Higher Prices from Entry:
Pricing of Brand-Name Drugs

Jeffrey M. Perloff[a]

Valerie Y. Suslow[b,*]

Paul J. Seguin[c]

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[a] University of California, Department of Agricultural and Resource Economics, 207 Giannini Hall, MC 3310, Berkeley CA 94720-3310
[b] University of Michigan, Stephen M. Ross School of Business, 701 Tappan Street, Ann Arbor, MI 48109-1234
[c] University of Minnesota, CSOM-UMN, 321 19th Avenue S., Minneapolis, MN 55455

* Corresponding author. Tel: 734-763-4510; Fax 734-936-0279

Email addresses: perloff@are.berkeley.edu; suslow@umich.edu; pseguin@csom.umn.edu

Abstract

When a new firm enters a market and starts selling a differentiated product, the prices of existing *and* new products may be higher than the incumbent's original price due to a better match between consumers and products. In other words, the average price in the market can rise upon entry. Market power alone does not explain this result: we would expect price to fall with entry or to stay constant if the incumbent and entrant form a cartel to achieve maximum profits. In contrast, product differentiation, by itself, can explain a price increase after entry for either a Bertrand or collusive game. We find support for our theory using data on brand-name entry in the anti-ulcer drug market between 1977 and 1993.

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1. Introduction

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. Consider a spatially differentiated goods market where location is exogenously determined and firms' only choice variable is price. A new firm then introduces a new product in this market where before there was a single firm with a single product. If the new product is located at the same point in characteristic space as the original one, the two goods are perfect substitutes and price must fall if the firms act non-cooperatively. However, suppose that the two products are located near enough to each other that they compete for the same customers but are not perfect substitutes. The former monopolist used to keep its price low enough to attract consumers located relatively far from its product in characteristic space. Now some of these distant customers prefer the new product, which has characteristics closer to their ideal than does the original product. After entry occurs, 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 only to consumers located near its product in characteristic space whose demand is relatively inelastic.

As this story suggests, we can use a spatial model of horizontal product differentiation to show that the effect of entry on price depends on how close together products are located in characteristic space. Entry may have three unusual effects under certain conditions in this type of setting. First, the new post-entry 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 to extensive media and regulatory scrutiny. Many politicians believe that rapid prescription drug price increases reflect increasing monopoly or collusive behavior. Our model offers an alternative explanation, which is consistent with either collusive or non-collusive behavior by firms.[1] As assumed in our model, location of brand-name drugs in

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[1] Our explanation is only part of the explanation for these rapid price increases. Some other explanations for the

characteristic space can reasonably be taken to be exogenous because it is very difficult for the firm to develop a drug with specific properties. For example, drugs may have unattended side-effects or must be taken more frequently than some patients prefer. We examine one of the largest prescription pharmaceutical markets, anti-ulcer drugs from 1977 through 1993. We show that unexpected price increases occur when new drugs enter that were differentiated from original drugs.

There are several possible alternative explanations for why entry may in general cause an increase in price. Ward, et al. (2002, pp. 963-64), for example, point to quality issues (particularly with private-label entry) or increasing consumer uncertainty as possible theories. Frank and Salkever (1992, footnote 3), point to theoretical models deriving this result where demand curves both shift and become less elastic with entry.

There is also a specific related literature on pricing of brand-name versus generic pharmaceuticals. The classic story in this pharmaceutical literature assumes undifferentiated products and posits price discrimination as the source of the price differences (e.g., Caves, Hurwitz, and Whinston, 1991). Frank and Salkever (1992), for example, assume that the brand name producer faces a loyal market segment, "whose demand is unaffected by the price of generic substitutes" and a price sensitive segment.[2] When manufacturers of generic pharmaceuticals are allowed to market a clone of a previously proprietary drug, they sell at a price far below that of the original. Price-sensitive consumers switch to the generics, so that brand-conscious consumers who continue to buy the brand-name drug are charged a higher price than they paid originally. In this standard price discrimination story, the lower generic price usually more than offsets the higher brand-name price so that the average market price falls. As Frank and Salkever conclude: "One outcome that is consistent with our model and supported by descriptive statistics is that brand-name price rises while the average price (including both brand-name and generic products) of a prescription falls" (p. 175).

Our explanation of why new product introduction increases the incumbent's price differs from the price discrimination story in four important ways. First, the generic entrant produces an

relatively rapid rise in the indexes of pharmaceutical prices concern changes in quality or biases in the sampling procedures for new goods. For further discussion, see Berndt, Griliches, and Rosett (1993), Griliches and Cockburn (1994), and Suslow (1996).

[2] Frank and Salkever (1992), p. 167.

undifferentiated product in the price discrimination models, whereas the entrant sells a differentiated product in our model. Second, consumers differ in terms of price sensitivity in the price discrimination model rather than in tastes as in our model. Third, in the typical brand-name versus generic drug model, only the original good's price rises while the generic price falls; in our model, all prices may be higher in the new equilibrium. Fourth, the price discrimination story can say nothing about how differentiation affects the price upon entry, whereas our model has different implications for the entry of close and distant substitutes. Thus, while the price discrimination story is well suited to explaining price movements for a brand-name incumbent upon entry of an equivalent (undifferentiated) generic, our story offers an explanation of pricing of brand-name drugs competing with each other over drug efficacy and other characteristics. Sometimes a new brand-name drug will differ substantially from existing products—a real innovation—and other times there will be marked similarities (so called "me too" drugs). Depending on the degree of differentiation, our model predicts different pricing patterns.

In the next section, we use Salop's (1979) spatial differentiation model to demonstrate several properties of the Bertrand and collusive equilibria and contrast these properties with those of other oligopoly models. In particular, we show that all prices, both the incumbent's and the entrant's, may rise with entry. Then, we use empirical evidence from the anti-ulcer drug market to show that prices rose following brand-name entry. Although this result does not prove that our model is the only explanation of this pricing pattern, it is consistent with our theory, and we are able to rule out several other possible explanations.

2. Spatial Model

Our analysis is based on Salop's (1979) spatial-differentiation model. We lay out the basic model and provide the intuition for our results, but relegate most of the formal mathematical treatment to Appendix 1. For simplicity, suppose that products differ in only one characteristic (e.g., breakfast cereals range from not sweet to very sweet). Products are located along a unit-length circle. A firm cannot change its location, t, but it can set its price. Customers are located uniformly along the circle. For simplicity, each consumer buys one unit.

The ideal choice 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 $U(\hat{t},\ t) = u - c\,|\,\hat{t} - t\,|$, 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 his or her 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's *best buy* 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-reduction therapies are outside goods. Let the best outside good give the consumer a surplus of u_o. A consumer buys a unit of the best-buy product i, only if its surplus exceeds u_o:

$$\max_i \left[U(\hat{t}, t_i) - p_i\right] \geq u_{o,} \tag{1}$$

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 willing to buy the best-buy brand only 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:

$$\max_i \left(v - c\left|\hat{t} - t_i\right| - p_i\right) \geq 0. \tag{2}$$

Henceforth for simplicity, we 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.

2.1. Monopoly

We start by describing a market with only one firm. If there is only one brand, product *A* located at t_A, 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.

The consumer is willing to buy the monopoly brand only if the consumer's net surplus is positive. This condition in turn defines the maximum distance x_m that a consumer can be located from the monopoly brand and still buy. In Figure 1, the horizontal axis shows consumers' distance from the brand, and the vertical axis shows the net surplus from that brand for a consumer at a given location. The greater the distance, x, a brand is from the consumer's most preferred product (shown on the horizontal axis), the lower is 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 the monopoly 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. Let there be L consumers uniformly spread around the circle. Then the total number of units sold by the monopoly is $q_m = 2x_mL$. We assume that the firm has a constant marginal cost, m, and no fixed costs.[3] Appendix 1 derives the monopoly price and consumer surplus.

To illustrate the various results the flow from this model, we use a simple numerical example. (None of our results depend on this special example: We prove them generally in Appendix 1.) There are four critical parameters: v (a consumer's reservation price), c (the transportation cost), L (the number of consumers in the market), and m (a firm's marginal cost). Let $v = 10$, $c = L = 1$, and $m = 2$. The monopoly's price and quantity are $p_m = 6$ and $q_m = 8$. The

[3] Adding positive fixed costs would not change any of our main results and would only complicate the presentation. Fixed cost affects whether the second firm enters, but not post-entry prices.

maximum distance at which a consumer can be located and still choose to purchase the monopoly's product is $x_m = 4$. The monopoly's profit is $\pi_m = 32$, and consumer surplus is $CS_m = 16$. The price elasticity of demand at the optimal monopoly price is -2.67. Below, we compare these values to those from the Bertrand and collusive equilibria.

2.2. Duopoly

A second firm now introduces a new product *B* that is located at t_B, which is close enough to the original product *A*, located at t_A, that they compete for some customers. The Euclidian distance between the products in characteristic space is $z = |t_A - t_B|$. The parameter *z* captures the degree of differentiation. 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.[4]

Now suppose that $z < \bar{z}$ so that a duopoly firm 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. Instead, it now loses some customers to its rival.

In a symmetric equilibrium, both firms charge the same price. Just as x_m was the maximum distance that a consumer could be from the monopoly's brand and still buy, let x_d be the maximum distance that a consumer could be from a duopoly firm's brand, when the brands are competing, and still buy. If each firm charges the relatively low price p_0, then product *A* captures the consumers to its right up to a distance of $x_d(p_0)$. A consumer located exactly $x_d(p_0)$ distance from each firm is indifferent between buying from either firm. As Figure 2 shows, there are other consumers located slightly farther than $x_d(p_0)$ from brand *A* who would obtain positive

[4] Capozza and Van Order (1977, 1980, and 1989) touch on some of these same issues. Their 1980 article analyzes the welfare implications of spatial competition first assuming "portable" firms and then "immobile" firms. There are multiple equilibria with positive profits. In their 1989 article they show that, in the simplest case, the consistent

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

Figure 2 illustrates what happens at prices higher than p_0. At the moderate price p_1 in Figure 2, the marginal customer is indifferent between buying from either brand or the outside good. 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.

Whether a duopoly firm is affected by its rival's price depends on the price that is set and the distance between the two firms. Thus, a fifth critical parameter in the model is z, the distance between products. If the price is set high enough that no customer is willing to buy from either firm, then the relevant demand curve is the monopoly demand curve. But this demand curve changes as the price changes, holding z constant. In other words, the demand facing the incumbent firm is now kinked. Figure 3 shows a kinked demand curve given the parameters we introduced earlier ($v = 10$, $c = L = 1$) where the distance between the two firms in characteristic space is set at $z = 7$. Then, in the "monopoly" or non-competitive duopoly region (prices above the kink), the demand curve is relatively flat. In the competitive duopoly region (prices below the kink), where some consumers receive positive surplus from both firms, the demand curve is relatively steep.[5] As Appendix 1 shows in general, the duopoly demand curve is less elastic than the monopoly demand curve.

Suppose the two firms engage in a Nash-in-prices (Bertrand) game. To find the equilibrium, we need to examine both parts of the demand curve. First, consider the case where the equilibrium price is below the kink in the demand curve. Then we have a standard interior solution to the Bertrand model, where the smaller is z (the closer the two firms are to each other), the lower is the Bertrand price. As the products become nearly homogeneous (as z approaches zero), the Bertrand price is below the monopoly price. If, on the other hand, the brands are highly differentiated (beyond some critical z) and there is an interior equilibrium, the Bertrand price is then greater than the monopoly price (see Appendix 1).

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price conjecture is one-third: a \$1 price increase will provoke a \$1/3 price increase by the closest competitors.

[5] We ignore the possibility that Salop (1979) notes of supra-competitive 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.

The surprising result that $p_b > p_m$ for some z occurs because Bertrand duopoly firms 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 found it optimal to keep 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 incumbent firm gives up on those consumers and sells its product at a higher price only to those consumers who are a good match for its product.

Next, consider the case where the Bertrand equilibrium is not on the lower portion of the demand curve and the two firms are not local monopolies. In this set of circumstances, the equilibrium must be at the kink in the demand curve (see Appendix 1).[6] In the kink region, as z increases, the Bertrand price falls. Our findings for the Bertrand equilibrium (which hold for all possible parameters—not just our example) can be summarized as follows:

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 such that the equilibrium is at the kink.
- As z approaches $\overline{z}$ the Bertrand price approaches the monopoly price.

Figure 4 illustrates how the Bertrand price varies with z using our numerical example (v = 10, $c = L = 1$, and $m = 2$). As the brands become more homogeneous ($z \rightarrow 0$), 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. At the critical level of $z > 6.86 = \hat{z}_b$, 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 $z \geq \overline{z} = 8$, the firms are "local" monopolies and charge p_m.

[6] 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 $p_b > p_m = (v + m)/c$.

Intuitively, in the symmetric equilibrium, the duopoly firm 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 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 total revenue because it does not gain any more customers (in the contested region) and it receives a lower price.

Now let the two firms collude. If the brands are not differentiated (firms are located at the same point in product space), the firms set the monopoly price and split the single-product monopoly profit. If the brands are so far apart that the firms could not compete for the same customers, they would set the monopoly price and each would earn the monopoly profit whether or not they colluded.

If the products are differentiated ($z > 0$), 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 near their preferred location than with a single-location monopoly. The cartel takes advantage of these customers' high reservation prices.

If the products are differentiated, and the firms are locating on the lower portion of the demand curve (below the kink), the cartel price, p_c, is above the monopoly price: $p_c = p_m + cz/4$. If the firms are operating at the kink, they set the same kink price as they would if they did not cooperate. Thus, our findings are:

Result 2. *Collusive Pricing*

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

Figure 4 shows the cartel price for our specific example. 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 $z \geq 5.33$.

2.3. Comparison of 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 less differentiated products (smaller z), the Bertrand price is below the collusive price.

In our numerical example, 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 $\overline{z}$, the Bertrand and collusive prices are equal, $p_b = p_c$, and approach the monopoly price, p_m.

Our key findings concerning profits then follow directly:

Result 4. *Profits*

- Regardless of the market structure, each duopoly firm earns less than a monopoly.
- However, for z between 0 and $\overline{z}$, the duopoly firms' combined profits are always greater under cartel than monopoly, and are sometimes greater under Bertrand (for $z \geq 1/3$ in our example) than monopoly.
- Regardless of market structure, a firm's profit is strictly increasing in the distance between the firms for $z < \overline{z}$.

Figure 5 illustrates these results for our numerical example, demonstrating how Bertrand consumer surplus, CS_b, rises and then falls as z increases. 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. Sanner (2005) shows that this result – as well as the result that prices may rise as the market moves from monopoly to competition – holds even under more general assumptions.[7] The reason for the pattern in CS_c illustrated in Figure 5 is that there are two offsetting effects for $z < \hat{z}_c$. First, as z increases, the cartel price rises, causing consumer surplus to fall. Second, as z increases, the benefit to consumers from better matching increases, causing consumer surplus to rise. Our results on consumer surplus are summarized as follows:

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 Figure 5, for $z \geq 1/3$, both consumer surplus and combined profits are greater after entry if the firms act as Bertrand competitors. 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). We can summarize the effects of entry in the following final result:

Result 6. *Overall Effect of Entry*

- Under Bertrand competition or collusion, *for some values of z*, entry raises prices, combined profits, and consumer surplus.

In summary, market power alone—without product differentiation—does not explain why the incumbent's price may increase after entry of a new product. A single firm sets the monopoly price. If a second firm that produces a homogeneous product enters into a previously monopolized market, 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 either Bertrand or a collusive game.

2.4. Hypothesis Testing

The actual observed price, of course, depends on both the degree of differentiation, z, and the market structure. Thus, to explain price movements, a reduced-form price equation needs to

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[7] Sanner (2005) extends our analysis to allow the amount purchased to differ across consumers and shows that

capture the change in differentiation (entry, changes in perceptions about the product, and reformulations) and any changes in market structure (possibly correlated with entry).

Information on how prices change may allow us to reject certain alternative theories of how firms compete. In particular, we can contrast our spatial-competition model to a non-spatial oligopoly model, such as a Chamberlinian (representative consumer) model of horizontal product differentiation. 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.[8]

In contrast, consider what could happen if there is spatial competition. If the firms collude, then prices rise unless brands are extremely differentiated (effectively not in the same market) or perfect substitutes. If the firms play Nash in prices there are three possibilities: (1) the incumbent's price falls if the products are very close substitutes, (2) the price rises if the products are moderately differentiated, and (3) 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 empirically that market prices rise with entry, we can reject the Chamberlinian non-cooperative oligopoly and collusive models. It is important to emphasize that we are looking for the average market price to rise; we are not looking for the brand-name price to rise a little while the average market price falls (implying that new generic products are priced substantially below brand-name prices). If prices stay constant (do not fall), we can reject the Chamberlinian non-cooperative oligopoly model. Prices falling with entry are consistent with any model, except the Chamberlinian collusive model where all entrants join the cartel.

3. Anti-Ulcer Drugs

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consumer surplus may be higher under monopoly in that case.

[8] Note that we are not trying to predict market structure. Instead, we focus on how price changes upon entry. For analysis of possible first-mover advantages in brand-name pharmaceuticals, see Berndt et al. (1995 and 2003) and Coscelli and Shum (2003).

We test whether the predictions of our theory are plausible using data on the anti-ulcer drug market. We first describe the institutional features of this market and then present empirical evidence.

3.1. H2-Receptor Antagonists

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 was highly effective in stopping acid formation and had fewer side effects. Tagamet was the only new-generation anti-ulcer drug in the United States from August 1977 until July 1983, when Glaxo introduced Zantac. 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.[9] When Zantac entered the market, it charged a substantial premium over Tagamet's price (Berndt et al. 1997). By the late 1980's, Zantac was outselling Tagamet.[10]

Within a few years, two new H_2-receptor antagonists entered the market, Pepcid in October 1986 and Axid in April 1988. This was (and is) an active market, with other entries in the 1980s (e.g., Carafate in 1981, Cytotec and Prilosec in 1989) and 1990s (e.g., Prevacid in 1995). The H_2-receptor drugs have since gone off patent (e.g., Tagamet in 1994), generating numerous generic entrants. We focus our analysis on the four major H_2-blockers at the time: Tagamet, Zantac, Pepcid, and Axid.[11] These products vary in several dimensions, such as the frequency

[9] 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.

[10] When it first entered, Zantac's share was about one-fourth that of Tagamet. Zantac's share steadily grew and, by 1988 Zantac's sales exceeded Tagamet's (Berndt et al 1997, p. 285). There is also evidence that Zantac as well as the other H_2-receptor drugs sold at prices substantially above the marginal cost of manufacturing, as one would expect for pharmaceuticals. For example, in the early 1990s, a 100-tablet bottle of Zantac sold for $170 in the United States, $013 in Canada, and only $39 in Mexico ("Worth Noting," *Business Week*, May 3, 1993, p. 162).

[11] Carafate and Cytotec both coat the ulcer area, but do not inhibit acid production. 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 was approved only for the prevention of those ulcers caused by non-steroidal anti-inflammatory drugs (such as Ibuprofen). Prilosec and Prevacid are examples of proton-pump inhibitors. These drugs were approved initially for short-term treatment only, as opposed to maintenance therapy. When Prilosec entered the market in September

with which one must ingest a pill, the number and seriousness of side effects, and their effectiveness for various groups of patients.

It is reasonable to think of firms in the anti-ulcer drug market engaging in type of spatial competition described in our model, given that their products are differentiated and cannot be easily relocated in space.[12] 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 dosage form. We therefore feel confident in assuming that the physical characteristics of marketed drugs are predetermined (except perhaps for occasional changes in dosage form).

Different drugs can be preferred by, or be more suitable for, different people, so the model of horizontal differentiation applies in this respect as well. According to our theory, the price effect of brand-name entry depends on how close in product space the entrant drug is to the existing product. The four H_2-antagonists (Tagamet, Zantac, Pepcid, and Axid) were roughly equal in terms of their average healing rate (and far superior to the older generation of drugs), but differed in other respects. In particular, Pepcid and Axid both came on the market with a once-a-day dosage, and they had fewer drug interactions and fewer side effects than Tagamet and Zantac, as Table 1 shows.[13]

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). Note that Berndt et al. (2003, pp. 245-46) also consider including Prilosec in their analysis, but decide that during their 1977-1993 sample period, Prilosec "was not a strong substitute for the H_2-antagonist drugs" and therefore they also focus only on Tagamet, Zantac, Pepcid, and Axid.

[12] The one exception is that SmithKline, within 18 months of Zantac's entry, was able to change the daily dose requirement for 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, 1996).

[13] The drug interaction count for 1989 reported in Table 1 differs from that reported in Berndt et al. (1997) 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. (Given that we would expect more interactions to be reported over time, we are unable to explain why the count of adverse drug interactions for Zantac fell between 1989 and 1993.)

We believe that the major split in the H_2-antagonists submarket at the time was between the two early entrants, Tagamet and Zantac, and the later entrants with superior side-effects profiles, Pepcid and Axid. The first two entrants, Tagamet and Zantac, had much larger market shares than the later entrants during our sample period. For example, in May 1993, Tagamet's share was 21 percent, Zantac's 55 percent, Pepcid's 15 percent, and Axid's 9 percent (Berndt et al., 1997, p. 285).

Because we want to keep an open mind about the relationships between these drugs, we use two approaches to categorizing entry. In the first 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. Since the entrants are similar to the incumbents, we expect their entry to cause a decline in the price charged by 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. Within this set of entry events the entrants are differentiated from the incumbents; therefore the incumbents' prices may increase if our theory holds. In contrast, our second approach treats all six drug entry events in the same manner.

3.2. Effects of Entry

We are interested in testing for the effect of entry on prices of anti-ulcer drugs. Although we could use a reduced-form specification with dummy variables for entry, we instead 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. Descriptive statistics for these price series are given in Table 2.

We use data from IMS America, Ltd. (see Appendix 2 on data sources). 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.[14] Also, as noted in Appendix 2, our sample covers only the tablet form of each anti-ulcer drug, even though these drugs may be available in other forms or "presentations." Tablets were the most popular form for these drugs.[15]

Realizing that the price series are highly autocorrelated, we dichotomize the price levels into two components: an expected or anticipated component, which is highly autocorrelated, and a residual, unexpected, or price-shock component, which is conditionally uncorrelated over time by construction. We limit our inference to the uncorrelated residuals.[16]

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.[17] 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 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

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[14] As noted in Appendix 2, the IMS drugstore audit covers approximately 67 percent of the U.S. pharmaceutical market (Berndt et al 1997, p. 282).

[15] Some of these drugs are also available in injection form. For 1993, the ending year of our sample, we know that "non-oral presentations of H_2-antagonists were less than one-thousandth of the values of revenues for oral presentations" (Berndt et al., 1997, p. 316).

[16] The empirical 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.

[17] 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 $\Delta p_t / p_t - p_{t-1} = \Phi + \beta p_{t-1} + u_t$. 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

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

criterion is to maximize the Akiake Information Criteria (AIC) subject to each AR or MA term being significant at the 5% (two-tailed) level.[18]

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:

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

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

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

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, 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 (Tagamet in August 1977, Zantac in July 1983, Pepcid in October 1986, and Axid in April 1988).[19] Similarly, 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

[18] 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.

[19] Berndt et al., 1997, p. 285.

event, then mean abnormal price responses should be dominated by the systematic product-entry effect.[20]

In Table 3, for months τ = -1 and τ = 0 (the month before an entry event and the month of an entry event), 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 randomly? Calculating the statistical significance of these results is hampered by the non-normality of the abnormal price 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 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 3 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.

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[20] 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 measurement error and firm, sector, or macro factors v_{jt}. If the v_{jt}'s are independently and identically distributed with a mean of zero and a constant variance of σ, then the $\overline{e}$'s calculated as the average across *J* events are unbiased with a mean of μ and a variance of σ/J.

The results in Table 3 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 3.[21] These empirical results are consistent with the predictions of our theory but not with the predictions of the standard Chamberlinian model or the usual price discrimination model.

In case our division of events into similar and dissimilar categories appears ad hoc, we also examine all the events simultaneously, as shown in the last row of Table 3. 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.

One possible alternative explanation for the price increases at the time of entry is that the demand for H_2-antagonist drugs was growing when these events occurred. Conceivably, this growth in demand could have 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 incumbent product volume falls with entry, as one would expect under either our theory or traditional entry theories. For each of the six events, the volume of the incumbent drugs falls at the time of entry. If we average over all six events, the

[21] 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.

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.

4. Conclusion

We have shown that in a spatially differentiated market with a single incumbent firm producing a single product, the entry of a new firm producing a differentiated product may result in the price of both products being higher than the original price. This price effect can occur either with collusion or with Bertrand competition where the products are sufficiently differentiated. Market power alone—without product differentiation—does not explain why the incumbent's price may increase after entry of a new product. In contrast, product differentiation, by itself, can explain a price increase after entry for either Bertrand or a collusive game

Using data for the anti-ulcer drug market from 1977 to 1993, we find that the price of existing brands rose at the time of entry when the entrant was relatively differentiated but not when the entrant's product was a relatively close substitute to existing products. This pricing pattern is inconsistent with the standard price-discrimination story in the literature on (non-differentiated) brand name and generic drug pricing. It is also inconsistent with a Chamberlinian (non-spatial) model of non-cooperative or collusive behavior. This pricing pattern is, however, consistent with our model of spatial competition under either non-cooperative or collusive behavior.

Appendix 1. Theory

We derive the various results cited in the paper in the order in which we discussed them. We start with monopoly, then duopoly in general, Bertrand duopoly, and finally cartel.

1. Monopoly

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 $q_m = 2x_mL$, where L is the number of consumers in the market (located uniformly along the line of unit length). Thus, the quantity demanded of the monopoly is

$$q_m = \frac{2L}{c}(v-p). \tag{3}$$

By differentiating equation (3) with respect to p, we find that the change in quantity demanded from the monopoly with respect to a change in price is $-2L/c$. Given that the monopoly has a constant marginal cost, m, and no fixed costs, the monopoly's profit-maximizing price is

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

Consequently, $x_m = (v - m)/(2c)$.

Consumer surplus for a monopoly is $CS_m = \left(u - \frac{v+m}{2}\right)\left(\frac{v-m}{2c}\right)L$. Given that we have assumed that there is no outside good ($u_o = 0$ so that $u = v$), consumer surplus for a monopoly is

$$CS_m = \frac{(v-m)^2}{4c}L\ . \tag{5}$$

2. Duopoly

A second firm introduces a new product B that is located at t_B, which is close enough to the original product A, located at t_A, that they compete for some customers. We assume that $z = |t_A - t_B| < \bar{z}$ so that a duopoly firm cannot ignore its rival's price when setting its own and that price discrimination is not possible. We look at symmetric equilibria in which both firms charge the same price.

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):

$$X(p, \underline{p}) \equiv x_m(p) + x_m(\underline{p}) = \frac{v-p}{c} + \frac{v - \underline{p}}{c} > z. \tag{6}$$

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

$$v - cx_d - p = v - c\ (z - x_d) - \underline{p}, \tag{7}$$

because the consumer who is x_d from the first brand is $z - x_d$ distance from the second brand. Solving equation (7) for x_d, we find that

$$x_d = \frac{z}{2} + \frac{\underline{p} - p}{2c}. \tag{8}$$

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

$$q_d = \frac{L}{2c}\left(2v + cz + \underline{p} - 3p\right). \tag{9}$$

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 3). Thus, the demand facing the original firm is kinked:

$$q_d = \begin{cases} \dfrac{L}{2c}\left(2v + cz + \underline{p} - 3p\right) & if\ X > z \\ \dfrac{2L}{c}\left(v - p\right) & if\ X < z. \end{cases} \tag{10}$$

If $p = \underline{p}$, the kink occurs at $p = v - cz/2$, which can be shown by equating the two demand expressions in Equation (10)—see Figure 3. 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.

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

$$CS_d = 2\left(\frac{(v - p)^2}{c} + (v - p)z - \frac{cz^2}{4}\right)L. \tag{11}$$

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.

3. Bertrand

Suppose the two firms engage in a Nash-in-prices (Bertrand) game. 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[22]

$$p_b = \frac{2v + cz + 3m}{5}. \tag{12}$$

In the interior where Equation (12) holds, the smaller is z (the closer the two firms are to

[22] 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.

each other), the lower is 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 $(v - m)/(2c) = x_m = \overline{z}/2$ and exceeds p_m for larger z. That is, if the brands are differentiated enough ($z > \overline{z}/2$) and there is an interior equilibrium, the Bertrand price is greater than the monopoly price.

Next, consider the case where the Bertrand equilibrium is not on the lower portion of the demand curve and the two firms are not local monopolies. Hence, the equilibrium must be at the kink in the demand curve. (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 $p_b > p_m = (v + m)/c$.) Assuming symmetry, $p_b = v - 2cz$, which is above the monopoly price.[23] In the kink region, as z increases, the Bertrand price falls. The surprising result that $p_b > p_m$ for some z occurs because Bertrand duopoly firms 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 found it optimal to keep 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 incumbent firm gives up on those consumers and sells its product at a higher price only to those consumers who really like its product.

4. Collusion

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

$$p_c = \frac{v + m}{2} + \frac{cz}{4} = p_m + \frac{cz}{4}. \tag{13}$$

Thus, if 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.

By the same reasoning as before, if the cartel does not set the price p_c at the interior solution in Equation (13), it sets it at the kink in the demand curve, $p_c = v - 2cz$. The cartel price and the Bertrand price are identical if $z > (6/7)(v - m)/c$, the smallest z such that the Bertrand firms price at the kink. Beyond $\hat{z}_b$, as z approaches $\overline{z}$, the Bertrand and collusive prices are equal, $p_b = p_c$, and approach the monopoly price, p_m.

We can show that, in intermediate ranges where $p_b > p_m$, the better-matching effect dominates the adverse price effect so that consumers are always better off with two Bertrand firms than with a single monopoly. If the firms charge the cartel price, consumer surplus is:

$$CS_c = \left(\frac{(v - m)^2}{4c} + \frac{(v - m)z}{4} - \frac{7cz^2}{16} \right) L. \tag{14}$$

At z equals zero, this expression is the same as consumer surplus under monopoly at the monopoly price, CS_m. 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, 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). Consequently, $CS_c < CS_m$ for some values in the interior range. At larger z where the collusive firms operate at the kink in the demand curve, CS_c is again greater than CS_m, as Figure 5 illustrates.

[23] Because the firms are operating at a kink in their demand curves, there is a range of Nash solutions. 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.

Appendix 2. Data Sources

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 anti-cholinergic 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 fifty products in the Antispasmodic/Antisecretory Agents category, the three H_2-antagonists available on the market at the time accounted for roughly 79 percent of total category sales.[26]

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 form, which account for the majority of the market. The excluded data, anti-ulcer drugs in vial or syringe form, are designed for the hospital market and comprise a very small part of drugstore sales.[27] Prices are converted into daily dose prices using the recommended dosage as listed in the *Physician's Desk*

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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.

[26] Suslow (1996), p. 55.

[27] Berndt et al. (1997, p. 316) 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 of the values of revenues for oral presentations."

Reference. We follow the conventions described in the data appendix of Berndt et al. (1997) to construct the price series.

Close inspection of the data reveals peculiar pricing patterns over the first month in which 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 date 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.

References

Berndt, Ernst R., Griliches, Zvi, Rosett, Joshua G. Rosett, 1993. Auditing the Producer Price Index: Micro Evidence from Prescription Pharmaceutical Preparations. Journal of Business and Economic Statistics 11, 251-64.

Berndt, Ernst R., Bui, Linda T., Reiley, David H., Urban, Glen L., 1995. Information, Marketing and Pricing in the U.S. Antiulcer Drug Market." American Economic Review, Papers and Proceedings 85 (2), 100-105.

Berndt, Ernst R., Bui, Linda T., Reiley, David H., Urban, Glen L., 1997. The Roles of Price, Quality, and Marketing in the Growth and Composition of the Antiulcer Drug Market. In Bresnahan, Timothy, Gordon, Robert J. (Eds.), The Economics of New Goods, NBER Studies in Income and Wealth, vol. 58. University of Chicago Press, Chicago, pp. 277-322.

Berndt, Ernst R., Pindyck, Robert S., Pierre, Azoulay, 2003. Consumption Externalities and Diffusion in Pharmaceutical Markets: Antiulcer Drugs. Journal of Industrial Economics 51, 243-70.

Bessembinder, Hendrik, Seguin, Paul J., 1993. Price Volatility, Trading Volume and Market Depth: Evidence from Futures Markets." Journal of Financial and Quantitative Analysis 28, 21-39.

Capozza, Dennis R., Van Order, Robert, 1977. Pricing Under Spatial Competition and Spatial Monopoly. Econometrica 45, 1329-1338.

Capozza, Dennis R., Van Order, Robert, 1980. Unique Equilibria, Pure Profits and Efficiency in Location Models. American Economic Review 70, 1046-1053.

Capozza, Dennis R., Van Order, Robert, 1989. Spatial Competition with Consistent Conjectures. Journal of Regional Science 29, 1-13.

Caves, Richard E., Whinston, Michael D., Hurwitz, Mark A., 1991. Patent Expiration, Entry, and Competition in the U.S. Pharmaceutical Industry. Brookings Papers on Economic Activity: Microeconomics, Brookings Institution Press, Washington, D.C., pp. 1-48.

Coscelli, Andrea, Shum, Matthew, 2003. An Empirical Model of Learning and Patient Spillovers in New Drug Entry. Journal of Econometrics 122, 213-246.

Efron, Bradley, Gong, Gail. 1983. A Leisurely Look at the Bootstrap, the Jackknife, and Cross-Validation. The American Statistician 37, 36-48.

Efron, Bradley, Tibshirani, R., 1986. Bootstrap Methods for Standard Errors, Confidence Intervals, and Other Measures of Statistical Accuracy. Statistical Science 1, 54-77.

Ellison, Glenn, Ellison, Sara Fisher, 2000. Strategic Entry Deterrence and the Behavior of Pharmaceutical Incumbents Prior to Patent Expiration. mimeo, MIT.

Frank, Richard G., Salkever, David S., 1992. Pricing, Patent Loss and the Market for Pharmaceuticals. Southern Economic Journal 59, 165-79.

Fuller, W. A., 1976. Introduction to Statistical Time Series. John Wiley & Sons Inc., New York.

Griliches, Zvi, Cockburn, Iain M., 1994. Generics and New Goods in Pharmaceutical Price Indexes. American Economic Review 84, 1213-32.

Hotelling, Harold, 1929. Stability in Competition. Economic Journal 39, 41-57.

Pankratz, Alan, 1983. Forecasting with Univariate Box-Jenkins Models. John Wiley & Sons Inc., New York.

Plosser, Charles I., Schwert, G. William, 1978. Money, Income, and Sunspots: Measuring Economic Relationships and the Effects of Differencing. Journal of Monetary Economics 4, 637-660.

Salop, Steven C., 1979. Monopolistic Competition with Outside Goods. Bell Journal of Economics and Management Science 10, 141-56.

Sanner, Helge, 2005. Price Responses to Market Entry With and Without Endogenous Product Choice. Nov. 1, 2005 (available at http://ideas.repec.org/p/pot/vwldis/81.html).

Spilker, Bert, 1989. Multinational Drug Companies: Issues in Drug Discovery and Development, Raven Press, New York.

Suslow, Valerie Y., 1996. Measuring Quality Change in Pharmaceutical Markets: Hedonic Price Indexes for Anti-Ulcer Drugs. In Helms, R. (Ed.), Competitive Strategies in the Pharmaceutical Industry, American Enterprise Institute, Washington, D.C., pp. 49-72.

Ward, Michael B., Shimshack, Jay P., Perloff, Jeffrey M., Harris, J. Michael, 2002. Effects of the Private-Label Invasion in Food Industries. American Journal of Agricultural Economics 84, 961-973.

Table 1
Characteristics of Anti-Ulcer Drugs (1989)

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

Source: Suslow (1996, p. 60). The data for these characteristics were gathered from the *U.S. Pharmacopeial Convention, Dispensing Information* (USP DI).
[*] The incidence of these reported side-effects was rare according to USP DI.

Table 2
Price ($ per day daily dose) Descriptive Statistics: August 1977 – May 1993*

Variable	*Mean*	*StdDev*	*Min*	*Max*
Tagamet	1.12	0.49	0.57	2.11
Zantac	1.99	0.40	1.36	2.64
Pepcid	1.88	0.23	1.47	2.26

* The first two months for each price series are dropped (see Appendix 2).

Table 3
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)

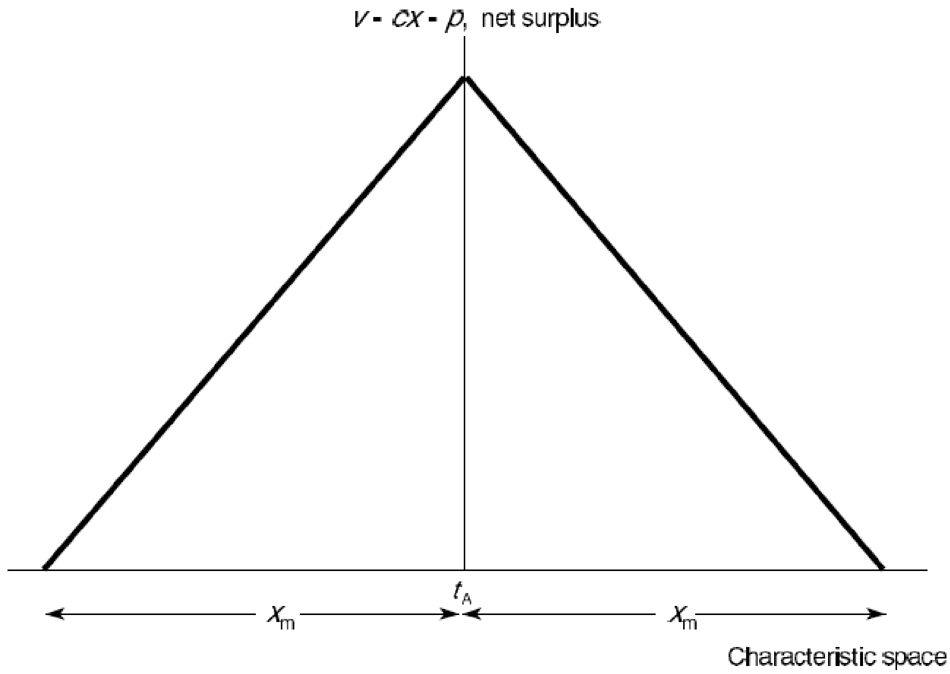

Figure 1
Monopoly Region in Characteristic Space

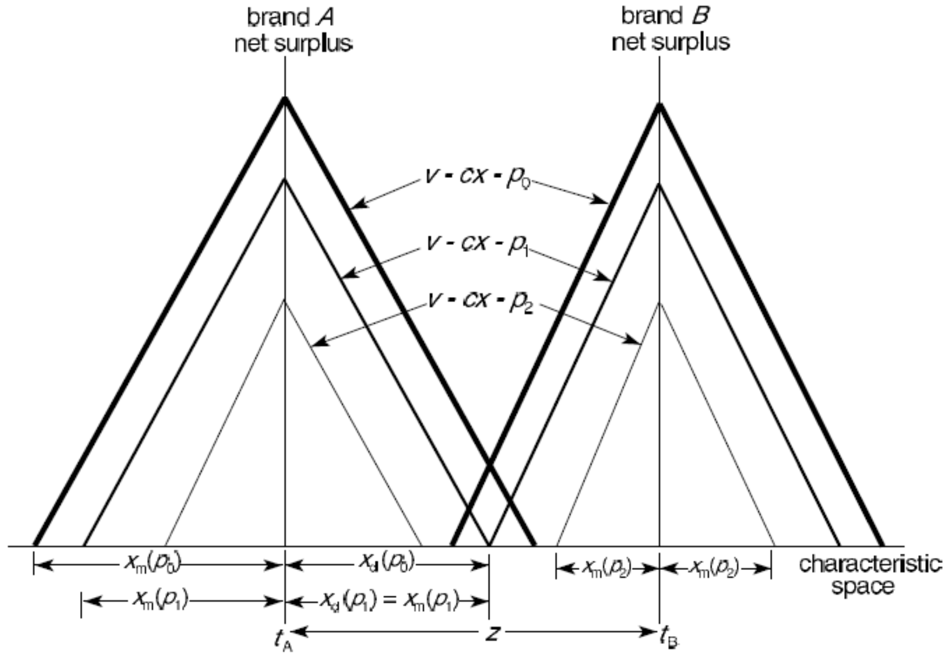

Figure 2
Duopoly in Characteristic Space

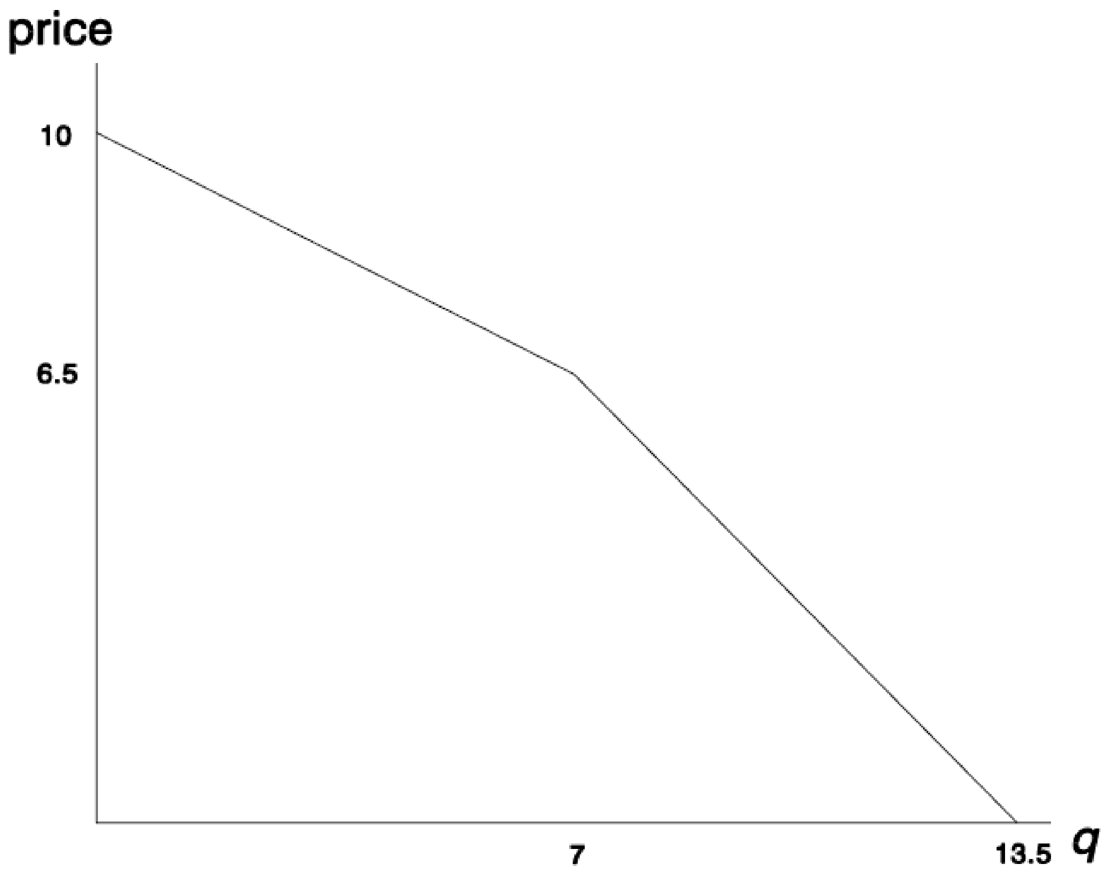

Figure 3
The Kinked Demand Curve

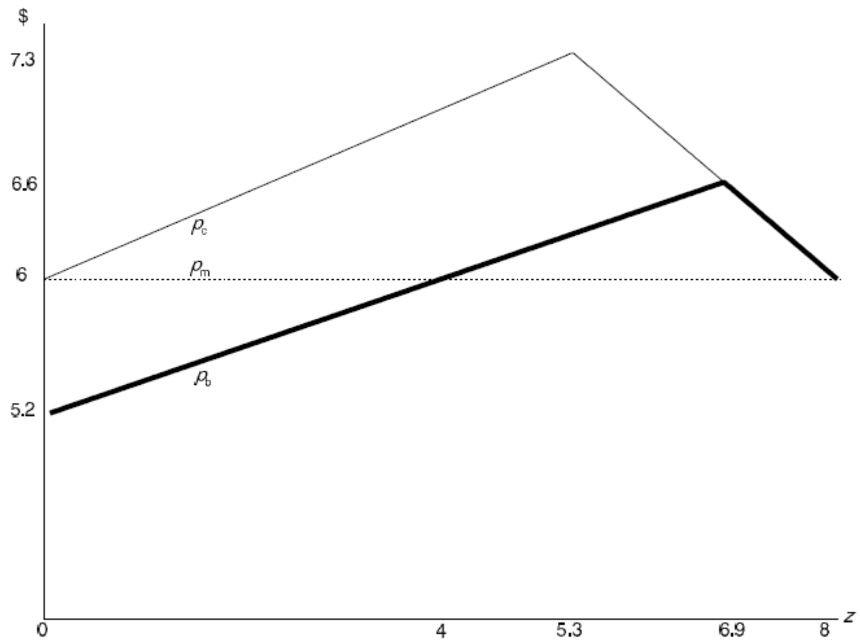

Figure 4
Bertrand and Cartel Prices Vary with *z*

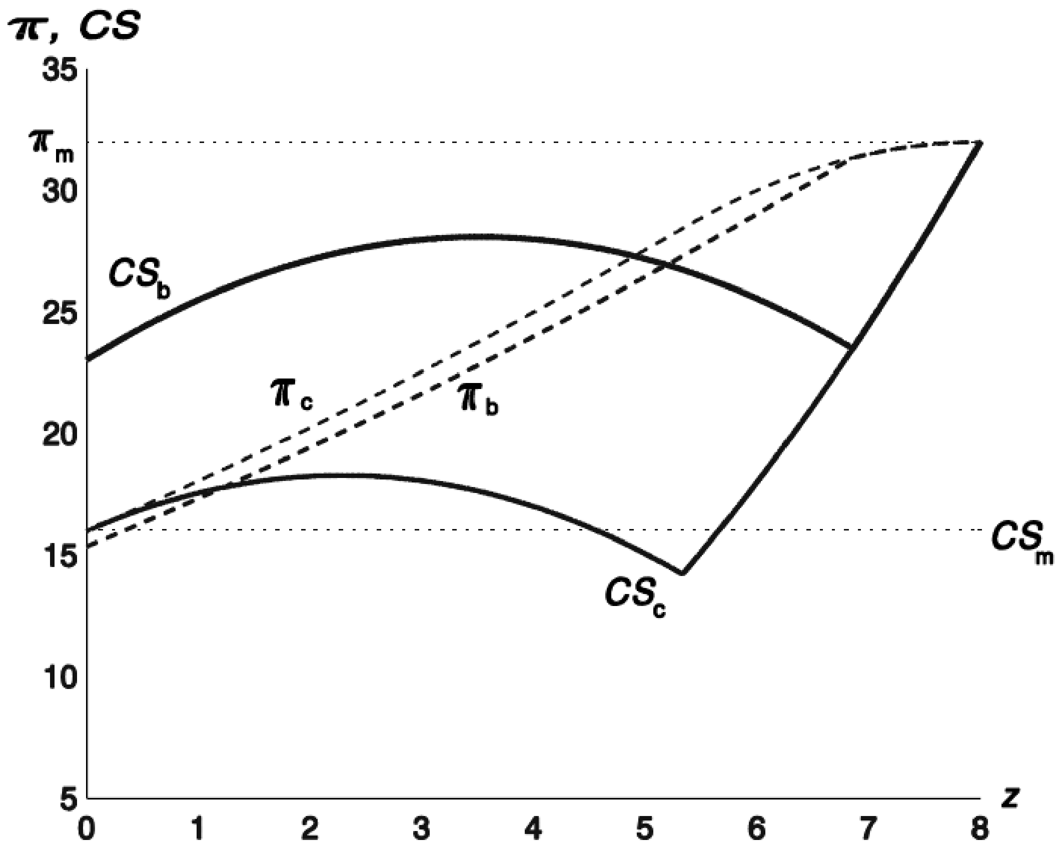

Figure 5
Profits and Consumer Surplus Vary with Distance

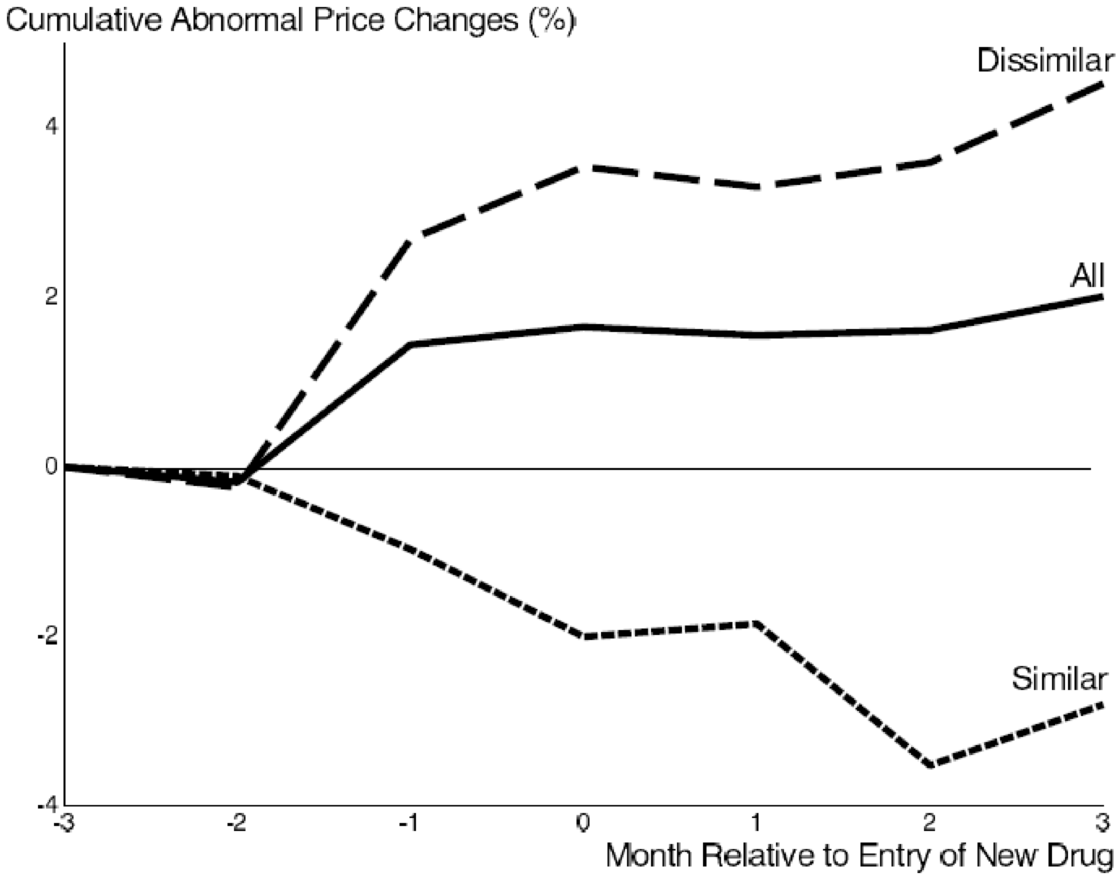

Figure 6
Cumulative Unexpected Price Effects