

## COUNTERVAILING POWER IN WHOLESALE PHARMACEUTICALS<sup>\*</sup>

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Using data on wholesale prices for antibiotics sold to U.S. drugstores, we test the growing theoretical literature on ‘countervailing power’ (a term for the ability of large buyers to extract discounts from suppliers). Large drugstores receive a modest discount for antibiotics produced by competing suppliers but no discount for antibiotics produced by monopolists. These findings support theories suggesting that supplier competition is a prerequisite for countervailing power. As further evidence for the importance of supplier competition, we find that hospitals receive substantial discounts relative to drugstores, attributed to hospitals’ greater ability to induce supplier competition through restrictive formularies.

### I. 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 buyer-size effects exist.<sup>1</sup> Recently,

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<sup>1</sup>See, for example, recent *Wall Street Journal* articles on the ability of ‘big-box’ stores to extract price discounts for beer and wine (Hallinan [2006]) and on alliances of auto manufacturers to extract price discounts from parts suppliers (Ingrassia [2006]). See also the score of earlier business-press sources cited in Scherer and Ross [1990] and Snyder [1998].

these effects have come to the fore in various policy debates. Critics of Wal-Mart, the largest U.S. retailer, contend that the price concessions it is able to extract from suppliers allow it to undercut smaller rivals and squeeze them out of business.<sup>2</sup> Politicians have proposed using the bargaining power of state and federal governments to reduce what citizens pay for pharmaceuticals (Mandel [2007]).

A growing theoretical literature has offered a variety of models of buyer-size effects. Much of this literature provides a nuanced view that large-buyer discounts do not emerge under all circumstances but depend on other factors in the economic environment. For example, one set of papers show that large-buyer discounts emerge from nonlinearities in the surplus function over which a monopoly supplier and buyers bargain under full information (Horn and Wolinsky [1988b]; Stole and Zwiebel [1996]; Chipty and Snyder [1999]; Raskovich [2003]; Segal [2003]; Adilov and Alexander [2006]; Inderst and Wey [2007]; Normann, Ruffle, and Snyder [2007]). In other bargaining models, large-buyer discounts hinge on risk aversion (Chae and Heidhues [2004], DeGraba [2005]).

Most relevant for the present paper are theories suggesting that competition among suppliers is the crucial strategic factor for large-buyer discounts 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. In Dana [2004], having buyers with heterogeneous preferences together in a group effectively reduces the differentiation between suppliers and leads them to compete more aggressively for the group's business. In Gans and King [2002] and Marvel and Yang [2006], transaction costs prevent suppliers from offering anything but linear contracts to small buyers. Supplier competition is more intense in the nonlinear contracts offered to large buyers. In Smith and Thanassoulis's [2008] bargaining model, supplier competition introduces variance in their market shares. If production exhibits increasing returns to scale, capturing the business of a large buyer lowers a supplier's expected average cost, translating into a large-buyer discount.<sup>3</sup>

<sup>2</sup> Newspaper articles discussing Wal-Mart's price discounts include *The Guardian* [2000] and Wilke [2004]. Basker [2007] reviews the economic literature on Wal-Mart.

<sup>3</sup> Related theoretical papers include Katz [1987] and Scheffman and Spiller [1992], in which the threat of potential competition from the backward integration of large buyers leads to discounts. Horn and Wolinsky [1988a] and Tyagi [2001] focus on downstream rather than upstream competition as a source of buyer-size discounts. Inderst and Wey [2003], Gal-Or and Dukes [2006], and Inderst and Shaffer [2007] examine bargaining models with multiple suppliers but do not study how an increase in the number of suppliers affects buyer-size discounts. Another related set of papers models how buyer size affects final-good prices (von Ungern-Sternberg [1996], Dobson and Waterson [1997], Chen [2003], Erutku [2005]).

In this paper we test whether the implication from the theoretical papers cited in the previous paragraph—supplier competition is required for buyer-size discounts to emerge—holds in the pharmaceutical industry. Our data on average wholesale prices charged by manufacturers to U.S. drugstores for antibiotics sold in the early 1990's contains variation in both buyer size and the intensity of supplier competition. Variation in buyer size comes from data on large-volume chain and small-volume independent drugstores. Variation in supplier competition comes from differences in drugstores' substitution opportunities across different antibiotics. At one extreme, drugstores cannot substitute away from a drug produced by a branded manufacturer with an unexpired patent—they refuse to stock it, and they lose sales from anyone carrying a prescription for it. 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. Using these sources of variation, we can identify instances in which buyers have good substitution opportunities, large size, both, or neither, and can therefore isolate the effect that each has on purchase price.

In order to obtain further evidence on the importance of supplier competition on price discounts, we analyze an additional source of variation in buyer's substitution opportunities. By issuing restrictive formularies, hospitals and health-maintenance organizations (HMO's) 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. We can further investigate the importance of substitution opportunities by comparing prices paid by drugstores to the prices paid by hospitals and HMO's.

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 may have policy implications as well. In particular, they could shed light on the likely success of large healthcare procurement alliances.<sup>4</sup> If size alone is not sufficient for

<sup>4</sup> A number of states have created or considered creating large pharmaceutical purchasing alliances. Maine led the way with a 2000 law designed to 'get volume discounts' for Maine residents who joined the alliance (Goldberg [2000]), and Vermont and Maryland have considered similar programs (Pear [2001]). Iowa, New Hampshire, Washington and West Virginia have created intrastate purchasing cooperatives for the elderly (Pear [2001]); and West Virginia, Georgia, North Carolina, South Carolina, New Mexico and Washington collaborated on a multi-state purchasing alliance (Gold [2001]).

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 another. Of course, consumers may oppose the resulting restriction of choice (similar to the much-publicized dissatisfaction with the restriction of choice and care by HMO's).

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 opportunities—chain drugstores receive a statistically significant but small discount relative to independents, at most 2%.

The implication of our findings for economic theory is that, at least for this particular market, papers including Snyder [1996, 1998], Gans and King [2002], Dana [2004], Marvel and Yang [2006], and Smith and Thanassoulis [2008] have correctly identified supplier competition as a necessary condition for large-buyer discounts. The implication of our findings for policy is that absent supplier competition (or the ability to use restrictive formularies to induce supplier competition), drug purchasing alliances are not likely to gain much from their increased size.<sup>5</sup>

## II. RELATED EMPIRICAL LITERATURE

Our paper is part of a larger empirical literature documenting the existence of buyer-size effects and countervailing power. The literature includes case studies,<sup>6</sup> experimental studies,<sup>7</sup> interindustry econometric studies,<sup>8</sup> and intraindustry econometric studies.<sup>9</sup> Our paper goes beyond merely documenting the existence of buyer-size effects to provide a more nuanced test of the sources of those effects.

There is a related literature on bargaining between buyers and suppliers in healthcare markets.<sup>10</sup> To understand how our paper fits into this literature,

<sup>5</sup> 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.

<sup>6</sup> See Adelman [1959] and McKie [1959].

<sup>7</sup> See Ruffle [2000], Engle-Warnick and Ruffle [2005], and Normann, Ruffle, and Snyder [2007].

<sup>8</sup> 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].

<sup>9</sup> For instance, Chipty [1995] finds that large cable operators charge lower prices to subscribers, possibly reflecting lower input prices paid to program suppliers.

<sup>10</sup> Pauly [1987, 1998] sketches out arguments for why size discounts could arise in healthcare.

recall that our central empirical question is whether buyer-size discounts emerge in the presence of a monopoly supplier or require buyers to have substitution opportunities. Our main focus is therefore on the *interaction* between a buyer's size and its substitution opportunities. Most other papers in the healthcare literature study the effect of just buyer size on price or of just substitution opportunities on price, not the interaction between the two. Feldman and Greenberg [1981] and Adamache and Sloan [1983] document the existence of buyer-size effects for insurers contracting with hospitals but do not examine how those buyer-size effects might vary with substitution opportunities. A number of papers study whether the enhanced substitution opportunities from the implementation of a restrictive formulary lowers drug prices (Grabowski [1988]; Dranove [1989]; Grabowski, Schweitzer and Shiota [1992]; Moore and Newman [1993]). The general finding is that restrictive formularies lower retail expenditures on drugs but do not lower overall healthcare expenditures because of input substitution.<sup>11</sup> These studies of restrictive formularies do not consider buyer-size effects. Three papers—Staten, Dunkelberg, and Umbeck [1987, 1988] and Brooks, Dor and Wong [1997]—consider the effect of buyer size and substitution opportunities on price, but consider the effects separately and do not estimate the interaction effect.

Outside of the healthcare industry, the results from a study of wholesale prices for transactions between grocery suppliers and retailers, published as part of a Competition Commission [2008] inquiry into the U.K. grocery industry, mirror ours. Using a price measure that subtracts off rebates and promotional discounts, the study finds significant buyer-size discounts for store-brand goods (for which the grocer can freely substitute among different suppliers) but not for supplier-branded goods (for which grocers have more limited substitution opportunities), similar to our finding that large drugstores obtain discounts only when generic substitutes are available.<sup>12</sup>

Within the healthcare industry, two studies, Melnik *et al.* [1992] and Sorensen [2003], come closest to performing the types of tests in which we are interested. Melnick *et al.* [1992] look at the prices negotiated between hospitals and health insurers as a function of the size of the health insurer,

<sup>11</sup> A study by the Congressional Budget Office [1998] examines how a measure of buyer discounts (the difference between the lowest price received 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. Of course scores of other empirical papers estimate the effect of increased substitution opportunities on price across a wide range of markets. Here, we have restricted attention to studies specifically on the pharmaceutical market.

<sup>12</sup> Other related studies outside of healthcare include Fee and Thomas [2004] and Shahrur [2005], who perform event studies of horizontal takeovers for a large cross-section of industries. The studies generally find that buyer mergers harm suppliers only when suppliers are concentrated.

the number of hospitals in a locality, and an interaction between the two. Unlike in our study, where the size of a drugstore, as measured by the number of retail outlets, can be taken to be exogenous in the short run, one would expect endogeneity to be an issue in the health-insurance study. In particular, size of the health insurer is measured as the fraction of patients in a particular hospital covered by that insurer. The results would be biased if patients who wanted to use a particular hospital tended to switch to the insurer that offered the best deal at that hospital, therefore giving it a larger market share at that hospital.<sup>13</sup>

Sorensen's [2003] results are broadly consistent with ours though for a different class of healthcare 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 [2003], substitution opportunities are a more important source of countervailing power than sheer size. One difference is our finding of a significant interaction between size and substitution opportunities, an interaction which is insignificant in Sorensen [2003]; however, the magnitude of the interaction effect in our results is small.

### III. INSTITUTIONAL DETAILS

Much of our empirical strategy hinges on the existence of different substitution opportunities across types of drugs (and buyers), which provides us with variation in the competitiveness 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, summarized in Table I; 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 on-patent impotence drug Cialis at the wholesale level. They know that some customers will come in off the street with prescriptions for Cialis that need to be filled, and there is little CVS can do at that point to alter the prescription, even though those customers might be equally happy with a

<sup>13</sup> In the absence of an econometrically valid technique to deal with the bias, the authors omit the size of insurer from their preferred specification (to 'avoid contamination'), but continue to include the interaction between it and the number of hospitals in the locality. The interaction term may suffer from a similar endogeneity bias as the insurer-size variable, and the omission of the insurer-size variable makes interpretation of the interaction term difficult.

TABLE I  
SUBSTITUTION OPPORTUNITIES FOR VARIOUS CHANNELS AND DRUGS

Drug Category	Hospitals, HMO's	Drugstores
1. On-Patent, Branded Drugs		
a. Therapeutically Unique	Poor	Poor
b. Not Therapeutically Unique	Moderate	Poor
2. Off-Patent, Branded Drugs		
a. Mandatory States	Excellent	Poor
b. Permissive States	Excellent	Moderate
3. Generic Drugs		
a. One Generic Manufacturer		
i. Mandatory States	Excellent	Poor
ii. Permissive States	Excellent	Moderate
b. 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.

prescription for Viagra. (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.

Suppose, instead, CVS is negotiating with Eli Lilly to purchase Prozac, its now off-patent antidepressant with generic versions on the market. Despite the fact that these very good substitutes exist in the market, CVS will still have quite limited substitution opportunities. Most 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 must be dispensed, therefore constraining drugstores' ability to substitute. A minority of states ("permissive") allow the drugstore to choose whether to dispense the branded or generic if neither is explicitly requested and/or prescribed, affording the drugstore a bit of latitude.<sup>14</sup> CVS might be able to use this increased latitude in its bargaining, but Eli Lilly knows that its ability to substitute will still be very modest. CVS's substitution opportunities will be similarly limited in the case that there is only one generic on the market.<sup>15</sup> The only case when a retail pharmacy such as CVS would have excellent substitution opportunities is choosing a generic version of a drug when multiple generics are on the market. They would typically stock only one, and the only constraint on their ability to substitute among them would be their hesitancy to change the size, shape, and color of a particular tablet too often.

<sup>14</sup> See Hellerstein [1998] for more detail on the institutions involving generic substitution.

<sup>15</sup> There is typically a period of six months after patent expiration when only one generic manufacturer receives FDA approval to be on the market, as provided by the Waxman-Hatch Act.

Of course, these examples extend to all retail pharmacies, not just large ones such as CVS. It is the fact that large and small pharmacies have similar substitution opportunities across these different types of drugs that will allow us to empirically identify the effect that size has in negotiating price in these different supply regimes.

As mentioned earlier, we supplement the core results on drugstores with additional results on the role that substitution opportunities play in these price negotiations. To do this, we compare prices paid by drugstores to prices paid by hospitals and HMO's, whose substitution opportunities are better than drugstores for every type of drug. To illustrate why, let us return to our example of Cialis. A hospital or HMO can enter into negotiations with Eli Lilly with the ability to threaten credibly that they will not purchase Cialis. The difference is that a hospital can induce or require its physicians to prescribe Viagra instead, a drug with similar therapeutic properties to Cialis'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 Viagra in this transaction. Not only do hospitals and HMO's 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. Furthermore, hospitals and HMO's can typically freely switch between branded and generic versions of a drug, if generics exist. Only in the first and last row of Table I do hospitals and HMO's not have strictly better substitution opportunities than drugstores. The first row (1a) turns out to be irrelevant in our study because all therapeutically unique drugs in our sample happen to be off patent. Therefore, hospitals should have strictly better substitution opportunities than drugstores for all on-patent drugs in our sample. Another feature of our data relevant for Table I is that it is at the national level, and so does not allow us to analyze differential effects across mandatory and permissive states.

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 is true not just across different drugs but also between branded and generic versions since generic penetration is unusually high in this class. Of course, these substitution opportunities would often only be available to hospitals and HMO's.

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.



## IV. DATA

Our dataset, collected by the pharmaceutical-marketing-research firm IMS America, covers virtually all prescription antibiotics sold in the United States from January 1992 to August 1996.<sup>16</sup> It includes nationwide quantities and revenues from wholesale transactions between manufacturers/distributors and retailers each month.

The data are aggregated up to buyer categories, referred to as distribution channels by IMS. The three main buyer categories are drugstores, hospitals, and HMO's.<sup>17</sup> The hospital category covers all nonfederal facilities, i.e., all private and nonfederal government hospitals. The drugstore category is further partitioned into three subcategories: chains, independents, and foodstores. A firm operating four or more drugstores is classified as a chain and three or fewer as an independent. The foodstore category reflects drugstores located within foodstores.

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. We have 132 different antibiotics, averaging 17 different presentations each.

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

<sup>16</sup> Our data also contain a small number of antifungals and antivirals.

<sup>17</sup> The HMO category includes prescriptions dispensed at HMO-owned hospitals and drugstores, not prescriptions dispensed elsewhere but paid for by an HMO drug benefit. Therefore, the HMO category reflects only a small portion of the influence that HMO's and other managed care have had on pharmaceutical purchasing.

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 affect our results for drugstores.

Although the main results we use to test the theories rely exclusively on the drugstore data, we also present some additional tests involving hospital and HMO data. Secret rebates are more likely to have occurred with these purchasers, so we discuss potential bias in these auxiliary results in Section IV(ii).

Table II defines the variables used in the analysis. 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. *NUMGEN* counts the number of generic competitors; it is used in the construction of related dummy variables *ONEGEN* and *MULTGEN* but does not appear in the regressions itself.

Table III provides descriptive statistics for the variables used in the analysis. 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

TABLE II  
DEFINITION OF VARIABLES

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

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

TABLE III  
DESCRIPTIVE STATISTICS

	Obs.	Mean	Std. Dev.	Min.	Max.
<i>BRANDED</i>	160,621	0.27	0.45	0	1
<i>ONPAT</i>	160,621	0.10	0.30	0	1
<i>NUMGEN</i>	144,719	16.8	9.7	0	39
<i>ONEGEN</i>	144,719	0.06	0.24	0	1
<i>PREEXP</i>	160,621	2.7	9.3	0	56
<i>POSTEXP</i>	160,621	37.8	20.0	0	71
<i>TREND</i>	160,621	3.19	1.38	1	6
<i>PRICE</i> by channel					
HMO's ( <i>O</i> )	73,576	54	103	0.04	1,294
Hospitals ( <i>H</i> )	124,358	55	107	0.22	2,291
Drugstores ( <i>D</i> )	139,767	55	109	0.16	2,190
Chains ( <i>C</i> )	112,966	51	101	0.13	1,916
Independents ( <i>I</i> )	133,150	55	109	0.25	2,900
Foodstores ( <i>F</i> )	88,777	44	86	0.33	2,627
<i>REV</i> by channel (in millions)					
HMO's ( <i>O</i> )	73,576	0.001	0.04	0.0	1.9
Hospitals ( <i>H</i> )	124,358	0.07	0.38	0.0	10.2
Drugstores ( <i>D</i> )	139,767	0.14	1.13	0.0	63.9
Chains ( <i>C</i> )	112,966	0.09	0.71	0.0	38.9
Independents ( <i>I</i> )	133,150	0.05	0.38	0.0	17.4
Foodstores ( <i>F</i> )	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.

on the observation being off-patent. The hundreds of thousands of observations comes from having data for 56 months for 132 different antibiotics and 189 manufacturers, resulting in over 1,000 unique drug-manufacturer pairs. Observations are further multiplied because the average antibiotic in our data comes in 17 different presentations, and our analysis is conducted at this disaggregated, presentation level.

The descriptive statistics for prices by themselves do not reveal large price differences on average across channels. 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 control for product mix by taking price differences across common presentations as the dependent variable. Another feature of the data worth noting is the relatively small fraction of observations (10%) 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.

## V. METHODOLOGY

The dependent variable in all our regressions is a difference in log price. For example, in the regression comparing chain versus independent drugstores discussed in Section IV(i), the dependent variable is

$$(1) \quad \Delta_{i,j,m,t}^{CI} = \ln\left(PRICE_{i,j,m,t}^C\right) - \ln\left(PRICE_{i,j,m,t}^I\right),$$

where  $PRICE_{i,j,m,t}^C$  is the average wholesale price in month  $t$  paid by chain drugstores for drug  $i$  in presentation  $j$  produced by manufacturer  $m$  and  $PRICE_{i,j,m,t}^I$  is that price paid by independent drugstores. In additional regressions using hospital and HMO data discussed in Section IV(ii), we introduce analogous dependent variables,  $\Delta^{HD}$ ,  $\Delta^{OD}$ ,  $\Delta^{HO}$ , where  $D$  denotes all drugstores,  $H$  denotes hospitals, and  $O$  denotes HMO's. This differenced specification has several advantages, providing readily interpretable coefficients and accounting for drug, presentation, manufacturer and time fixed effects, as well as their interactions.

We regress the dependent variable on an exhaustive set of dummy variables which identify the four main circumstances under which a drug is purchased: the drug is branded and still on-patent (*ONPAT*), the drug is branded but has generic competitors (*OFFPAT*  $\times$  *BRANDED*), the drug is generic but there is only one generic manufacturer (*OFFPAT*  $\times$  *GENERIC*  $\times$  *ONEGEN*), and the drug is generic and there are multiple generic manufacturers (*OFFPAT*  $\times$  *GENERIC*  $\times$  *MULTGEN*). We will interpret these categories as identifying different supply regimes. Our richest specification adds controls for other covariates such as secular time trends and time before and after patent expiration.

As the index on the dependent variable in equation (1) indicates, observations are at the drug-presentation-manufacturer-month level. The disaggregated nature of the data requires us to account for possible dependence within certain groups of observations. In particular, it is unlikely that parties negotiate the price of every presentation separately, so it is natural to account for dependence within manufacturer-drug clusters. This is the clustering option used for the reported regressions. We have also tried other clustering options, including manufacturer clusters, to allow for the possibility of bundling arrangements across drugs. The results are robust to these choices. Note that these clustering options also allow for possible serial correlation and that the reported standard errors account for arbitrary heteroskedasticity.

The reported regressions weight observations by revenue (total across two channels). 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.

## VI. RESULTS

### VI (i). *Main Results on Buyer-Size Discounts*

The first column of Table IV presents results from our main regression. It examines the difference in prices paid by chain drugstores and independent drugstores in different supply regimes and, as such, provides a fairly clean test of the importance of size in those different supply regimes. Chain drugstores and independent drugstores should not differ in their substitution opportunities: they cannot be restrictive against on-patent brand-name drugs and can only be 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 chains will tend to be larger-volume buyers than independents. Recall that the dependent variable is the log of the difference between prices paid by chain and independent drugstores. Therefore, the interpretation of the 0.002 coefficient estimate on *ONPAT* 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.

TABLE IV  
WEIGHTED LEAST SQUARES REGRESSIONS OF THE DIFFERENCE IN LOG PRICE

	$\Delta^{CI}$	$\Delta^{HD}$	$\Delta^{OD}$	$\Delta^{HO}$	$\Delta^{HC}$
<i>ONPAT</i>	0.002 (0.001)	-0.077*** (0.017)	-0.079*** (0.018)	0.015 (0.016)	-0.071*** (0.015)
<i>OFFPAT</i> × <i>BRANDED</i>	-0.003** (0.002)	-0.328*** (0.059)	-0.205*** (0.055)	-0.043 (0.040)	-0.288*** (0.053)
<i>OFFPAT</i> × <i>GENERIC</i> × <i>ONEGEN</i>	-0.017* (0.010)	-0.151*** (0.057)	-0.121** (0.051)	-0.005 (0.018)	-0.124*** (0.044)
<i>OFFPAT</i> × <i>GENERIC</i> × <i>MULTGEN</i>	-0.003 (0.002)	-0.145*** (0.020)	-0.043** (0.017)	-0.054*** (0.015)	-0.117*** (0.017)
$R^2$	0.0003	0.0355	0.0209	0.0038	0.0351
Observations	107,164	107,287	71,463	69,644	93,181
Manufacturer-Drug Clusters	791	740	630	588	694

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. Standard errors are adjusted for non-independence within manufacturer-drug clusters. 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 \*10% level; \*\*5% level; \*\*\*1% level.

This result taken on its own suggests that the variants of theoretical models in which buyer-size discounts emerge with a monopoly supplier may not be relevant in our market. In the variant of symmetric-information bargaining models (see Horn and Wolinsky [1988b]; Stole and Zwiebel [1996]; Chipty and Snyder [1999]; Raskovich [2003]; Segal [2003]; Adilov and Alexander [2006]; Inderst and Wey [2007]; and Normann, Ruffle and Snyder [2007]), large-buyer discounts emerge with a monopoly supplier if the bargaining-surplus function is concave. Lott and Roberts [1991] and Levy [1999] suggest that large-buyer discounts may be a pass-through of cost savings from lower per-unit warehousing and distribution costs. Such cost savings would also be passed through by a monopoly supplier. We find that large buyers are not able to extract any discount at all in our market in the face of a monopoly supplier.

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 in the first column of Table IV 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 low  $R^2$  of 0.0003 in the first column reflects the fact that all of the coefficients are fairly close to 0. Any differences between them therefore must also be close to 0 and are swamped by unexplained variation in the dependent variable.<sup>18</sup> By comparison, the  $R^2$ s in the other regressions in

<sup>18</sup> Although small, the differences are statistically significant: the coefficient on *ONPAT* is significantly different from that on *OFFPAT* × *BRANDED* at the 5% level and from those on the other variables interacted with *OFFPAT* at the 10% level.

Table IV are at least an order of magnitude higher. The higher  $R^2$ s reflect larger coefficients that differ more across supply regimes in these regressions.<sup>19</sup>

#### VI (ii). *Additional Results on Restrictiveness*

Comparing the prices paid by drugstores with those paid by hospitals and HMO's will provide additional evidence on the importance of restrictiveness and the supply regime. Unlike the previous results, though, they cannot provide a direct test of the importance of the interaction of purchaser size and supply regime because we do not have information on the relative sizes of drugstores and hospitals or HMO's. The second column of Table IV presents the first of these results, how the supply regime affects the discount that hospitals receive relative to drugstores.

All four coefficient estimates in the second column of Table IV 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 8%, 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 33% 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 manufacturers 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 sensitive to changes over time. It seems unlikely, however, that this effect would be important enough to account for a 15% discount.

The third column of Table IV compares prices paid by HMO's and drugstores. HMO's have the same potential as hospitals to be restrictive. 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

<sup>19</sup> The relatively low value of all the  $R^2$  values in Table IV is an artifact of our specification involving price differences. If instead of differencing, we included the second log price as a regressor (along with the other explanatory variables), we would generate  $R^2$  of higher than 0.99 in all cases.

one at a hospital, so the smaller discount is consistent with the explanation in the above paragraph.

Recall that hospital and HMO transactions may have included secret rebates, which are not reflected in our price data. In this case, our prices for hospitals and HMO's would thus be overstatements of the true prices paid by hospitals and HMO's. This issue will lead to a bias in these additional results, understating the discounts that hospitals and HMO's can extract relative to drugstores. Recall, though, that the main results we rely on to test the theories derive from the drugstore data where secret rebates should not pose a problem. Furthermore, note that despite this bias, we find very large discounts for hospitals and HMO's relative to drugstores.

The fourth column of Table IV compares hospitals and HMO's. The one circumstance where hospitals receive a discount relative to HMO's 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 HMO's 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 last column indicates.

We have focused on restrictiveness as the explanation for the substantial hospital and HMO discounts relative to drugstores. An alternative explanation would be that hospitals and HMO's are much bigger than the average drugstore and are gaining substantial buyer-size discounts (for strategic or technological reasons). Our data do not allow us to compare the size of drugstores versus hospitals and HMO's, so we cannot test the alternative explanation directly. The results in the first column of Table IV provide some evidence against it. There is wide variation in the size of chain versus independent drugstores: the largest chain, CVS, currently operates over 6,200 stores, while independents operate three or fewer by definition. Despite this wide variation in size, buyer-size discounts are at best small. This puts a ceiling on how much size effects could be contributing to the hospital-drugstore or HMO-drugstore discount. The last column of Table IV provides more direct evidence. To help purge size effects we consider hospital prices relative to just chain drugstores'. While we do not have comprehensive data on the relative sizes, we noted that the largest chain drugstores operate thousands of stores, whereas the largest U.S. hospital chain, HCA, operates about 170 hospitals, and most hospital chains are much smaller than this. The last column, examining the difference between hospital and chain-drugstore prices, mirrors the results in the second column, suggesting that size effects probably are not contributing much to the hospital-drugstore or HMO-drugstore discounts.



TABLE V  
WEIGHTED LEAST SQUARES REGRESSIONS OF THE DIFFERENCE IN LOG PRICE WITH  
TREND VARIABLES

	$\Delta^{CI}$	$\Delta^{HD}$	$\Delta^{OD}$	$\Delta^{HO}$	$\Delta^{HC}$
<i>ONPAT</i>	-0.011 (0.008)	-0.218*** (0.053)	-0.228*** (0.034)	-0.003 (0.037)	-0.204*** (0.048)
<i>OFFPAT</i> × <i>BRANDED</i>	-0.011** (0.005)	-0.392*** (0.086)	-0.217*** (0.062)	-0.035 (0.076)	-0.356*** (0.086)
<i>OFFPAT</i> × <i>GENERIC</i> × <i>ONEGEN</i>	-0.023* (0.012)	-0.174** (0.060)	-0.224*** (0.055)	0.070** (0.028)	-0.119** (0.047)
<i>OFFPAT</i> × <i>GENERIC</i> × <i>MULTGEN</i>	-0.009 (0.007)	-0.167*** (0.032)	-0.147*** (0.025)	0.024 (0.023)	-0.110*** (0.029)
<i>TREND</i> ( × 10 <sup>-1</sup> )	0.043 (0.033)	0.210 (0.150)	0.513*** (0.103)	-0.152 (0.135)	0.111 (0.140)
<i>TREND</i> <sup>2</sup> ( × 10 <sup>-2</sup> )	-0.033 (0.044)	0.142 (0.168)	-0.379** (0.148)	0.258 (0.191)	0.279* (0.162)
<i>PREEXP</i> ( × 10 <sup>-1</sup> )	0.001 (0.001)	0.021*** (0.008)	0.011 (0.008)	0.013* (0.007)	0.023*** (0.007)
<i>POSTEXP</i> × <i>BRANDED</i> ( × 10 <sup>-1</sup> )	-0.001 (0.001)	-0.005 (0.013)	-0.001 (0.007)	0.002 (0.009)	0.000 (0.012)
<i>POSTEXP</i> × <i>GENERIC</i> ( × 10 <sup>-1</sup> )	-0.001 (0.001)	-0.015* (0.008)	-0.004 (0.005)	-0.014** (0.006)	-0.018*** (0.007)
<i>R</i> <sup>2</sup>	0.0005	0.0388	0.0262	0.0060	0.0391
Observations	107,164	107,287	71,463	69,644	93,181
Manufacturer-Drug Clusters	791	740	630	588	694

Notes: See Table IV.

### VI (iii). Adding Secular and Drug-Life-Cycle Trends

Our next set of results, Table V, 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. The variables *PREEXP* and *POSTEXP* control for drug-life-cycle effects by allowing for different trend lines before and after patent expiration. We interact *POSTEXP* with dummy variables for a drug being branded or generic to allow for different trend lines for those two types of manufacturers within a drug.

The coefficient estimates on the four main variables have a similar pattern after controlling for trends. Magnitudes of discounts increase in some cases—the estimated discount that hospitals receive relative to drugstores for on-patent drugs has increased to 21%—and the comparison of hospitals and HMO's yields somewhat different results. When we control for trends, HMO's 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 HMO's somewhat.

## VII. CONCLUSION

Our findings suggest that ability to substitute is a more significant source of countervailing power in the wholesale market for antibiotics than buyer size. The results lend support to the theories of countervailing power cited in the introduction that maintain that supplier competition is a necessary condition for large-buyer discounts. Support for these theoretical implications comes from 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). In another set of models cited in the introduction which involve bargaining under symmetric information, large-buyer discounts emerge even with a monopoly supplier under some conditions, namely when the bargaining-surplus function is concave. The absence of size discounts for on-patent antibiotics suggests that proposed conditions for buyer-size discounts to emerge with a monopoly supplier do not hold in our market. Furthermore, the absence of size discounts for on-patent antibiotics also provides evidence against a simple cost-based explanation for large-buyer discounts in this market (see Lott and Roberts [1991], Levy [1999]). If serving large buyers involves lower per-unit warehousing and distribution costs and these lower costs are passed through as a large-buyer discount, then such discounts should also be evident with a monopoly supplier.

Comparing our results to studies of other markets, they are broadly consistent, providing assurance of their robustness and suggesting the findings may have general applicability across industries. Our results are similar to those in Sorensen [2003] and closely mirror those in Competition Commission [2008] even though the three studies consider different markets—pharmaceuticals, hospital services, and groceries.

Our analysis of the discounts obtained by hospitals and HMO's relative to drugstores further points out the importance of substitution opportunities. Hospitals and HMO's have better substitution opportunities across the board compared to drugstores and obtain substantial price discounts relative to them. The discount is largest where the hospitals and HMO's 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.

The consistent finding that size discounts are at best small in the absence of seller competition across the variety of markets studied by Sorensen [2003], Competition Commission [2008] and our paper may have broad implications for when consolidation of buyer power through purchasing coalitions might be successful in any market. Such coalitions may be ineffectual in the absence of meaningful seller competition.

Our results have antitrust implications as well. Galbraith's [1952] 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 could foster, might be required for size discounts to emerge, and even then the discounts may not be substantial.

Our results also contribute to an understanding of the Brand Name Prescription Drug Litigation, an important antitrust case from the mid 1990's involving a class of drugstores that sued pharmaceutical manufacturers over discounts offered to HMO's. The plaintiffs alleged that the discriminatory discounts violated the Robinson-Patman Act. Some of the parties settled for \$350 million and a promise from the manufacturers to give the same discounts to any retailer with "an ability to affect market share", e.g., through their own formulary and physician-contact activities" (Scherer [1997], pp. 249–250). Echoing Scherer's [1997] views, our results suggest that the promise does not rule out discounts but merely describes the market forces leading manufacturers to extend discounts to various parties.

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