Countervailing Power in Wholesale Pharmaceuticals

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Abstract: There are a number of theories in the industrial organization literature explaining the conventional wisdom that larger buyers may have more "countervailing power" than small buyers, in that they receive lower prices from suppliers. We test the theories empirically using data on wholesale prices for antibiotics sold through various distribution channels—chain and independent drugstores, hospitals, HMOs—in the U.S. during the 1990s. Price discounts depend more on the ability to substitute among alternative suppliers than on sheer buyer size. In particular, hospitals and HMOs, which can use restrictive formularies to enhance their substitution opportunities beyond those available for drugstores, obtain substantially lower prices. Chain drugstores only receive a small size discount relative to independents, at most two percent on average, and then only for products for which drugstores have some substitution opportunities (i.e., not for on-patent branded drugs). Our findings are roughly consistent with collusion models of countervailing power and inconsistent with bargaining models and have implications for recent government proposals to form purchasing alliances to reduce prescription costs.

JEL Codes: L43, L65, D43, C78

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1 Introduction

Galbraith (1952) suggested that large buyers have an advantage in extracting price concessions from suppliers. He called this effect the *countervailing power* of large buyers because he foresaw it as countervailing the market power of large suppliers. It has long been the conventional wisdom in the business press that such a buyer-size effect exists.[1] The conventional wisdom was recently in evidence in the enthusiasm over collective purchasing websites, the best-known of which was Mercata, which sold items at a price which declined as more customers signed up to purchase. As a columnist wrote soon after Mercata's launch:

> It's an old idea: Round up a bunch of people who promise to buy an item and then go to the manufacturer or distributor and work out a volume discount. But add the Internet, with millions of potential customers and the ability to modify prices every second, and you've got the makings of a dramatic transformation in retailing (*Boston Globe*, July 11, 1999).

The subsequent closure of Mercata and failure of other similar business ventures (MobShop, LetsBuyIt) suggests the importance of understanding the sources of buyer-size effects rather than simply accepting the conventional wisdom that such effects exist. The economics literature offers a number of theories on the sources of buyer-size effects. The theories can be roughly divided into two categories, those involving a monopoly supplier and those involving competing suppliers.[2] The first category includes models in which the monopoly supplier bargains with buyers under symmetric information as in Horn and Wolinsky (1988), Stole and Zwiebel (1996b), Chipty and Snyder (1999), and Chae and Heidhues (1999a, 1999b) and in which it makes take-it-or-

[1] See, e.g., an article on the power of large cable operators to extract price discounts from program suppliers (*Cablevision*, February 1, 1988), an article on the power of Wal-Mart to extract price discounts from manufacturers (*The Guardian* (London), July 25, 2000), and the score of other business press sources exhibiting the conventional wisdom cited in Scherer and Ross (1990) and Snyder (1998).

[2] While this categorization captures the theories that turn out to be relevant to our particular empirical application, it is not exhaustive. The technology of warehousing and distribution may be such that large buyers are cheaper to supply per unit than small, in which case large buyers would be expected to pay lower prices than small for a broad range of supplier market structures (see, e.g., Lott and Roberts 1991 and Levy 1999). Size discounts in Katz (1987) and Scheffman and Spiller (1992) can be thought of as involving potential supplier competition, arising from the threat of backward integration by a large buyer.

leave-it offers under asymmetric information as in Maskin and Riley (1984). The models share the common implication that there exist conditions under which buyer-size discounts emerge in equilibrium with a monopoly supplier. The second category suggests that competition among suppliers may be crucial for the buyer-size effect to emerge. In the supergame framework of Snyder (1996, 1998), tacitly-colluding suppliers compete more aggressively for the business of large buyers and are forced to charge lower prices to large buyers to sustain collusion. Buyer-size discounts do not emerge with a monopoly supplier but rather require multiple competing suppliers.

The two classes of theories, in sum, have contrasting implications for whether the buyer-size effect emerges even with a monopoly supplier (as in the first class) or whether instead the buyer-size effect only emerges if buyers are able to substitute among competing suppliers (as in the second class). These contrasting implications provide the basis of the empirical tests we conduct in this paper using data from the pharmaceutical industry. In particular, we study wholesale prices charged by pharmaceutical manufacturers to various buyers including chain drugstores, independent drugstores, hospitals, and health maintenance organizations (HMOs) for antibiotics. Our data provide a unique opportunity to test the theories since we observe buyers of different sizes—chain drugstores are larger than independents—purchasing drugs providing different substitution opportunities. At one extreme, drugstores cannot substitute away from a drug produced by a branded manufacturer with an unexpired patent; in such markets, drugstores effectively face a monopoly supplier. At the other extreme, once a patent expires on a drug and several generic manufacturers enter, drugstores can freely substitute among the competing generics. Another source of variance in our data is in the substitution opportunities across buyers. By issuing restrictive formularies, hospitals and HMOs can control which drugs their affiliated doctors prescribe, effectively allowing their purchasing managers to substitute among branded drugs with similar indications for drugs on patent and between branded and generic manufacturers for off-patent drugs. Drugstores substitution opportunities are more limited: they can substitute

among multiple generic manufacturers and in some states can substitute between branded and generics for off-patent drugs, but otherwise need to fill the prescriptions their customers bring in as written. Using these sources of variation, we can identify instances in which buyers have good substitition opportunities, large size, both, or neither, and can therefore isolate the effect that each has on purchase price.

While we may have an academic interest in the sources of countervailing power and may have been fortunate that the pharmaceutical industry provides a good setting to explore the academic question, our findings about countervailing power in pharmaceuticals have policy implications as well. The U.S. federal government and individual states have designed a number of bills with the goal of reducing prescription drug costs by aggregating buyers into large health care procurement alliances. At the federal level, a core proposition of the Clinton health care reform plan was that large savings would come from the formation of buyer alliances (*White House Domestic Policy Council* 1993). More recently, a law enacted in Maine was based on the idea that the countervailing power of an intrastate alliance would reduce drug costs. Maine Governor Angus King stated:

> If the [pharmaceutical] industry can consolidate and increase its market power, so can we. We're going to bargain on behalf of 50 percent of our citizens and we think that they deserve the same consideration as other groups that get discounts based on their volume (*New York Times*, May 12, 2000).

Other states have considered similar legislation or are taking part in discussions about interstate purchasing alliances.[3] The success of such proposals succeeding hinges on the nature of countervailing power. If size alone is not sufficient for countervailing power but supplier competition is also required, forming large alliances may not result in substantially lower prices unless the purchasing manager can induce supplier competition by being willing to substitute one drug for

[3]Iowa, New Hampshire, Washington and West Virginia have created intrastate purchasing cooperatives for the elderly. Vermont and Maryland have considered similar programs to Maine's (*New York Times*, April 23, 2001). West Virginia, Georgia, North Carolina, South Carolina, New Mexico, and Washington collaborated on a multistate purchasing alliance (*Wall Street Journal*, March 20, 2001).

another. Consumers may oppose the resulting restriction of choice (similar to the much-publicized dissatisfaction with the restriction of choice and care by HMOs), as noted in the following story about a congressional inquiry into the cost savings from joint procurement by the Department of Defense and Veterans Administration:

> 'The driving expectation is that, as the two agencies buy more of a particular drug, their leverage . . . will permit them to exact discounts from drug manufacturers,' the report said. VA and Defense officials said the audit does not take into account some negative consequences, including the likelihood that a joint contract with a single drug maker might force many patients to change medications (*Boston Globe*, July 5, 2000).

Our results show that large buyers (chain drugstores) receive no discount relative to small buyers (independent drugstores) on antibiotics with unexpired patents—antibiotics for which drugstores have no substitution opportunities and thus effectively face monopoly suppliers. For off-patent antibiotics—antibiotics for which drugstores have some substitution opportunites—chain drugstores receive a statistically significant but small discount relative to independents, at most 2%. Much larger discounts are observed in the comparison of hospitals and HMOs to drugstores. While it is unclear whether hospitals and HMOs can be characterized as being larger or smaller than drugstores on average, it is clear that they have better substitution opportunities due to their use of restrictive formularies. Hospitals' and HMOs' discounts are as much as a third on branded drugs that have expired patents. These are drugs for which hospitals and HMOs can substitute generics freely; drugstores can do so only to a more limited extent. Hospitals and HMOs receive discounts of as much as 10% for branded drugs with unexpired patents, presumably because they can use the ability to purchase a therapeutically similar substitute while drugstores cannot.

The implication of our findings for economic theory is that, at least for the wholesale antibiotics market, models focusing on competition among suppliers (e.g, Snyder 1996, 1998) are better able to explain the buyer-size effect than bargaining models (e.g., Horn and Wolinsky 1988;

Stole and Zwiebel 1996b; Chipty and Snyder 1999; Chae and Heidhues 1999a, 1999b) or other models involving a monopoly supplier (Maskin and Riley 1984). The implication of our findings for policy is that absent the ability to be restrictive, drug purchasing alliances are not likely to gain much from their increased size.[4]

The fact that hospitals and HMOs receive substantial discounts relative to drugstores is well known. Indeed, the discounts were the focus of a high-profile antitrust case in the 1990s.[5] Our results go beyond merely documenting the presence of hospital/HMO discounts: we provide formal estimates of the magnitude of the discounts, an analysis of how the discounts vary with the market structure of suppliers, a measure of the discounts due to buyer size alone, and a comparison of the relative importance of the various effects.

Our paper is part of a larger empirical literature documenting the existence of buyer-size effects and countervailing power. The literature includes case studies,[6] interindustry econometric studies,[7] and intraindustry econometric studies.[8] While these papers document the existence a buyer-size effect, they do not provide a more nuanced test of the sources of those effects, as we do.

There is also a related literature on bargaining between buyers and suppliers in health care markets.[9] The focus of much of this literature is the welfare effects of the monopsony power of insurers. Two exceptions are Congressional Budget Office (1998) and Sorensen (2001). The CBO studies how a measure of buyer discounts (the difference between the lowest price received

[4]An alternative is for states simply to regulate drug prices rather than engage in voluntary negotiations. Indeed, the Maine law cited above has a provision triggering price controls if group purchasing does not result in substantially lower prices. See Dranove and Cone (1985) for a study of the effect of price regulation on hospital costs.

[5]See the November 1997 symposium on the Brand Name Prescription Drugs Antitrust Litigation in the November 1997 issue of the *International Journal of the Economics of Business* (Frech, ed., 1997).

[6]See Adelman (1959) and McKie (1959).

[7]See Brooks (1973); Porter (1974); Buzzell, Gale, and Sultan (1975); Lustgarten (1975); McGuckin and Chen (1976); Clevenger and Campbell (1977); LaFrance (1979); Martin (1983); and Boulding and Staelin (1990).

[8]Chipty (1995) finds that large cable operators charge lower prices to subscribers, possibly reflecting lower input prices paid to program suppliers.

[9]See Pauly (1987, 1998); Staten, Dunkelberg, and Umbeck (1987); Melnick *et al.* (1992); Brooks, Dor, and Wong (1997); Congressional Budget Office (1998); and Sorensen (2001).

by any non-government buyer, reported under the Medicaid drug rebate program, and the average price offered to drugstores) varies with the presence of substitution opportunities. Our data have the virtue of allowing us to identify which type of buyer received the discounts and the pervasiveness of the discounts on average for each type of buyer, rather than a single reported extreme. More importantly, there is no information on buyer size in the CBO data, so they cannot conduct the tests involving buyer-size discounts, one of the main focuses of our study. The closest paper to ours is concurrent research by Sorensen (2001). His objective, as is ours, is to test among various theories of countervailing power. His results are broadly consistent with ours though for a different class of health care expenditure: hospital services. He finds some evidence that large insurers obtain discounts for hospital services, but the size effect is small. More significant is the discount obtained by insurance companies that are able to channel patients to lower-priced hospitals. In both our paper and Sorensen (2001), substitution opportunities are a more important source of countervailing power than sheer size. One difference is our finding of an interaction between size and substitution opportunities, an interaction which is insignificant in Sorensen (2001); however, the magnitude of the interaction effect in our results is small. This detail aside, our papers can be viewed as being complementary, providing some comfort in the robustness of the results and their applicability beyond the particular market studied in either paper individually.

Finally, there is an experimental paper of relevance. Ruffle (2000) shows that larger buyers are more likely to use a strategy of demand withholding to extract lower prices in a repeated posted-offer market.

Our paper is also part of the literature on pharmaceuticals, specifically pharmaceutical pricing.[10] The most closely related paper on pharmaceutical pricing is Moore and Newman (1993), one of a few studies of the economic effects of restrictive formularies.[11] They find that restrictive

[10]See, e.g., Caves, Whinston, and Hurwitz (1991); Grabowski and Vernon (1992); Griliches and Cockburn (1994); Baye, Maness, and Wiggins (1997); Ellison *et al.* (1997); Scott Morton (1997); and Ellison and Wolfram (2000).

[11]See also Grabowski (1988); Dranove (1989); and Grabowski, Schweitzer, and Shiota (1992).

formularies lower retail expenditures on drugs but do not lower overall health care expenditures because of input substitution. Our finding that restrictive formularies appear to allow hospitals and HMOs to extract price concessions is related, but our analysis is at the wholesale rather than retail level.

2 Background

2.1 Theory

As noted in the Introduction, there are a number of theoretical papers which show buyer size confers countervailing power even with a monopoly supplier (Maskin and Riley 1984; Horn and Wolinsky 1988; Stole and Zwiebel 1996b; Chipty and Snyder 1999; and Chae and Heidhues 1999a, 1999b).[12] While all of these models are of interest for the general question of the sources of countervailing power, some are not relevant for our empirical exercise. For instance, in Maskin and Riley (1984), buyers differ not so much in size as in the intensity of their demand; size is endogenously determined by the size of the bundle selected. At least in the short run, the size of our buyers, for example drugstores, is exogenous, determined by the number of stores in the chain and the number of customers at each store. Also, it is unreasonable to imagine that drugstores, hospitals, or other distribution channels would integrate backward in the manufacture of drugs, so Katz (1987) and Scheffman and Spiller (1992) are not relevant in the present context. The models of bargaining under symmetric information of Horn and Wolinsky (1988), Stole and Zwiebel (1996b), Chipty and Snyder (1999), and Chae and Heidhues (1999a, 1999b) are potentially relevant, though, and we will review them briefly. For simplicity, we will review Chipty and Snyder (1999) as representative of the literature.[13]

[12]There is an additional literature on the effect of buyer size on supplier price when downstream firms compete (Horn and Wolinsky 1988 and Tyagi 2001) which we will not treat in detail here.

[13]Horn and Wolinsky (1988), Stole and Zwiebel (1996b), and Chipty and Snyder (1999) all share the insight about the effect of surplus function curvature on bargaining outcomes. Chipty and Snyder (1999) generalize Horn

Consider a market with a monopoly supplier and three equal-sized buyers having inelastic demand for q units of a homogeneous good. Let $V(Q)$ be the total joint surplus of buyers and supplier generated by trade of Q units. Normalize the surplus from no trade for all parties to be zero. Suppose the supplier engages in independent, simultaneous Nash bargains with each buyer over the transfer price. Each buyer conjectures that other buyers bargain successfully with the supplier in equilibrium. Referring to Figure 1, the object of negotiation between the supplier and a given buyer is the marginal surplus $A - B$; assume a transfer price is agreed upon which results in an equal division of this surplus,

$$\frac{A-B}{2}. \tag{1}$$

Suppose two of the three buyers merge or otherwise form an alliance allowing them to bargain as a single unit. The unmerged (small) buyer continues to obtain surplus given in expression (1). The merged (large) buyer bargains over surplus $A - C$, and obtains half of this in equilibrium. Assuming an equal division of surplus between the subsidiaries of the merged buyer, after algebraic manipulation each can be seen to obtain

$$\frac{1}{2}\left(\frac{A-B}{2}+\frac{B-C}{2}\right). \tag{2}$$

Merging effectively allows the buyers to bargain over inframarginal surplus $B - C$ as well as the marginal surplus $A - B$. Whether large buyers obtain lower prices than small depends on the relative values of expressions (1) and (2). If the joint surplus function is concave as in Panel A of Figure 1, then the inframarginal surplus $B - C$ exceeds the marginal surplus $A - B$, implying

and Wolinsky (1988) to allow for n buyers and decompose the change in surplus into several components. Stole and Zwiebel (1996b) assume contracts are non-binding, appropriate given their focus on intra-firm bargains between workers and managers. One virtue of Stole and Zwiebel's (1996b) framework is that equilibrium is guaranteed to exist, while it may not in the convex case in Chipty and Snyder (1999), though the non-existence problem in Chipty and Snyder has since been resolved by Raskovitch (2000). The relationship between these papers and Chae and Heidhues (1999a, 1999b) is discussed below.

(2) exceeds (1), in turn implying a subsidiary of the merged buyer obtains more surplus and pays a lower price than the small. We have thus demonstrated the existence of cases—namely cases with concave surplus functions—in which larger buyers have countervailing power even against a monopoly supplier. The theory does not guarantee such an outcome, however; in the convex case in Panel B a subsidiary of the merged buyer obtains less surplus and pays a higher price than the small.

Unfortunately, the symmetric bargaining models have not been extended to multiple suppliers, so it is difficult to determine the comparative-static effect of an increase in the number of suppliers on price discounts for large buyers. Stole and Zwiebel (1996a) show that their extensive form game generates the same allocation as the Shapley value; so one way to proceed would be to compute the Shapley value in the multiple supplier/multiple buyer game, recognizing the lack of an extensive-form foundation for the Shapley value in this extension. As shown in the Appendix, the Shapley value calculations produce ambiguous results: the surplus premium that subsidiaries of large buyers obtain relative to small may increase or decrease as the number of suppliers increases. This result leads us to suspect that bargaining models may not produce robust comparative statics results concerning the effect of more competitive supplier market structures on the discounts offered to large buyers.

Given the existence of countervailing power for large buyers depends crucially on the concavity of the surplus function, it is worth asking what the shape of the surplus function is in the market for wholesale pharmaceuticals. The source of concavity can be either on the cost side, from diseconomies of scale, or on the benefit side, say from negative demand externalities which reduce the value of the product as more units are sold.[14] It is unlikely that pharmaceutical manufacture exhibits substantial diseconomies of scale. It is possible that antibiotics have a form of negative demand externality, in that resistances may be more likely to develop for widely

[14]See Chipty and Snyder (1999) for a discussion of factors producing concavity/convexity in the cable television industry, and an example of a test for concavity/convexity of the surplus function.

prescribed antibiotics, though we suspect that such effects may not produce strong concavities. As Chae and Heidhues (1999a, 1999b) show, however, bargaining models with monopoly suppliers can still produce buyer-size effects in the absence of concavities if there are risk averse parties involved in the negotiations. Therefore, there remain *a priori* grounds to test the bargaining models in the particular context of the pharmaceutical industry.

In the second category of models, the existence of buyer-size discounts is related to the process of competition among suppliers. Snyder (1996, 1998) examines the ability of competing suppliers to sustain collusion in the presence of buyers of varying sizes.[15] For expositional purposes, here we will consider a simplified treatment of Snyder (1998), in which buyers arrive on the market sequentially in each of an infinite number of periods indexed by t.[16] A buyer arriving in period t has demand for s_t units of the good, each unit providing it with value v. Assume $s_t \in [\underline{s}, \bar{s}]$ is independently and identically distributed according to distribution function F. The homogeneous product is produced by N suppliers, which have constant marginal and average cost $c < v$, and which set prices p_{it} simultaneously each period. The suppliers may sustain collusion in the supergame with threats of low future prices as punishment for undercutting. The logic of Rotemberg and Saloner (1986) suggests that it is difficult for suppliers to collude during booms since the benefit from undercutting is large relative to the loss of future (average) profits. The benefit of undercutting can be reduced by colluding on a lower price during booms. The same intuition holds here: collusion is difficult when facing a large buyer and price needs to be reduced, resulting in buyer discounts.

As a corollary of Proposition 1 in Snyder (1998), it can be shown that if the following

[15] Elzinga and Mills (1997) present a static model of duopoly competition in which greater substitutability between products leads to lower prices. Unlike Snyder (1996, 1998), their model does not have comparative statics results on buyer size.

[16] A drawback of this model is that suppliers may make essentially simultaneous sales to buyers of various sizes each period in practice (although Scherer and Ross 1990, p. 307, discuss the case of government procurement auctions for tetracycline in the mid 1950s, which may be better characterized as sequential). Snyder (1996) shows that the same effects arise in a model in which buyers of various sizes purchase simultaneously each period.

conditions hold:

$$N < \frac{1}{1-\delta} \tag{3}$$

$$N > 1 + \frac{\delta E(s_t)}{(1-\delta)\bar{s}} \tag{4}$$

where $E(x) = \int_{\underline{s}}^{\bar{s}} x\, dF(x)$ is the expectations operator and $\delta \in (0,1)$ is the discount factor, then there exists $s^* \in (\underline{s}, \bar{s})$ such that the collusive price in the extremal equilibrium (the equilibrium maximizing supplier profit), $p^*(s_t)$ equals v for $s_t \leq s^*$ and declines with s_t for $s_t > s^*$. That is, buyers smaller than a cutoff are charged the monopoly price; buyers larger than the cutoff receive an increasingly large discount. Condition (4) is clearly violated if $N = 1$; in this (monopoly) case there is no problem of sustaining collusion. The supplier charges v per unit to all buyers regardless of size, so there are no size discounts. At the other extreme, as N grows without bound, eventually condition (3) is violated and the only equilibrium involves marginal cost pricing, and hence no discounts for large buyers. In sum, as depicted in Figure 2, the collusion models imply that buyer size does not confer countervailing power when facing a monopoly or sufficiently competitive suppliers but does for some intermediate number of suppliers.

The testable difference between the bargaining and collusion models is whether large buyers receive a discount even in the presence of a monopoly seller. An additional testable implication of the collusion models is that large-buyer discounts should increase as one moves from monopoly to more competitive supplier market structures.

2.2 Institutional Details

Much of our empirical strategy hinges on the existence of different substitution opportunities across types of buyers and drugs, which essentially provides us with variation in the competi-

tiveness of the supply side. The difference in these substitution opportunities stem mainly from two sources: the closeness of a drug's therapeutic indications to other drugs' and the institutional constraints on certain buyers' ability to switch between therapeutically similar drugs. In the remainder of this subsection, we will discuss the nature of substitution opportunities in wholesale pharmaceuticals relevant to our empirical work; further detail can be found in Elzinga and Mills (1997) and Levy (1999).

Consider an illustrative example. Suppose CVS, a large chain of retail pharmacies, is negotiating with Eli Lilly over the price they will pay to purchase their drug Prozac at the wholesale level. They know that some customers will come in off the street with prescriptions for Prozac that need to be filled, and there is little CVS can do at that point to alter the prescription. (The decision has already been made by a physician at another location who is difficult to contact and over whom CVS has no control.) Eli Lilly knows this and views itself (roughly) as a monopolist in that transaction. In contrast, a hospital or HMO can enter into negotiations with Eli Lilly with the ability to threaten credibly that they will not purchase Prozac. The difference is that a hospital can induce or require its physicians to prescribe Paxil or Zoloft instead, drugs with similar therapeutic properties to Prozac's, if Eli Lilly does not offer it favorable contract terms. In other words, Eli Lilly would view itself as competing against the manufacturers of Paxil and Zoloft in this transaction. Not only do hospitals and HMOs have the ability to make such threats, it is standard to carry through on them, resulting in what is known as a restrictive formulary, a list of approved drugs that affiliated physicians may prescribe.

The ability for purchasers to threaten and make such substitutions varies not just with the type of purchaser (e.g., drugstore versus hospital or HMO), but also with the drug. Some drugs, for instance, are therapeutically unique and must be included on restrictive formularies. At the other extreme, all purchasers can fairly easily substitute one generic for another for an off-patent drug with multiple generics.[17]

[17]It may be slightly easier for a hospital to make generic-generic substitutions over time than a drugstore because

Finally, the case of substituting a generic for a branded drug, or vice versa, is more complicated. Hospitals and HMOs have excellent substitution opportunities, again using the mechanism of the restrictive formulary. The substitution opportunities for drugstores, however, depend on state regulation. Some states ("mandatory") mandate that the drugstore must fill the prescription with a generic unless the customer specifically requests, or the doctor explicitly notes, that the branded drug be dispensed. In mandatory states, drugstores' ability to substitute between branded and generic is constrained. Other states ("permissive") allow the drugstore to choose whether to dispense the branded or generic if neither is explictly requested and/or prescribed. In permissive states, the drugstore has some ability to substitute between branded and generics. Even in these states, there is a limit to the ability to substitute between branded and generic: the branded price will typically be higher than the generic since the drugstore must carry the branded product to serve those customers who bring in a prescription explicitly specifying the branded drug.[18]

Table 1 summarizes the variation in subsitution opportunites by type of purchaser, type of drug, and type of state. Since our data are collected at the national level, we will have to think of drugstore sales as reflecting an average across the different legal regimes and cannot exploit the variation in that dimension.[19] Note that during the period our data were collected, roughly twelve states had mandatory substitution laws, and thirty-eight states had permissive substitution laws.

Since our study focuses on one therapeutic class, antibiotics, a few words should be said about how it might differ from other therapeutic classes. First, the product space is densely populated for this class of drugs, meaning that it often is the case that a physician will have many good alternatives for treating a specific infection. Substitution opportunities abound. This

a relatively transient patient population would not know that the size, shape, and color of a tablet was different than the one dispensed a few months ago.

[18]See Hellerstein (1998) for more detail on the institutions involving generic substitution.

[19]For the largest chains, it would be appropriate to average across states in any event since they negotiate centrally for the drugs they retail in stores located throughout the country. For chains or stores operating in a single state (or multiple states sharing a common legal regime), state-level data would be useful if it existed.

is true not just across different drugs but also between branded and generic versions since generic penetration is unusually high in this class.

While some good substitution opportunities were important for our empirical exercise, we were hoping to identify some therapeutically unique drugs as well, i.e., drugs where even hospitals and HMOs were essentially facing monopoly supply. An exhuastive search convinced us that they simply did not exist in the case of antibiotics. We did identify a few that had to be included on most formularies, for example vancomycin, a last resort antibiotic for methicillin-resistant *S. aureus*, but all were available in generic form or from multiple sources.[20] We are therefore unable to exploit variation in substitution opportunities from that particular source given the category of pharmaceutical we study.

Finally, the issue of drug resistance can complicate formulary decisions involving antibiotics. One way to mitigate the problem of bacteria becoming resistant to certain antibiotics is to rotate similar antibiotics through the formulary periodically. The effect that this practice might have on our analysis is simply to decrease the degree to which a purchaser can freely substitute relative to other therapeutic classes whose substitution opportunities appear similar.

3 Data

The data set we use to examine wholesale pricing patterns covers virtually all prescription antibiotics[21] sold in the United States between September 1990 to August 1996. It was collected by IMS America, a pharmaceutical marketing research firm, and it contains monthly wholesale quantities and revenues from transactions between manufacturers or distributors and retailers of various types. The data are aggregated up to the level of type of buyer. IMS refers to the type

[20] We consulted a number of sources in an attempt to construct a measure of therapeutic uniqueness. The most useful was Nettleman and Fredrickson (2001), a handbook intended to teach new physicians how to prescribe antibiotics. All of the compounds that were suggested to be therapeutically unique turned out to be off patent and thus to have generic substitutes.

[21] Our data also contain a small number of antifungals and antivirals.

of purchaser as a "channel of distribution," and we will often do so as well.

The data set comes in two parts. From September 1990 to December 1991, the data are reported by two types of buyer: drugstores and hospitals, the hospital category covering all non-federal facilities, i.e., all private and nonfederal government hospitals. From January 1992 to August 1996, the data is more refined: drugstores are partitioned into chain drugstores, independent drugstores, and foodstores; the hospital (nonfederal facility) category is retained; and four new categories are introduced—federal facilities, clinics, HMOs, and longterm care—leading to eight types of buyer.[22] We used the data to create two samples. We created long sample spanning September 1990 to August 1996 containing just drugstores and hospitals by aggregating chain drugstores, independent drugstores, and foodstores for the January 1992 to August 1996 period to make a consistent drugstore series. We created a short sample spanning January 1992 to August 1996 using five of the eight buyer types: HMOs, hospitals, chain drugstores, independent drugstores, and foodstores. We also included an aggegrate drugstore category (the sum of chain drugstores, independent drugstores, and foodstores) in the short sample along with the component types.

In the dimension of product characteristics, the data are quite disaggregated, at the level of presentation for each pharmaceutical product. A presentation is a particular choice of packaging and dosage for a drug, for example, 150 mg coated tablets in bottles of 100, or 25 ml of 5% aqueous solution in a vial for intravenous injection. A drug will often be sold in many presentations simultaneously.

Since the prices reported by IMS in these data will be central to our analysis, it is important

[22]Federal facilities are all types of federal government hospitals, nursing homes, and outpatient facilities. Clinics include outpatient clinics, urgent care centers, and physician offices. The HMO category includes prescriptions dispensed at HMO-owned hospitals and drugstores, not prescriptions dispensed elsewhere but paid for by an HMO drug benefit. The HMO channel of distribution, then, reflects only a small portion of the influence that HMOs and other managed care have had on pharmaceutical purchasing. Chain drugstores are in chains of four or more stores. Independent drugstores are owned independently or are in chains not qualifying for the chain drugstore category. Foodstores are drugstores located in a foodstore. Longterm care includes nursing homes and convalescent centers and retail drugstores with more than half of their sales to nursing homes. Home health care is not included in this category.

to explain exactly what they contain. These prices are transactions prices, not list prices. They reflect the deals negotiated between the retailer purchasing the drug and the drug's manufacturer, even if the transaction occurs through a wholesaler. If a purchaser negotiates a discount with the manufacturer and then purchases through a wholesaler, they are given a "chargeback" to reflect their discount. Our data account for chargebacks. Second, further discounts are sometimes given to purchasers in the form of rebates. Rebates are secret, so our data do not contain them. Such an omission might have the potential to seriously bias our results, but discussion with data specialists at IMS and a marketing executive at a pharmaceutical firm have given us confidence that we understand the nature and direction of the bias.

It is our understanding from these discussions that rebates are not given systematically, say based on a formula depending on volume, but rather are negotiated on a company-by-company basis. During the period of time covered by our data, rebates to drugstores were rare. When rebates were given to drugstores, they were given for purchases mediated by a pharmacy benefit manager. In other words, the prices we have for drugstore purchases should be a fairly accurate reflection of the prices paid by drugstores for the portion of their purchases not mediated by a pharmacy benefit manager. A bias may still remain in the drugstore revenue variable: omitting rebates results in an overestimate of revenue, akin to considering all drugstore sales to be non-mediated sales, when only a portion of the sales would be non-mediated, the rest mediated and possibly reflecting a discount. Since we only use revenues as weights in the weighted least squares procedure, and our results, as we discuss below, are quite robust to different weighting schemes, including not weighting at all, we do not think secret rebates substantially affects our results for drugstores.

Secret rebates, however, are more pervasive in hospital and HMO sales. Our prices for hospitals and HMOs would thus be overstatements of the true prices paid by hospitals and HMOs. This issue will lead to a bias in our results, understating the discounts that hospitals and HMOs can extract relative to drugstores. We will discuss this bias again in the results section, but

note that despite it, we find very large discounts for hospitals and HMOs relative to drugstores.

For our regression analysis, we have defined a number of variables and have included short descriptions of them in Table 2. A few of them need additional explanation. *BRANDED* is a dummy variable equaling one for manufacturer m selling drug i if manufacturer m is the originator of drug i. *ONPAT* is a dummy variable equaling one if no generics have entered drug i at time t. To be precise, a patent could have expired with no generic entry, but for our purposes, it is generic entry, not patent expiration per se, that is relevant.

Table 3 presents descriptive statistics for the variables we use in the analysis. The table contains two sets of descriptive statistics, one for the long sample with the aggregate buyer types and one for the short sample with the finer breakdown of buyer types. Note that *NUMGEN* and *ONEGEN* are only defined for off-patent observations—hence the smaller number of observations for those two variables—and the accompanying descriptive statistics are thus conditional on the observation being off-patent.

Considering the descriptive statistics for prices, it is interesting to note that comparing average prices across channels, both in the long sample and the short sample, does not reveal large differences. Controlling for the mix of products purchased through each of these channels will turn out to be important. In particular, hospitals tend to be both restrictive purchasers as well as purchasers of more expensive presentations. The regression analysis will look at price differences across common presentations to control for the different mix. Another interesting feature of the data is the relatively small fraction of observations (11%) for drugs still on patent and the relatively large mean of number of generic competitors (16.8) across off-patent observations. This feature is in part an artifact of the structure of the data: once a compound's patent expires and there is generic entry, each manufacturer of the compound accounts for a separate observation. This feature is also due to the higher generic penetration of antibiotics relative to many other types of drugs. Many of the most popular antibiotics are quite old. Old antibiotics do not necessarily become obsolete as new ones enter the market; the available variety, in fact, is an important tool

for combating drug resistance.

4 Methods and Results

In order to study empirically the factors that give rise to countervailing power and distinguish among various theories, we will want to see how prices change across different supply regimes and with different buyer sizes. In other words, we will regress prices (in some form) on a series of dummy variables which identify the four main circumstances under which a drug is purchased: the drug is branded and still on-patent, the drug is branded but has generic competitors, the drug is generic but there is only one generic manufacturer (single-source generic), and the drug is generic and there are multiple generic manufacturers. We include dummy variables and interactions to describe each of those four circumstances and then omit the constant, for ease of interpretation. One would also want to include drug, presentation, manufacturer, and time fixed effects; we estimate a differenced model which accounts for those fixed effects as well as all combinations of them. An additional virtue of the differenced specification is that the coefficients are readily interpretable. In sum, we estimate a base regression in which the dependent variable is the difference in price paid by, for instance, drugstores and hospitals and the regressors are dummy variables for categories of drug as described above. To be precise, the dependent variable for the hospital-drugstore regression is

$$\Delta^{HD}_{i,j,m,t} = \ln\left(PRICE_{i,j,m,t,H}\right) - \ln\left(PRICE_{i,j,m,t,D}\right).$$

In addition to examining the difference between prices paid by hospitals and drugstores, we look also at the difference between chain and independent drugstores, HMOs and drugstores, and HMOs and hospitals. We denote those dependent variables as Δ^{CI}, Δ^{OD}, Δ^{HO}, respectively. The regressions comparing price differences between chain and independent drugstores give us

a fairly clean comparison of the relative importance of size and restrictiveness as we look across coefficients. The regressions comparing drugstores to hospitals and HMOs are less clean because we do not have information on relative size, but these results will still provide information on the importance of restrictiveness.

We can, of course, control for other covariates in a regression framework, such as a time trend, which we do in some specifications. Finally, note that the observations are at the level of presentation-drug-manufacturer, and we discuss how to account for the detail of our data in computing standard errors below.

Table 4 presents results from our base regressions. The first column seeks to explain the difference in prices paid by chain drugstores and independent drugstores. Chain drugstores and independent drugstores should not differ in their restrictiveness—neither can be restrictive against on-patent brand-name drugs and they can be only slightly restrictive against off-patent brand-name drugs or single source generics, but both can be restrictive against multiple source generics. The only difference is that chain drugstores will tend to be large-volume buyers whereas independent drugstores will not. Recall that the dependent variable is the log of the difference between prices paid by chain and independent drugstores. The interpretation, therefore, of the 0.002 coefficient estimate on $ONPAT \times BRANDED$ is that chain drugstores pay 0.2% more for branded on-patent drugs than independent drugstores do. The coefficient is not significantly different from zero, and given its small standard error, one should conclude that the effect is precisely estimated to be about zero. This result taken on its own would tend to cast doubt on the relevance of the bargaining models in our market. In the face of monopoly supply, large buyers are not able to extract any discount at all. Strikingly, the prices they pay seem not to even reflect transactions-cost savings from high-volume transactions, a portion of which would presumably be passed through to the buyer.

The next two coefficients represent supply regimes in which drugstores might have limited ability to substitute, depending on the state laws. For the off-patent branded drugs, the chains

receive a small (0.3%) but statistically significant discount. The discount for the single source generics is larger (1.7%), but only marginally significant. These results provide some tentative support for the dynamic models of countervailing power in this setting—holding other factors fixed, as the supply regime becomes slightly more competitive, large buyers are able to extract small discounts from the sellers relative to small buyers.

Finally, somewhat surprising perhaps is the essentially zero coefficient on the fourth interaction, indicating that chains receive no discount on multiple source generics. Our first instinct would be to believe that the dynamic models would predict larger buyer-size effects in this situation, one of greater supply competition. It is the case, however, that if competition is fierce enough among suppliers to approximate perfect competition, which may be the case for multiple source generic drugs, then discounts given to large buyers would simply reflect cost differences. The first coefficient in this regression implied that cost differences were negligible, which would be consistent with the zero coefficient here. Overall, the results of this regression indicate that chain drugstores are not receiving substantial discounts relative to independents, either in the presence or absence of restrictiveness. Small discounts are being extracted when the supply regime is slightly competitive.

The second and third columns of Table 4 present the results for the difference in prices paid by hospitals and drugstores. In these regressions, we have little information about the relative sizes of the competitors, but we do know that hospitals have greater substitution opportunities due to their ability to use restrictive formularies. To reiterate the main points from Section 2, certainly for any off-patent drug, hospitals, unlike drugstores, can choose to stock either the branded or generic and do not need to stock both. For on-patent drugs, hospitals may have less discretion, but they can choose to eliminate a drug from their formularies if close substitutes exist whereas drugstores clearly cannot. In other words, these regressions comparing hospital and drugstore prices will provide a test of how important restrictiveness is.

The results from the short sample (starting in January 1992) and the long sample (going back to

August 1990) do not differ in any appreciable way, so we will focus on the long sample. All four coefficient estimates are highly significant and are negative, meaning hospitals receive significant discounts relative to drugstores in all circumstances. The smallest discounts occur for on-patent drugs, about 10%, consistent with hospitals being able to exercise only limited restrictiveness in that case. For off-patent drugs, where hospitals can always be restrictive, discounts are steeper, including a 35% discount for the off-patent branded drugs. Branded manufacturers know steep discounts are necessary to keep their drugs on formularies in the presence of generics. Notably, for multisource generic drugs, hospitals still receive a sizeable discount, 15%, despite drugstores' ability also to be restrictive in that one circumstance. One possible explanation is that although drugstores can be restrictive against multisource generics, they are reluctant to switch manfacturers once one is chosen because their customers might complain about changes in the size, shape, and color of the drug. The hospital population, being more transient, would not be as sensitve to changes over time. It seems unlikely, however, that this effect would be important enough to account for a 15% discount.

The fourth column of Table 4 compares prices paid by HMOs and drugstores. HMOs would be similar to hospitals in their restrictiveness despite the HMO channel containing data from on site HMO pharmacies. Not surprisingly, then, the results we obtain from this regression are similar to the ones for hospitals and drugstores, but the discounts are not as deep and the coefficients are not as significant. Interestingly, the HMO discount for multisource generic drugs is only 4%, compared with 15% for hospitals relative to drugstores. The HMO patient population, especially one purchasing from an on site pharmacy, would be more permanent than one at a hospital, so the smaller discount is consistent with the explanation in the above paragraph.

Recall that if anything, these results are likely to understate the true discount given to hospitals and HMOs relative to drugstores because hospitals and HMOs may receive secret price discounts not reflected in our transactions prices.

Finally, the fifth column of Table 4 compares hospitals and HMOs. The one circumstance

where hospitals receive a discount relative to HMOs is for multisource generic drugs. This result, of course, is the complement to the results on multisource generics in the two previous regressions, and is, therefore, consistent with the explanation that hospitals can be even more restrictive than HMOs due to their transient populations. Since our data do not include secret rebates, we cannot rule out the possibility that HMOs receive more secret rebates than hospitals (or vice versa) and thus receive steeper discounts relative to hospitals (or vice versa) than the fifth column indicates.

In all of the regressions in Table 4 (as well as those in Table 5 below), we have weighted observations by revenue (total across two channels) and computed heteroskedasticity-robust standard errors. We tried other weighting schemes, such as weighting by minimum revenue across the two channels and not weighting the observations at all, and the quantitative results were nearly identical. In addition to allowing for an arbitrary form of heteroskedasticity, we also account for non-independence within certain groups of observations. Our data are at the level of presentation—surely the parties are not negotiating the price of every presentation independently—so non-independence is an important consideration, and accounting for the correlation within manufacturer-drug clusters seems the most natural grouping (and the one we have reported here). We have also tried a variety of other clustering options, including manufacturer clusters to allow for the possibility of bundling arrangements across drugs, but the results are robust to these choices. These clustering options also effectively account for the possibility of serial correlation.

Our next set of results, Table 5, is from a richer specification of the base regressions. We introduce additional controls to check the robustness of our main results. In addition to the original four regressors, we include overall trend variables and drug-specific trend variables in Table 5. The variables *PREEXP* and *POSTEXP* control for drug-life-cycle effects by allow for different trend lines before and after patent expiration. We have also interacted *POSTEXP* with dummy variables for a drug being branded and generic to allow for different trend lines for those two types of manufacturers within a drug.

Looking at Table 5, we notice that the patterns of coefficient estimates on the four main variables are very similar when we control for trends. Magnitudes of discounts increase in some cases—for instance, the estimated discount that hospitals receive reletive to drugstores for on-patent drugs has increased to 21%—and the comparison of hospitals and HMOs yields somewhat different results. When we control for trends, HMOs actually receive a discount relative to hospitals on single source generics of 7%. HMO penetration is growing rapidly during this period and markets are adjusting to their presence, so it is not surprising that controlling for trends might change the results involving HMOs somewhat.

Where it is possible to compare our results to other studies, they are broadly consistent, providing further assurance of the robustness of our results. The Congressional Budget Office (1998) study found price discounts that varied with buyers' substitution opportunities in a similar pattern to ours. As stated in more detail in the Introduction, with a few minor exceptions, our results are similar to those in Sorensen (2001) even though we consider two different classes of health care expenditure, pharmaceuticals in our case and hospital services in his. This provides some confidence that our results generalize beyond the market we consider in this paper.

5 Conclusion

Our findings suggest that ability to substitute is a more significant source of countervailing power in the wholesale market for antibiotics than size alone. The results are broadly consistent with theories of countervailing power involving competition among buyers, in particular the collusion-based models of Snyder (1996, 1998). The theory implies that there should be no price discounts for large buyers in the presence of a monopoly seller, but only if there is some competition among sellers in the market. We find support for these theoretical implications in our comparison of chain versus independent prices: chain drugstores do not obtain a price discount relative to independents if they have no substitution opportunities (for on-patent branded antibiotics), but do

have modest price discounts if they have some substitution opportunities (for off-patent branded and generic antibiotics). The finding of no size discounts for on-patent antibiotics is evidence against the pure bargaining models which imply that large buyers can obtain price discounts even when bargaining against a monopoly supplier.

Our analysis of the wholesale discounts obtained by hospitals and HMOs relative to drugstores further points out the importance of substitution opportunities. Hospitals and HMOs typically have better substitution opportunities across the board compared to drugstores and indeed obtain substantial price discounts relative to them. The price discount is largest where the hospitals and HMOs would be expected to have the greatest advantage in substitution opportunities relative to drugstores: for off-patent branded drugs.

The results have implications for recent policy initiatives to form purchasing alliances to obtain lower prescription prices. Such initiatives may not succeed in lowering costs substantially unless the alliance develops a restrictive formulary. In fact, it would be interesting to know whether, in the presence of a restrictive formulary, a group would gain anything by its size beyond what it could gain from restrictiveness. Our results cannot address this question directly, but they imply that size commands only very small discounts in the presence of modest restrictiveness. Our results also suggest that any cost advantages to large transactions are negligible.

Another policy implication of our results returns us to the cite to Galbraith (1952) from the Introduction. Galbraith's view was that large size could be a countervailing force against the market power of concentrated suppliers; the presence of large buyers might make antitrust enforcement unnecessary. Our results suggest that buyer size does not obviate the need for antitrust enforcement; at least a moderate degree of supplier competition, which antitrust enforcement might foster, appears to be required for size discounts to emerge, and even then the size discounts themselves may not be substantial.

Our results suggest an explanation for the failure of Mercata and other websites offering declining prices for items as the number of consumer purchasers increased. Mercata's business

model involved contracting with a manufacturer of an item, say with Hewlett-Packard concerning a particular CD drive, and only then sought consumers for the item. After signing such a contract, Mercata would have little ability to substitute for other CD drives, what we found to be the key ingredient for gaining wholesale discounts. A better business model might have been to obtain customers for a specified type of CD drive—but not for a specified manufacturer—and then shop on behalf of the customers, exploiting the benefits of competition among manufacturers.

Appendix

Shapley Value Calculations Consider a game with two buyers, a small buyer B_s with inelastic demand for one unit and a large buyer B_ℓ with inelastic demand for two units. There are N suppliers, $S_1, \ldots, S_N$, supplying homogeneous goods. A single supplier can generate marginal surplus v_1 if it supplies the buyers one unit, v_2 for the second, and v_3 for the third, where $v_1 > v_2 > v_3 > 0$, so the joint surplus function associated with trade between a single supplier and the buyers is concave. There is no demand for more than three units. A coalition of two suppliers and both buyers could generate total surplus $2v_1 + v_2$ by having one supplier trade one unit to the small buyer and the other supplier trade two units to the large buyer.

A buyer's Shapley value can be computed by examining all permutations of the players, computing the buyer's marginal contribution to the coalition of all players up to and including the buyer in the ordering, and taking the average of this marginal contribution across permutations. With one supplier, B_s's Shapley value per unit of demand can be shown to be $(2v_1+v_3)/6$, while B_ℓ's is $(2v_1 + 3v_2 + v_3)/12$. The ratio of B_ℓ's to B_s's per unit Shapley value is thus

$$\frac{1}{2}\left(1 + \frac{3v_2}{2v_1 + v_3}\right). \tag{5}$$

With two suppliers, $B's$ per unit Shapley value is $(12v_1 + 2v_2 + 2v_3)/24$, while B_ℓ's is $(9v_1 + 6v_2 + v_3)/24$. The ratio is thus

$$\frac{1}{2}\left(1 + \frac{3v_1 + 5v_2}{6v_1 + v_2 + v_3}\right). \tag{6}$$

In the limit as v_2 and v_3 approach zero, expression (5) approaches 1/2 and (6) approaches 3/4, implying the large-buyer advantage increases with the number of suppliers. On the other hand, in the limit as v_2 approaches v_1 and v_3 approaches zero, expression (5) approaches 5/4 and (6) approaches 15/14, implying the large-buyer advantage falls with the number of suppliers.

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Table 1: Substitution Opportunities for Various Channels and Drugs

Drug Category	Hospitals, HMOs	Drugstores
On-Patent, Branded Drugs		
•Therapeutically Unique	Poor	Poor
•Not Therapeutically Unique	Moderate	Poor
Off-Patent, Branded Drugs		
•Mandatory States	Excellent	Poor
•Permissive States	Excellent	Moderate
Generic Drugs		
•One Generic Manufacturer		
○Mandatory States	Excellent	Poor
○Permissive States	Excellent	Moderate
•Multiple Generic Manufacturers	Excellent	Excellent

Notes: Mandatory states require drugstores to fill prescriptions with the generic unless prescriber or purchaser explicitly request otherwise. Permissive states make this optional for the pharmacist. According to the *National Pharmaceutical Council* (1992), Florida, Hawaii, Kentucky, Massachusetts, Mississippi, New Jersey, New York, Pennsylvania, Rhode Island, Virginia, Washington, and West Virginia were mandatory states as of 1992 and the rest permissive.

Table 2: Definition of Variables

Variable	Indexes Varies Over	Definition
PRICE	i, j, m, t, c	Average wholesale price in nominal U.S. dollars
REV	i, j, m, t, c	Revenue in nominal U.S. dollars
BRANDED	i, m	Dummy equaling one if produced by drug's patent holder
GENERIC	i, m	Dummy equaling $1 -$ *BRANDED*
ONPAT	i, t	Dummy equaling one if patent is in force (i.e., no generics)
OFFPAT	i, t	Dummy equaling $1 -$ *ONPAT*
NUMGEN	i, t	Number of competing generic manufacturers of drug
ONEGEN	i, t	Dummy equaling one if *NUMGEN* equals one
MULTGEN	i, t	Dummy equaling one if *NUMGEN* exceeds one
PREEXP	i, t	Months before patent expiration (set to zero after expiration)
POSTEXP	i, t	Months after patent expiration (set to zero before expiration)
TREND	t	Integer for year, beginning with zero in 1990

Notes: i indexes drugs; j indexes presentations of each drug; m indexes manufacturers; t indexes month; c indexes distribution channel.

Table 3: Descriptive Statistics

	Long Sample (Sep. 1990 to Aug. 1996)					Short Sample (Jan. 1992 to Aug. 1996)				
	Obs.	Mean	Std. Dev.	Min.	Max.	Obs.	Mean	Std. Dev.	Min.	Max.
BRANDED	203,791	0.28	0.45	0	1	160,621	0.27	0.45	0	1
ONPAT	203,791	0.11	0.32	0	1	160,621	0.10	0.30	0	1
NUMGEN	180,956	16.8	9.6	0	39	144,719	16.8	9.7	0	39
ONEGEN	180,956	0.06	0.24	0	1	144,719	0.06	0.24	0	1
PREEXP	203,791	3.3	12.0	0	72	160,621	2.7	9.3	0	56
POSTEXP	203,791	31.2	22.0	0	71	160,621	37.8	20.0	0	71
TREND	203,791	2.58	1.71	0	6	160,621	3.19	1.38	1	6
PRICE by channel										
HMOs (O)	—	—	—	—	—	73,576	54	103	0.04	1,294
Hospitals (H)	157,553	55	109	0.18	2,394	124,358	55	107	0.22	2,291
Drugstores (D)	176,840	55	110	0.16	2,273	139,767	55	109	0.16	2,190
Chains (C)	—	—	—	—	—	112,966	51	101	0.13	1,916
Independents (I)	—	—	—	—	—	133,150	55	109	0.25	2,900
Foodstores (F)	—	—	—	—	—	88,777	44	86	0.33	2,627
REV by channel (in millions)										
HMOs (O)	—	—	—	—	—	73,576	0.001	0.04	0.0	1.9
Hospitals (H)	157,553	0.07	0.37	0.0	10.2	124,358	0.07	0.38	0.0	10.2
Drugstores (D)	176,840	0.13	1.08	0.0	63.9	139,767	0.14	1.13	0.0	63.9
Chains (C)	—	—	—	—	—	112,966	0.09	0.71	0.0	38.9
Independents (I)	—	—	—	—	—	133,150	0.05	0.38	0.0	17.4
Foodstores (F)	—	–	—	—	—	88,777	0.02	0.16	0.0	7.6

Notes: The unit of observation is a drug-presentation-manufacturer-month combination. The statistics for *NUMGEN* and *ONEGEN* are computed only for those observations in which drug is off patent (i.e., $ONPAT = 0$). The number of observations varies for *PRICE* and *REV* across distribution channels because some presentations of some drugs were not supplied to certain channels during certain months.

Table 4: Weighted Least Squares Regressions of the Difference in Log Price

	Δ^{CI}	Δ^{HD}		Δ^{OD}	Δ^{HO}
		short sample	long sample		
ONPAT	0.002	-0.077^{***}	-0.095^{***}	-0.079^{***}	0.015
	(0.001)	(0.017)	(0.017)	(0.018)	(0.016)
OFFPAT × *BRANDED*	-0.003^{**}	-0.328^{***}	-0.347^{***}	-0.205^{***}	-0.043
	(0.002)	(0.059)	(0.061)	(0.055)	(0.040)
OFFPAT × *GENERIC* × *ONEGEN*	-0.017^{*}	-0.151^{***}	-0.166^{***}	-0.121^{**}	-0.005
	(0.010)	(0.057)	(0.046)	(0.051)	(0.018)
OFFPAT × *GENERIC* × *MULTGEN*	-0.003	-0.145^{***}	-0.149^{***}	-0.043^{**}	-0.054^{***}
	(0.002)	(0.020)	(0.021)	(0.017)	(0.015)
R^2	0.001	0.165	0.173	0.054	0.013
Observations	107,164	107,287	134,385	71,463	69,644
Manufacturer-Drug Clusters	791	740	793	630	588

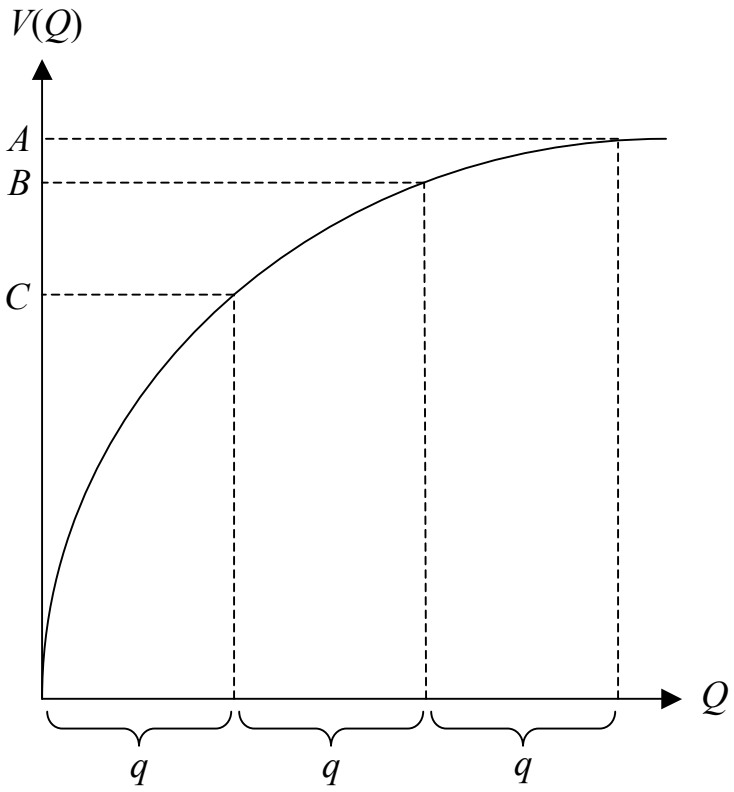
Notes: For each observation, the weight in the weighted least squares estimation procedure is the natural logarithm of the sum of revenue in the two relevant channels. An exhaustive set of dummies is included in each regression and the constant term omitted. White (1980) heteroskedasticity-robust standard errors reported in parentheses below coefficient estimates. The reported standard errors are also adjusted to account for the non-independence of manufacturer-drug pairs across time and presentations. Significantly different from zero in a two-tailed t-test with degrees of freedom equal to the number of unique manufacturer-drug clusters minus one at the *ten percent level; **five percent level; ***one percent level.

Table 5: Weighted Least Squares Regressions of the Difference in Log Price with Trend Variables

		Δ^{HD}			
	Δ^{CI}	short sample	long sample	Δ^{OD}	Δ^{HO}
ONPAT	-0.011	-0.218^{***}	-0.214^{***}	-0.228^{***}	-0.003
	(0.008)	(0.053)	(0.037)	(0.034)	(0.037)
OFFPAT × *BRANDED*	-0.011^{**}	-0.392^{***}	-0.407^{***}	-0.217^{***}	-0.035
	(0.005)	(0.086)	(0.077)	(0.062)	(0.076)
OFFPAT × *GENERIC* × *ONEGEN*	-0.023^{*}	-0.174^{**}	-0.183^{***}	-0.224^{***}	0.070^{**}
	(0.012)	(0.060)	(0.047)	(0.055)	(0.028)
OFFPAT × *GENERIC* × *MULTGEN*	-0.009	-0.167^{***}	-0.168^{***}	-0.147^{***}	0.024
	(0.007)	(0.032)	(0.027)	(0.025)	(0.023)
TREND $(\times 10^{-1})$	0.043	0.210	0.227^{**}	0.513^{***}	-0.152
	(0.033)	(0.150)	(0.093)	(0.103)	(0.135)
TREND^2 $(\times 10^{-2})$	-0.033	0.142	0.116	-0.379^{**}	0.258
	(0.044)	(0.168)	(0.133)	(0.148)	(0.191)
PREEXP $(\times 10^{-1})$	0.001	0.021^{***}	0.012	0.011	0.013^{*}
	(0.001)	(0.008)	(0.013)	(0.008)	(0.007)
POSTEXP × *BRANDED* $(\times 10^{-1})$	-0.001	-0.005	0.017^{***}	-0.001	0.002
	(0.001)	(0.013)	(0.007)	(0.007)	(0.009)
POSTEXP × *GENERIC* $(\times 10^{-1})$	-0.001	-0.015^{*}	-0.002	-0.004	-0.014^{**}
	(0.001)	(0.008)	(0.010)	(0.005)	(0.006)
R^2	0.001	0.168	0.178	0.059	0.015
Observations	107,164	107,287	134,385	71,463	69,644
Manufacturer-Drug Clusters	791	740	793	630	588

Notes: For each observation, the weight in the weighted least squares estimation procedure is the natural logarithm of the sum of revenue in the two relevant channels. An exhaustive set of dummies is included in each regression an d the constant term omitted. White (1980) heteroskedasticity-robust standard errors reported in parentheses below coefficient estimates. The reported standard errors are also adjusted to account for the non-independence of manufacturer-drug pairs across t ime and presentations. Significantly different from zero in a two-tailed t-test with degrees of freedom equal to the number of manufacturer-drug clusters minus one at the *ten percent level; **five percent level; ***one percent level.

Panel A: Concave Surplus Function



Panel B: Convex Surplus Function

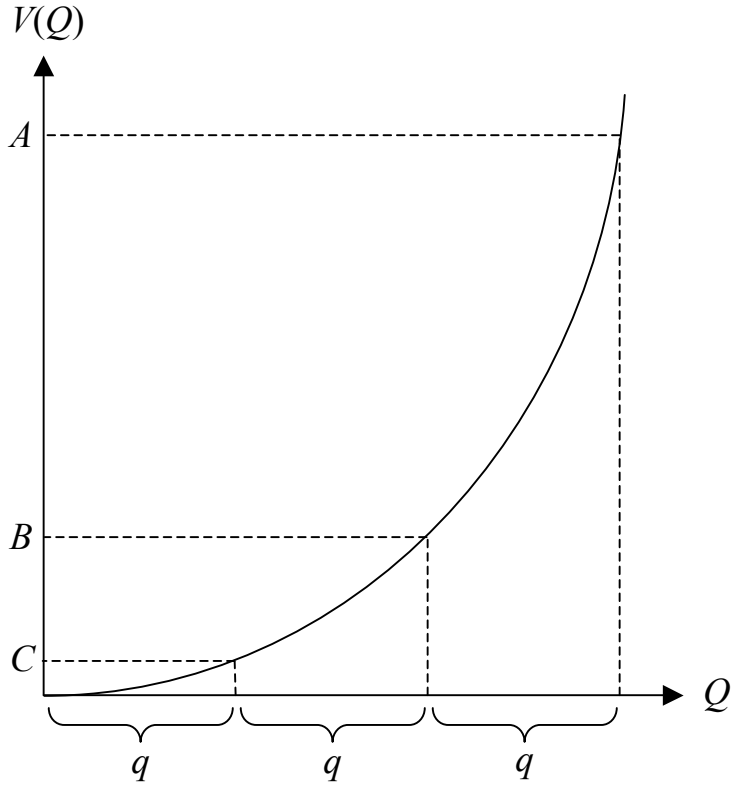


Figure 1: Bargaining Model Example

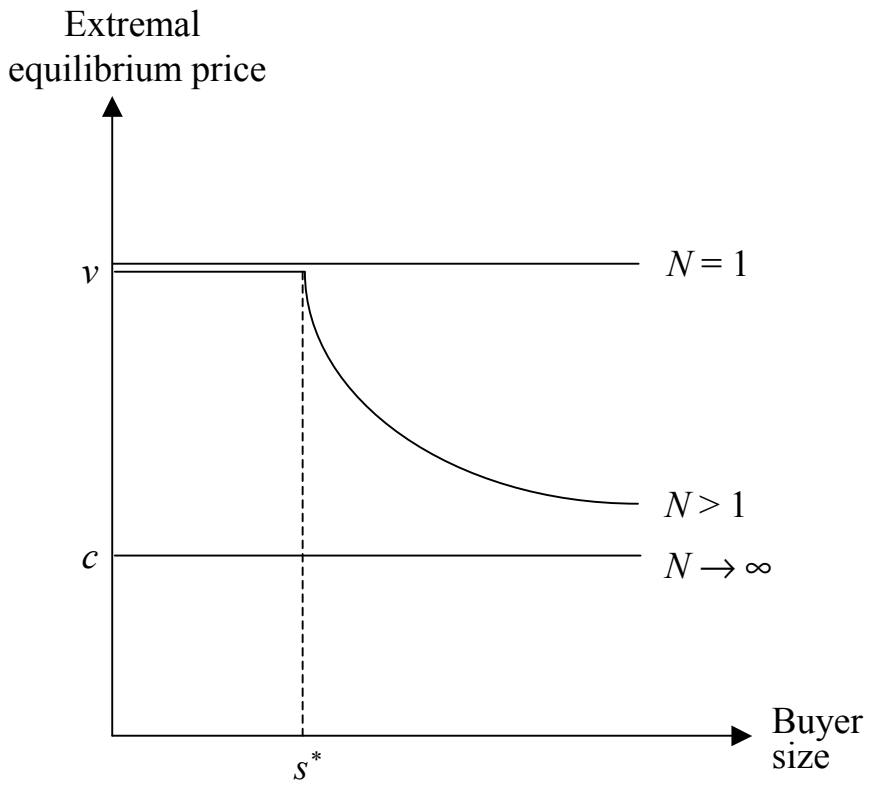


Figure 2: Buyer-Size Discounts in Collusion Model