the event is defined to reflect the lack of independence between drug price series. The actual average abnormal price moves are then compared to this distribution yielding bootstrapped *p*-values. Specifically, assume that there are two existing drugs, *Z* and *T*, and two dissimilar drugs, *A* and *P*, that enter in different months. An event is defined by choosing a month at random and collecting the abnormal price responses for *Z* and *T* for that same month. Then a second month is chosen at random and the abnormal price responses for *Z* and *T* for that second month are collected. Finally, these four numbers are averaged yielding one observation in the empirical distribution. Bootstrapped *p*-values for two-month accumulated returns are constructed in a similar fashion.

The results in Table 2 are consistent with our predictions. Across all dissimilar drugs, there is an unexpected price increase in the month before entry of 2.85% (with a *p*-value of 0.003). The unexpected price increase in the month of entry is 0.82% (0.174). Across the two periods, the unexpected price effect is 3.67% (0.006). Thus, there is strong evidence that the price of dissimilar drugs rose with entry. If anything, the similar drug prices fell with entry (though the *p*-values are very high). Figure 6 shows the cumulative unexpected price effects (starting at $\tau = -3$) for the similar, dissimilar, and complete sets of events. The cumulative series for the dissimilar and similar groups diverge at about $\tau = -1$. This difference in effects between the dissimilar and similar drugs is pronounced, as is also shown by the row of differences in Table 2.[22] These empirical results are consistent with the predictions of our theory but not with the predictions of the standard Chamberlinian model.

Because some observers of this industry might dispute our division of events into similar and dissimilar categories, we also examine all the events simultaneously, as shown in the last row of Table 2. The results for the complete set of events lie between those for the similar and dissimilar effects. The unexpected price increase is 1.63% (with a *p*-value of 0.027) in the month before entry, 0.21% (0.369) in the month of entry, and 1.84% (0.052) across the two periods. Thus, even if we treat all six events in the same manner, we find more evidence of price increase than price decrease from entry.

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[22] We also calculated abnormal price responses and corresponding bootstrapped *p*-values for other months and aggregation windows other than [-1, 0]. In no case did we find statistically significant results except for those multi-month aggregation periods that include the one month lag or the month of entry or both.

We also examined how the entry of Prilosec, the best-selling non-H_2-antagonist drug, affected the prices of the four H_2-antagonist drugs. Prilosec did not statistically significantly affect the prices of Tagamet and Zantac, but may have raised the price of Pepcid and Axid.[23] The effect of Prilosec's entry for the [-1, 0] window was -1.42% (with a *p*-value of 0.743) for Tagamet, -0.9% (0.498) for Zantac, and -1.16% (0.852) for the average of these two drugs. The effect on Pepcid was 3.38% (0.117), on Axid was 3.71% (0.153) and the average across them was 3.55% (0.059). Again, the prices of Tagamet and Zantac move together, and the prices of Pepcid and Axid move together, and the two groups move statistically significantly differently: The difference for the [-1, 0] window between Tagamet-Zantac and Pepcid-Axid was 4.71% (0.039). Based on this evidence one might conclude that Prilosec is located nearer to Axid and Pepcid in product space than to Tagamet and Zantac.

One possible alternative explanation for the price increases at the time of entry is that the demand for H_2 drugs was growing when these events occurred. Conceivably, this growth in demand resulted in higher prices independent of the effects our theory describes. We believe this alternative explanation is implausible for three reasons. First, our initial detrending should remove systematic time-series effects of growing demand. Second, there is no reason to believe that demand for an existing drug should independently increase exactly when a new drug enters. Third, we used the same type of event analysis to examine volume changes and found that detrended volume falls with entry, as one would expect under our theory or traditional entry theories. For each of the six events, the volume of the incumbent

[23] One might interpret this result as supporting our division of events into similar and dissimilar groups.

drugs fall at the time of entry. Averaged over all six events, the detrended fall in volume from one month before entry to entry was -12.1%. By two months after entry, the cumulative abnormal volume was -18.0%.

Thus, we believe that the price increases with entry are unlikely to be due to unrelated demand increases. These price increases are consistent with our theory, though not with traditional models of entry.

V. Conclusions

Entry by a second product may cause prices to rise in a spatially differentiated market. The new price is *above* the monopoly price if the two firms collude and may be above if the firms play Bertrand and the products are sufficiently differentiated. The Bertrand and collusive price may be identical. Further, prices, combined profits, and consumer surplus may all rise with entry.

Based on data for the anti-ulcer drug market, the price of existing brands rose at the time of entry by other firms. This pricing pattern is inconsistent with standard, Chamberlinian, nonspatial models of noncooperative oligopoly or collusive behavior, but is consistent with our model of spatial competition under either noncooperative oligopolistic or collusive behavior.

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Data Appendix

The data are monthly observations on units and sales from the IMS America, Ltd., U. S. Drugstores Audit.[24] This audit reports monthly sales value and physical units sold of ethical and proprietary pharmaceuticals purchased for resale by retail outlets in the continental United States. The national estimates are based on the purchases of a panel of independent pharmacies, chain operations, and wholesalers. Not covered are purchases in hospitals, pharmacies in department stores and supermarkets, health maintenance organizations, mail-order pharmacies, dispensing physicians, nursing homes, or clinics.[25] Prices that are calculated from these data represent prices charged by manufacturers or wholesalers to pharmacies.

The IMS database is organized by therapeutic category. Our data cover the category "Antispasmodic/Antisecretory Agents," which includes the anticholinergic drugs (most of which were developed in the 1950s), Carafate, Cytotec, Prilosec, and the four H_2-antagonist drugs (Tagamet, Zantac, Pepcid, and Axid). The H_2-antagonist drugs dominated the market during our sample period of January, 1977 through May 1993. In 1984, for example, although there were over 50 products in the Antispasmodic/Antisecretory Agents category, the 3 H_2-antagonists available on the market at the time accounted for roughly 79% of total category sales.

The IMS audit supplies information for each "presentation" of a particular drug, be it in capsule form, tablet, or injection. More specifically, the data are gathered at the product pack level (e. g., 150 mg tablets in bottles of 100). Our sample covers presentations only in tablet

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[24] IMS America, 660 W. Germantown Pike, Plymouth Meeting, PA 19462.

[25] According to the *IMS Pharmaceutical Database Manual*, its drugstore audit covers 67% of the U.S. pharmaceutical market. IMS estimates that the hospital market share of the H_2 antagonist drugs was approximately 13% in 1989.

form, which account for the majority of the market. The excluded data, anti-ulcer drugs in vial or syringe form, are a very small part of drugstore sales (they are designed for the hospital market).[26] Prices are converted into daily dose prices using the recommended dosage as listed in the Physician's Desk Reference. We follow the conventions described in Berndt et al. (1996) to construct the price series.

Close inspection of the data indicates peculiar pricing patterns over the first month a drug is available. Because we calculate prices by dividing total monthly revenues by total monthly quantity, inaccurate prices may be obtained where we have only a partial month of data — especially if one series slightly lags the other. To avoid such problems, we dropped the first two months of price data after entry in our time-series estimation. Our results are virtually unchanged if we drop only one month.

In our estimations, however, we use the actual entry month to determine the price response of existing drugs. For example, we measure the abnormal price responses of Tagamet to the entry of Zantac in July 1983, which is the actual data of Zantac's entry. The July and August 1983 price observations for Zantac are not used in the univariate time-series analysis of the effect of later entrants on the price of Zantac.

[26] Berndt, et al. (1994, p. 51) report that, for the twelve-month period ending in May 1993, "drugstore sales revenues for non-oral presentations of H_2-antagonists were less than one thousandth as much as revenues for oral presentations."

Table 1

Characteristics of Anti-Ulcer Drugs

Drug	*Dose* (Mg; times per day)	*Drug Interactions*	*Side Effects Needing Medical Attention*[*]
Tagamet	400; 2	7	6
Zantac	150; 2	7	6
Pepcid	40; 1	1	6
Axid	300; 1	1	1

[*] The incidence of all of these reported side-effects was rare according to U. S. Pharmacopeial Convention, Dispensing Information (USP DI).

Source: Suslow (1995), Table 3A, which shows the 1989 characteristics of the H2 drugs. The data for the characteristics were gathered from the USP DI.

Table 2

Effects of Entry

Unexpected Percentage Price Change (p-value)

		Month Relative to Entry		
Existing Drug	*Entrant*	-1	0	(-1, 0)
Dissimilar Entrants				
Tagamet	Pepcid	6.59%	-.62%	5.97%
		(.015)	(.650)	(.067)
Tagamet	Axid	.60	5.29	5.89
		(.207)	(.023)	(.077)
Zantac	Pepcid	5.18	-1.18	4.00
		(.012)	(.813)	(.086)
Zantac	Axid	-.97	-.22	-1.19
		(.775)	(.396)	(.614)
Average across Entry of Dissimilar Drugs		2.85	.82	3.67
		(.003)	(.174)	(.006)
Similar Entrants				
Tagamet	Zantac	-.43	-.80	-1.23
		(.520)	(.756)	(.697)
Pepcid	Axid	-1.22	-1.21	-2.43
		(.828)	(.814)	(.923)
Average across Entry of Similar Drugs		-.83	-1.01	-1.84
		(.892)	(.951)	(.960)
Difference = Dissimilar - Similar		3.68	1.83	5.51
		(.001)	(.054)	(<.001)
All Events		1.63	.21	1.84
		(.027)	(.369)	(.052)