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Pharma rebates, pharmacy benefit managers and employer outcomes

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Abstract Corporate employers contract with pharmacy benefit managers (PBMs) with the goals of lowering their employee prescription drug coverage costs while maintaining health care quality. However, little is known about how employer-PBM contract elements and brand drugmakers' rebates combine to influence a profit-maximizing PBM's actions, and the impact of those actions on the employer's outcomes. To shed more light on these issues, the authors build and analyze a mathematical simulation model of a competitive pharmaceutical market comprised of one generic and two branded drugs, and involving a PBM contracted by a corporate employer to help it lower prescription drug costs while achieving a minimum desired quality of health care for its employees. The brand drugmakers' rebate offers, the PBM's assignment of drugs to formulary tiers, and the resulting employer outcomes under varying contracts and pharma brand marketing mix environmental scenarios are analyzed to provide insights. The findings include that the pharma brands offer rebates for the PBM's ability to move prescription share away from the unpreferred brand, but reduce these offers when the PBM's contract requires it to proactively influence physicians to prescribe the generic drug alternative. Further, Pareto optimal contracts that provide the highest health benefit for a given employer cost budget for the employer are analyzed to provide managerial implications. They are found to involve strong PBM influence on physician prescribing to discourage unpreferred brands, as well as high patient copayment requirements for unpreferred brands to align the patient prescription fill probability with the formulary, while other copayment requirements provide an instrument to determine the level of desired health benefit—cost tradeoff.

Keywords Pharmacy benefit manager · Rebates · Employer cost · Competition · Prescription drug marketing · Health benefit · Pareto optimal · Contract

1 Introduction

Pharmacy benefit managers (PBMs) play an important role in the United States (U.S.) pharmaceutical industry. According to Atlantic Information Services, Inc. (AIS) they manage the prescription drug benefits for 57% of the population [1], and process a large majority of the prescriptions written in the U.S.[1]

Corporate employers contract with PBMs with the goals of lowering their employee prescription drug coverage costs while maintaining health care quality. PBMs control the large prescription volume they impact via tiered drug formularies that specify preferred and unpreferred drugs with different patient copayment levels, and by influencing physicians to prescribe in compliance with these formular-

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[1] PBMs processed 3.9B Rxs annually for the 2009 Q1 [2], compared with a total of 3.8B Rxs for 2008 according to IMS Health [3].

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ies. Drug utilization review and medication therapy management activities, prior authorization requirements for off-formulary drugs, and clinical consultants calling on physicians and providing information about treatment protocols are some examples of PBMs' efforts to influence physicians to prescribe cheaper drugs [4, 5]. PBMs leverage this ability and power to affect demand to negotiate favorable prices—via price rebates—from drugmakers seeking inclusion and/or preferred status for their products in the PBM's formulary. According to Tenaglia and Angelastro [6], for many pharma companies, the dollars they have rebated back to managed care organizations, PBMs and national insurers represent a cash outflow that is now greater than all their direct-selling expenses combined, and may be as much as 20% of gross sales.

In recent years, the growth of highly profitable PBMs even as health care costs continue to rise has been of concern to employers as well as consumer coalition groups and legislators, e.g., the Consumer Federation of America, the U.S. Public Interest Research Group (PIRG),the National Legislative Association on Prescription Drug Prices, etc. This has led to a variety of moves at the state or federal level to pass laws requiring greater transparency with respect to PBMs' revenue sources, especially the rebates they receive from drugmakers. However, past Congressional Budget Office analyses of such legislative proposals have indicated that greater transparency could result in drugmakers offering smaller discounts to PBMs, which could ultimately lead to higher drug costs for insurers and consumers [7]. More research and understanding of how interactions between drugmakers, PBMs and employers impact patient and employer outcomes is clearly needed to inform policymakers, health care managers, and scholars concerned about PBM transparency and prescription drug costs.

This paper's goal is to shed light on how employer-PBM contract elements and pharmaceutical company rebates combine to influence a profit-maximizing PBM's actions, and the impact of those actions on the employer's outcomes. As it is almost impossible for independent analysts to obtain information on actual costs and rebates from PBMs and drugmakers due to their sensitivity, we employ a simulation analysis research approach. More specifically, we build a comprehensive mathematical simulation model of a competitive pharmaceutical market involving a PBM contracted by a corporate employer to help it lower prescription drug costs while achieving a minimum desired quality of health care for its employees. The drugmakers' actions with respect to rebate offers, the PBM's assignments of drugs to formulary tiers, and the resulting employer outcomes under varying contract structures and competitive pharmaceutical marketing mix environmental scenarios are analyzed to provide insights.

To our knowledge, this is the first paper in the health care management science literature that investigates a PBM's incentives and actions in a model-based simulation study. The insights we obtain regarding profit-maximizing PBM behavior as well as the nature *of pareto optimal contracts* should be useful for employers in their contract negotiations with PBMs. Further, our model-based simulation tool can serve as a platform for examining the effects of specific contract element modifications of interest to policymakers and analysts.

The rest of the paper is organized as follows: Section 2 develops the simulation model while Section 3 describes the simulation experimental design employed in this study. Section 4 describes and explains how the competitive sequential game between the two brands and the PBM is solved. Key insights from the simulation analysis results relating contract elements to employer cost and health benefits are presented in Section 5. We conclude with a summary of our insights into pharma brand rebating and PBM behaviors, implications for employers contracting with PBMs, and future research directions. The fixed model parameter values used in the simulation study and their sources in extant empirical research are listed in the Appendix.

2 The model

To accomplish our research objective, we construct a simulation model of the employer cost and health benefit resulting from PBM management under specific contracts and competitive pharma marketing mix environmental scenarios (hereafter simply called *Scenarios*). As explained below, in this model the pharmaceutical brands make strategic rebate offer decisions by considering the incremental profit potential that they can realize - taking into account the other brand's rebate offer and profit-maximizing PBM's response in terms of formulary tier assignment, which is subject to its contract with the employer and prevailing *Scenario*. The impact of all actors' decisions on employer outcomes under the specific contract and Scenario is reported. We begin our model development with a description of the simulated market structure.

2.1 The market structure

We consider a market where the prescription drug benefits of all patients are managed by one PBM using a *three-tier formulary* and focus on one therapeutic drug market

comprised of three alternative medications that can treat the same problem (e.g., high cholesterol): two branded drugs (still under patent) *with differing molecular structures* (e.g., two newer statins), and a generic version of an older molecule that has gone off-patent (e.g., an older statin). The drugs differ in terms of their *quality* (efficacy-safety profiles), *prices* and *pull marketing* efforts aimed at physicians (*detailing*) and patients (direct-to-consumer ads, i.e., *DTC advertising*).

In the model, the subscript i=1,2,3 is used for drugs, denoting Brand 1, Brand 2, and the Generic drug respectively, while j=1,2,3 is used for the PBM's formulary tiers, where Tier 1 is for the Generic drug, Tier 2 for *preferred* drug brand/s, and Tier 3 for *unpreferred* drug brand/s.

2.2 The rebate competition

In the specified market setting, we analyze the brands' competition for formulary position as a three-stage sequential game with perfect information, where Brand 2 is viewed as the leader and Brand 1 as the follower. The sequence of actions is as follows:

1. Brand 2 makes its rebate (i.e., volume discount) offer to the PBM
2. Brand 1 then makes a competitive rebate offer to the PBM taking into account Brand 2's rebate offer.
3. Given the rebate offers, the PBM assigns the brands to formulary tiers.

Under any given employer-PBM contract structure and pharma brand marketing Scenario, the pharma companies and the PBM choose their respective actions to maximize own profits, with full knowledge of the decisions of other actors who moved before them, and accounting for the best responses of the actors who follow. In game theory terminology, this is a three-stage non-cooperative sequential game with perfect information, and the resulting decisions are called equilibrium decisions [8].

All actors are assumed to use the same model of pharmaceutical product sales and resulting profits. Due to the complexity of the model we determine the equilibrium decisions numerically, and calculate the corresponding outcomes for the PBM and employer. We obtain and examine these results under varying combinations of the exogenous employer-PBM contract elements and Scenarios in a large numerical experiment which is described in Section 3.

2.3 The model of pharmaceutical product sales

The number of patients who are (ultimately) treated with Drug i, n_i, is modeled as:

$$n_i = N\, p_{vis} p_i\, pfill_i, \text{ for i} = 1, 2, 3 \tag{1}$$

where:

N	the total number of patients suffering from a condition (health problem)
p_{vis}	probability of a sufferer making a visit (presenting the condition) to a physician
p_i	probability of a physician prescribing Drug i to a presenting patient
$pfill_i$	the probability of a patient with a prescription for *Drug i* actually filling the prescription

The detailed specifications of these three components of demand are as follows: *The probability of a sufferer visiting a physician* (p_{vis}) increases with his/her awareness that depends on DTC advertising efforts in the category [9]. Thus

$$p_{vis} = P0_{vis} + \gamma_{visDTC} Aware(DTC_1 + DTC_2) \tag{2}$$

Here, $P0_{vis}$ denotes the probability of a patient presenting the condition independent of DTC advertising efforts, and $\gamma_{visDTC}>0$ is the coefficient for category awareness due to DTC effort. DTC_i is the advertising effort by drug i. Further, we assume that awareness increases with DTC advertising at a decreasing rate, i.e.,

$$Aware\ (DTC) = \alpha quad_{DTC} DTC^2 + \alpha lin_{DTC} DTC; \quad \alpha quad_{DTC} < 0 \text{ and } \alpha lin_{DTC} > 0. \tag{3}$$

Pharmaceutical demand functions A number of recent studies have found that detailing affects drug prescription choice response behavior in a positive and significant manner, with decreasing returns as detailing is increased [10–12]. Following recommendations in the literature, we posit that the probability of a presenting patient receiving a prescription for *Drug i* from the physician, p_i, is given by the ratio of *Drug i*'s *attraction* to the sum of the attractions of the three alternatives. The attraction of *Drug i* is a linear function of its intrinsic quality, Q_i, pharmaceutical company detailing effort on its behalf, Det_i, *moderated by* $PBMInf_i$, *the PBM influence multiplier* with respect to *Drug i*. That is, $PBMInf_i$ shrinks or boosts Drug i's attraction.

Thus, for Drug i=1, 2, 3:

$$p_i = \left(\beta_q Q_i + \beta_{\text{det}} Det_i\right) PBMInf_i \Big/ \left[\left(\beta_q Q_1 + \beta_{\text{det}} Det_1\right) PBMInf_1 + \left(\beta_q Q_2 + \beta_{\text{det}} Det_2\right) PBMInf_2 + \left(\beta_q Q_3\right) PBMInf_3\right] \tag{4}$$

Here β_q, and β_{det}, are nonnegative coefficients for drug quality and detailing, respectively. Next, the *prescription fill probability* ($pfill_i$) is modeled as follows:

$$pfill_i = P0_{fill} - \gamma_{fillcost} OOP_i + \gamma_{fillDTC} Aware(DTC_i), \quad \text{for i} = 1,2,3. \tag{5}$$

Thus, the prescription fill probability decreases with the patient's related out-of-pocket (OOP) expenditure for Drug i, OOP_i, and increases with the awareness level due to DTC advertising by Drug i [13]. The constant ($P0_{fill}$) captures the baseline probability to fill prescriptions, based on the perceived severity of the disease and/or inertia. The sensitivities of prescription fill probability to OOP spending, and to awareness of DTC by Drug i, are represented by $\gamma_{fillcost} > 0$ and $\gamma_{fillDTC} > 0$, respectively.

For the sake of analytical simplicity, we assume, without loss of generality, that every patient who visits a physician receives medication therapy. We also assume that the consumers are homogeneous in their sensitivity to OOP and response to DTC advertising, while physicians are homogeneous in their response to the intrinsic quality of drugs, detailing, and PBM influence.

2.4 The brands' objective function and decisions

The objective of the pharmaceutical companies is to maximize their net profits from the PBM segment given by the gross profit less the *rebate dollar amount* ($Rebate_i$) paid to the PBM. Thus, denoting gross profit margin by GP,

$$BrandProfit_i = n_i Price_i GP - Rebate_i \quad \text{for i} = 1,2. \tag{6}$$

Pharmaceutical manufacturers typically tie rebates to the demonstrated increase in their market share [5], and while they announce their rebate offer (expressed as the discount fraction off the price, denoted *DiscOffer*) to the PBM at the beginning of the period, the actual rebate amount paid out is realized only at the end of the period. To reflect this practice, we model the rebate percentage as proportional to the achieved market share, which is multiplied by the nominal cost of goods sold to provide the dollar rebate amount paid out by brand i as follows.

$$Rebate_i = n_i \, Price_i DiscOffer_i [n_i/(n_1 + n_2 + n_3)] \quad \text{for i} = 1,2 \tag{7}$$

The maximum discount rate offer to the PBM, $DiscOffer_i$, applies if Brand i achieves 100% share of the PBM prescription drug sales. In this simulation, each brand chooses its $DiscOffer_i$ from a set of discrete values. This assumption facilitates the analysis and is also consistent with practice.

2.5 PBM's objective function and decision problem

The PBM's profit Π_{PBM} is derived from three components: 1) the retained portion, *after pass-through to the employer*, of the rebate dollar amount received from the pharma brand manufacturers; 2) the transaction fees received from the employer; and 3) the 'spread' the PBM is able to negotiate from the pharmacies [14]. Thus,

$$\Pi_{PBM} = \Sigma_i \{Rebate_i(1 - Pass) + (Spread_i + C_t)n_i\} \tag{8}$$

where:

C_t	is the transaction fee per filled prescription that the PBM charges to the payer
$Spread_i$	are other volume-based discounts that the PBM is able to obtain from the supply chain, including the pharmacies
Pass	is the proportion of rebate dollars passed through to the employer by the PBM.

(Note that the generic drug does not offer discounts to the PBM. Rather, it relies on its low price and pharmacy discounts that are passed on to the PBM in the form of higher spreads than those for brands.)

The PBM operating the 3-tier formulary specified by the contract decides the brands' tier assignments. With the generic drug always assigned to Tier 1, the PBM chooses one of four possible combinations for brand-to-tier assignments: either *both brands assigned to Tier 2*; *both brands assigned to Tier 3*; *assignment of first brand to Tier 2 and the second to Tier 3, or vice versa*. The PBM decisions are thus represented by T_{ij}, for i=1,2; j=2,3

$$\begin{aligned} T_{ij} &= 1 \text{ if Drug } i \text{ is assigned to Tier j,} \\ &= 0 \text{ otherwise.} \end{aligned} \tag{9}$$

Table 1 summarizes the decision makers and their decision variables in each stage of the game that was outlined in section 2.2.

2.6 The elements of the PBM—employer contract

In our model, the PBM and the employer agree on a contract containing (A) *plan design* and (B) *PBM incentive-related* elements. We do not model the mechanics of how the PBM and the employer would agree on a contract, but

Table 1 Decision makers and variables at each stage of the rebate competition game

Stage	Decision maker	Decision variable(s)
1	Brand 2	$DiscOffer_2$
2	Brand 1	$DiscOffer_1$
3	PBM	$\{T_{ij}\}$

demonstrate the consequences of any given contract structure for the employer. Our contribution is to help the employer to determine which contract elements it should try to move, and in which direction, before negotiating with the PBM.

A. Plan design elements

These elements have two components in our model:

a) *The PBM influence* on the physician prescription choice decision for a drug in Tier j, $TierInf_j$. As already noted, PBM influence moderates the attraction of the drug(s) that are assigned to Tier j in Eq. (4), and enters the equation as a multiplier, $PBMInf_i$, for Drug i, specified as follows:

$$PBMInf_i = \sum_j TierInf_j\, T_{ij} \quad \text{for i} = 1,\ 2,\ 3 \tag{10}$$

More specifically, we take the PBM influence with respect to a drug assigned to Tier 2 as 'neutral' (represented in our numerical experiment by $TierInf_2$=1). Then, the level of PBM's encouragement of physicians to prescribe the Tier 1 generic drug is expressed by $TierInf_1$ ($TierInf_1 \geq 1$), while the level of the PBM's dissuasion of physicians from prescribing unpreferred Tier 3 brand/s is expressed by $TierInf_3$, ($0 < TierInf_3 \leq 1$).

b) *The required patient co-payment for drugs in formulary Tier j, $Copay_j$*. Given a drug's formulary tier assignment, the patient's out-of-pocket costs for Drug *i* is determined as follows:

$$OOP_i = \sum_j T_{ij}\, Copay_j, \ \text{for}\, i = 1,\ 2,\ 3. \tag{11}$$

B. PBM incentive elements

The PBM incentive elements of the contract are as follows:

a) the proportion of the rebate dollars that are to be passed through to the employer, denoted *Pass*;
b) the fee per transaction paid by the employer to the PBM, C_t.

2.7 The employer outcomes

The employer would like to minimize the pharmacy benefit cost, comprised of the cost of the prescribed drugs and the transaction fees paid to the PBM, less the portion of the pharmaceutical companies' rebates passed through by the PBM and the patient co-payment amounts. That is,

$$Employer\ Cost = \Sigma_i\, n_i(Price_i + C_t - OOP_i) - (Pass\ Rebate_i) \tag{12}$$

The employer is also concerned with the patient outcomes, namely, the total health benefit from the pharmaceutical drugs it pays for, and the average out-of-pocket expense. Low health benefits have the potential of causing larger medical costs for the employer in the long run, while high OOP can cause employee dissatisfaction. We specify the Health Benefit to the patient body as proportional to the number of sufferers who receive medication therapy and the quality of the drugs they use, i.e.,

$$Health\ Benefit = \Sigma_i\, n_i\, Q_i/N \tag{13}$$

3 The numerical experiment design

To understand the impact of the contract elements on the employer outcomes as given by (12), and (13), we conduct a full factorial designed experiment varying the contract elements with four pharma marketing mix environmental Scenarios as blocks, resulting in 3,456 ($=2^3 3^3 4^2$) runs.

The pharma marketing mix blocks (Scenarios) and their levels are listed in Table 2.

Specifically, we use four Scenarios differing in drug quality, price and pull marketing efforts, as depicted in Table 2. The pull marketing efforts are indicated as fractions of maximum possible efforts. In the first two scenarios the brands are symmetric, i.e., have equal quality, price, and pull marketing levels. The pull marketing levels are high in the first Scenario, called 'Symmetric Brands High Pull', and low in the second one, called 'Symmetric Brands Low Pull'. In the third Scenario which is called 'Asymmetric Brands', the second brand has higher quality, price and pull marketing levels. In the first three Scenarios, the generic drug, an older technology product, has 75% of the efficacy and safety levels of the highest quality of two branded drugs. The last 'Strong Generic' scenario, however, depicts a situation where the newer brands do not offer an advantage over the older generic drug. Lastly, guided by the typical range of prescription drug prices in the anti-cholesterol category, the price per prescription is set at $100 for the brands when they are equal in quality and, in the asymmetric brand scenario, the price of the lower quality brand prescription is set at $80. The generic drug price is set at $50 in all Scenarios, based on typically observed intra-molecular generic to branded drug price ratios [15].

The contract elements varied in the simulation experiment and their levels are displayed in Table 3. The $Copay_j$ amounts in Table 3 are based on the most common co-payment amounts reported by benefit design surveys (Verispan, 2004) and encompass a range of commonly

Table 2 Pharma Marketing Mix Environmental Scenarios used in the experimental design

	Symmetric brands high pull	Symmetric brands low pull	Asymmetric brands	Strong generic
Q_i	{1, 1, 0.75}	{1, 1, 0.75}	{0.75, 1, 0.75}	{1, 1, 1}
$Price_i$	{100, 100, 50}	{100, 100, 50}	{80, 100, 50}	{100, 100, 50}
DTC_i	{0.5, 0.5, 0}	{0, 0, 0}	{0, 0.5, 0}	{0, 0, 0}
Det_i	{1, 1, 0}	{0.25, 0.25, 0}	{0.5, 1, 0}	{1, 1, 0}

used three-tier options. The *PBM influence* on physician prescribing spans the range of no influence to doubling or halving the attraction of the drug. As regards the PBM transaction fee, based on reports by Eber et al. [4] and Kopenski [14], we allow it to vary over levels in the range of \$0–\$5. Also, the rebate pass-through rate varies from 25% to 100%—at which point the PBM does not retain any rebates.

Lastly, the values of all other fixed model parameters in the simulation are summarized in Table 4, and the rationale for the values and sources are provided in the Appendix.

4 Solving the three-stage sequential game

In each run of the experiment, under each contract and Scenario combination, we numerically determine the equilibrium rebate discount offers by the two brands and the PBM's formulary tier assignments in the game described in Section 2.2.

To solve the game, first we determine the best tier assignment response of the PBM to any possible combination of rebate (discount) offers from the brands as follows:

$$\left\{T_{ij}^{*}\right\}(DiscOffer_1, DiscOffer_2) \tag{14}$$
$$= \underset{T_{ij}\in\{0,1\}}{argmax}\, \Pi_{PBM}\left(\{T_{ij}\}, DiscOffer_1, DiscOffer_2\right),$$
$$\text{for } i = 1,2; j = 2,3$$

Next, we determine Brand 1's (the follower's) best discount offer in response to the discount offer by Brand 2 (the leader), and taking into account the PBM's optimal assignment decision (14). Brand 1's optimal action is then given by:

$$DiscOffer_1^{*}(DiscOffer_2) \tag{15}$$
$$= \underset{0\le x\le 1}{argmax}\, BrandProfit_1\left(x, \left\{T_{ij}^{*}\right\}(x, DiscOffer_2)\right)$$
$$i = 1,2; j = 2,3$$

Lastly, we determine the discount offer of Brand 2 (the leader) that will maximize its profits taking into account the best response actions of Brand 1 and the PBM. This is expressed as:

$$DiscOffer_2^{*} \tag{16}$$
$$= \underset{0\le x\le 1}{argmax}\, BrandProfit_2\left(x, \left\{T_{ij}^{*}\right\}\left(DiscOffer_1^{*}(x), x\right)\right)$$
$$i = 1,2; j = 2,3$$

In our numerical simulation, the possible values that brand discount offers can take are specified at discrete levels as follows: $DiscOffer_i \in \{0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0\}$.

Illustration For each specified contract and Scenario, the following steps are executed to derive the actors' equilibrium actions in the three-stage sequential game:

1. $BrandProfit_1$, $BrandProfit_2$, and Π_{PBM} are calculated for all possible combinations of $DiscOffer_1$, $Discoffer_2$, and the four tier assignment possibilities under the given Scenario and contract parameter values ($11\times11\times4$ combinations).

Table 3 Contract elements varied in the experimental design and their levels

Contract plan design elements	Copayment requirements	$Copay_1$	\$5, \$10
		$Copay_2$	\$10, \$20
		$Copay_3$	\$20, \$40
	PBM influence on physician	$TierInf_1$	Low =1, Med=1.25, High=2
		$TierInf_3$	Low =1, Med=0.8, High=0.5
Contract PBM incentive elements	Transaction fee	C_t	0, \$0.5, \$5
	Rebate pass-through rate	Pass	0.25, 0.5, 0.75, 1

Table 4 Fixed model parameter values in the simulation

Parameter	Value
$\alpha quad_{DTC}$	−0.7
αlin_{DTC}	1.24
$P0_{vis}$	0.5
γ_{visDTC}	0.153
$\gamma_{fillDTC}$	0.05
$\gamma_{fillcost}$	−0.006
β_q	100
β_{det}	75
GP	80%
$Spread_1$	$3
$Spread_2$	$4
$Spread_3$	$11

2. For each $DiscOffer_1$ and $Discoffer_2$ combination the tier assignment that maximizes the Π_{PBM}, i.e. $\left\{T_{ij}^*\right\}$ $(DiscOffer_1, DiscOffer_2)$ is found.
3. For each $Discoffer_2$, the $DiscOffer_1$ that maximizes the $BrandProfit_1$, i.e., $DiscOffer_1^*(DiscOffer_2)$ is determined, taking into account that the PBM will act according to the optimal tier assignment rule.
4. Finally the $DiscOffer_2$ that provides the maximum $BrandProfit_2$ among the remaining combinations is determined as $DiscOffer_2^*$.

Table 5 illustrates part of the solution by backward induction of the three-stage game solution process in the case of a contract with Copayment requirements {5, 10, 20}; 'medium' settings for $TierInf_1$, $TierInf_3$, C_t, and $Pass$=50%, under the High Pull Symmetric Brands Scenario. In this illustration, Brand 2's discount offer is set at 0.1. Then, for each possible pair of the brands' discount offers shown in a row of Table 5, the PBM evaluates its profits from each of its four possible options for tier assignments (shown in columns 3–6 in Table 5) and chooses its profit –maximizing option (shown in column 7). Brand 1 knows and accounts for this profit-maximizing behavior by the PBM, and, considering that Brand 2's offers $DiscOffer2$=0.1, chooses 0.2 as its own profit-maximizing discount offer.

Moving backwards to the first stage of the 3-stage noncooperative game, Table 6 illustrates how the leader (Brand 2) decides its discount offer. Specifically, Brand 2 conjectures the PBM's and Brand 1's best response to a discount offer by Brand 2 from its feasible set {0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0} Based on these conjectures, Brand 2 as the leader chooses its own profit-maximizing discount offer. It turns out that the equilibrium decisions under this illustrative contract and Scenario then are $DiscOffer2^*$=0.1, $DiscOffer_1^* = 0$, and PBM exclusively assigns Brand 2 to the preferred brand tier.

5 Analysis of the experiment results

We analyzed the experiment results, specifically the brand rebates, the PBM's formulary tier assignments, the *Employer Cost* and the health benefit outcomes, under different combinations of the contract elements and the environmental Scenarios, using ANOVA with main effects and two-way interactions. (All the results can be made available upon request.) Here, due to space constraints, we report only those effects that are statistically significant as well as large in

Table 5 Illustration of PBM's and Follower Brand's Decisions in Sequential Game

Brand rebate offers		Normalized PBM profit with preferred status given to				PBM's profit maximizing choice for preferred status	Normalized $BrandProfit_1$
$Disc\ offer_1$	$Disc\ offer_2$	Brand 2	Neither brand	Both brands	Brand 1		
0	0.1	0.67	0.66	0.65	0.63	Brand 2	1.20
0.1	0.1	0.71	0.70	0.71	0.71	Brand 2	1.15
0.2	0.1	0.75	0.75	0.77	0.78	Brand 1	1.48
0.3	0.1	0.79	0.80	0.84	0.86	Brand 1	1.40
0.4	0.1	0.83	0.85	0.90	0.93	Brand 1	1.31
0.5	0.1	0.87	0.90	0.96	1.01	Brand 1	1.22
0.6	0.1	0.92	0.95	1.02	1.08	Brand 1	1.13
0.7	0.1	0.96	1.00	1.09	1.16	Brand 1	1.05
0.8	0.1	1.00	1.05	1.15	1.23	Brand 1	0.96
0.9	0.1	1.04	1.10	1.21	1.31	Brand 1	0.87
1	0.1	1.08	1.15	1.28	1.38	Brand 1	0.78

Table 6 Determination of the Leader Brand's decision in the illustrative example

$DiscOffer_2$	$BrandProfit1$ maximizing $DiscOffer_1$	PBM Profit maximizing tier decision	Normalized $BrandProfit_2$
0	0	None	0.95
0.1	0	Brand 2	**1.23**
0.2	0	Brand 2	1.12
0.3	0	Brand 2	1.00
0.4	0	Brand 2	0.88
0.5	0	Brand 2	0.76
0.6	0	Brand 2	0.64
0.7	0	Brand 2	0.52
0.8	0	Brand 2	0.41
0.9	0.6	Both	0.30
1	0.7	Both	0.20

magnitude. In the following tables and charts all output variables are reported as normalized to average 1 over the complete experiment of 3,456 runs.

5.1 Brand rebate and PBM tier assignment decisions

Insight 1 When Pass= 1, i.e., the PBM is required to passthrough 100% of any rebate dollars it receives, the brands never offer rebates. This is because, under this constraint, the PBM acts simply to maximize its transaction fees and spread incentives by maximizing the volume of transactions, particularly the volume of the generic drug due to its higher spread (supply chain discounts). What is more interesting, however, is the next insight.

Insight 2 The PBM can assign preferred status to one or both brands even when Pass= 1 and the brands offer no discounts. This is indicated in Table 7 which shows the distributions of the PBM's optimal tier assignments without any rebate incentive for All runs (second column), and under particular $Copay_3$-$Copay_2$, $TierInf_3$ and $TierInf_1$ levels (third, fourth and fifth blocks of columns). Note that in nearly 38% of All runs in column 2 of Table 7, the profit-maximizing PBM assigns preferred status to both brands. This occurs when the PBM applies (or has) no influence to dissuade physicians from prescribing brands if they were placed in the unpreferred tier. On the other hand, as indicated in the tier influence blocks of Table 7, the proportions of runs in which PBM assigns unpreferred status to both brands increases as its influence on physicians' prescribing increases (higher $TierInf_3$ or $TierInf_1$). Also, we see in Table 7 that the proportion of runs in which the PBM assigns both brands to preferred status increases as the *Copay3-Copay2* difference increases. This is because if brands are kept unpreferred then the higher associated copayments will reduce patients' prescription taking, thereby lowering the PBM's transaction revenues. Consequently, the PBM gains more by assigning the brands to preferred status that will increase patient prescription fill rates due to the lower associated copayments.

Insight 3 If the PBM retains some portion of the rebate dollars it receives from the brand drugmakers i.e., Pass< 1, then the brands' rebate dollars increase *as the PBM's influence against unpreferred brands' prescribing* ($TierInf_3$) increases; and decrease *as the PBM influence in favor of generic drug prescribing* ($TierInf_1$) increases. The supporting results are shown in Table 8 and imply that the brands pay for the PBM's ability to move prescription share between brands, but reduce rebates when the PBM at the same time influences physicians to prescribe more of the generic drug. Table 8 does not show all the combinations of $TierInf_3$ and $TierInf_1$ levels as the combinations do not show significant interaction effects.

Insight 4 When brands are symmetric in quality and pull marketing efforts, the PBM is more likely to assign both brands to the preferred drug tier (when Pass< 1). Thus symmetric brands end up paying rebates for access to the employer's pool of patients but do not gain an advantage relative to each other. When brands are asymmetric, the

Table 7 PBM's assignment of brands to preferred tier when *Pass= 1* as copayment differentials and tier influence levels are varied

Without rebate incentive		$Copay_3$-$Copay_2$				$TierInf_3$			$TierInf_1$		
Preferred	All	0	10	20	30	Lo	Med	Hi	Lo	Med	Hi
Brand 2	0.5%	0.0%	0.0%	0.9%	0.9%	0.0%	0.7%	0.7%	1.0%	0.3%	0.0%
None	61.7%	100%	61%	50%	36%	25%	62%	98%	57%	61%	67%
Both	37.8%	0%	39%	49%	63%	75%	38%	1%	42%	39%	33%
Brand 1	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
# runs	864	216	216	216	216	288	288	288	288	288	288

Table 8 Average normalized rebate amount by tier influence copayment differentials

With rebate incentive	$TierInf_3$			$TierInf_1$			$Copay_3$-$Copay_2$			
	Lo	Med	Hi	Lo	Med	Hi	0	10	20	30
Avg normalized rebate amount	–	0.82	3.18	1.48	1.43	1.09	0.90	1.23	0.99	0.89
# runs	864	864	864	864	864	864	648	648	648	648

PBM is more likely to assign only the brand superior in quality to the preferred tier. These results are shown in Table 9.

5.2 Employer outcomes and Pareto optimal contracts

As Table 10 indicates, we find in our numerical experiments that the *Employer Cost* and *Health Benefit*s are highly positively correlated, while the Average OOP is negatively correlated with both. Rebates, on the other hand, exhibit a small negative correlation with the *Employer Cost*.

Further, based on our ANOVA analyses of the experiment results, Scenario and $Copay_2$ are the largest contributors to the *Health Benefit*, *Employer Cost*, and the Average OOP paid by patients. Higher copayment requirement reduces the fill rate of prescriptions and, consequently, the *Health Benefit* and *Employer Cost* that follow. Higher copayment requirements also increase the share of the cost that the patients pay, thereby further reducing the *Employer Cost.* This is shown in Table 11: Higher $Copay_2$ is associated with lower *Employer Cost* and *Health Benefit*, but higher OOP for the patients. (The ANOVA analyses can be provided upon request.)

Next, the average patient and employer outcomes by Scenario are shown in Table 12, along with the average rebate amounts. Comparing the two symmetric brand scenarios which only differ with respect to the level of pull marketing (detailing and DTC), we see that greater pull marketing increases the *Employer Cost* and the *Health Benefit*s in three ways: by increasing the percent of patients who present their condition to the physician, by increasing the physician's demand for the newer generation branded drugs, and by increasing the fill rate for those drugs. On the other hand, the Strong Generic scenario provides the lowest *Employer Cost*, and second-highest *Health Benefit*s.

Figure 1 shows the *Health Benefit* versus *Employer Cost* resulting from all contract combinations under the four Scenarios. The large effects of the competitive Scenario on these two employer outcomes, as well as the positive correlation between them are evident from the plot.

5.2.1 Pareto optimal contracts

The desirable contracts for the employer are those that maximize *Health Benefit*s for a given *Employer Cost* budget. Consistent with the multi-criteria optimization literature [16], we define a *Pareto Optimal Contract* for a Scenario from the employer's point of view as a contract that provides the highest *Health Benefit* among contracts with same or higher *Employer Cost* within the Scenario. Figure 2 displays the *Efficient Frontier* of Pareto optimal contracts under each Scenario.

The contract at the top right corner of the Efficient Frontier for each Scenario in Fig. 2 provides the *maximum Health Benefit for the Scenario,* and there is no contract that can provide this level of *Health Benefit* for a lower *Employer Cost.* Similarly, at the bottom-left corner of the Efficient Frontier, the contract for each Scenario represents the *minimum Employer Cost for the Scenario,* and there is no contract that provides higher *Health Benefit* for that budget. There are 83 contract—Scenario combinations that represent Pareto optimal contracts for the Scenario out of the 3,456 total.

In Fig. 2 we observe that the Strong Generic scenario can provide ten to twenty percent higher *Health Benefit*s than the Low Pull Symmetric Brands scenario for any budget level, because the generic drug is of high quality. On

Table 9 PBM's assignment of Brands to Preferred tier when Pass<1, as pharma marketing Scenario is varied

Preferred	High pull symmetric brands	Low pull symmetric brands	Asymmetric brands	Strong generic
Brand 2	8%	5%	18%	5%
None	10%	11%	11%	11%
Both	75%	80%	67%	81%
Brand 1	8%	4%	4%	2%
Average normalized rebate	1.6	1.3	1.3	1.2

Table 10 The Pearson correlation coefficients between employer outcomes, N=3,456

Correlations	Rebates	Employer cost	Avg OOP
Health benefit	0.17	0.78	−0.43
Rebates		−0.10	−0.13
Employer cost			−0.61

the other hand, the high *Health Benefit* in the Symmetric Brands-High Pull marketing scenario cannot be achieved under the other Scenarios (Notice that this scenario has the same product quality and pricing as Low Pull- Symmetric Brands scenario, yet it yields a much higher *Health Benefit* for the patient population.) This increase is achieved by higher patient pull marketing contributing to increased patient presentation of the problem to the physician and high prescription fill rates. Similarly, high physician pull marketing increase the physician demand for the high quality products, again increasing the *Health Benefit*s.

Insight 5 The employer outcomes are highly dependent on the marketing mix of the pharmaceutical brands and their quality relative to the older generation generics. While the employer cannot control the environmental conditions (Scenario), it is important to recognize that the relative quality and price of the drugs, as well as their pull marketing levels are large drivers of employer outcomes. Hence, comparative analyses of contract outcomes should account for these environmental conditions. Further, the appropriate contract may depend on these conditions.

5.2.2 Common elements of Pareto optimal contracts

Now we look closer at the Pareto optimal contracts that we identified in the previous section. In Table 13 we list the *Employer Cost minimizing* and *Health Benefit maximizing* contracts that constitute the two ends of the efficient frontier as well as the *generic share maximizing* and *rebate maximizing* (as a percent of Employer Cost) contracts, since they are commonly expressed employer strategies in managing pharmacy benefits. We observe that the Pareto optimal contracts that maximize/ minimize these objectives do exist in all scenarios, and that they are ordered as follows in the Employer Cost increasing, Health Benefit decreasing order under all scenarios: *1) Employer Cost minimizing, 2) generic share maximizing, 3) rebate maximizing, 4) Health Benefit maximizing.* There are typically multiple contracts that maximize an objective, e.g. rebate maximization but only one of them is also Pareto optimal.

Table 11 The average normalized *Employer Cost* , *Health Benefit*, and Patient OOP by Tier 2 copayment requirement (N=3,456)

	$Copay_2$=10	$Copay_2$=20	All
Average of employer cost	1.07	0.93	1.00
Average of health benefit	1.03	0.97	1.00
Average of Avg OOP	0.77	1.23	1.00

The Employer Cost minimizing contracts are the same under each scenario. Maximum encouragement of generic prescribing (high $TierInf_1$), and maximum discouragement of unpreferred brand prescribing (high $TierInf_3$) increase the generic's share of physician prescriptions, while high copayment requirements ($Copay_1$=10, $Copay_3$=40) ensure that a) fewer prescriptions are filled, and b) the patient pays for a higher portion of the filled prescriptions costs. The incentive compensation components are designed to focus the PBM on the lower-priced generic by making the "no preferred brand" assignment attractive for the PBM. Full pass-through of rebates prevents the PBM from making the brands preferred in exchange for rebates. There is no transaction fee which reduces the PBM's volume maximization incentive, which could result in highly prescribed brands to be put into Tier 2 even without rebates.

The generic share maximizing Pareto optimal contracts are similar to the *Employer Cost* minimizing contracts, but they differ by requiring a low copayment for the generic drug ($Copay_1$). Therefore, the fill rate of the generic prescriptions is higher and consequently the Health Benefit and Employer Cost are higher.

The rebate maximizing Pareto optimal contracts, consistent with the previous section, have maximum discouragement of unpreferred brand prescribing, and no encouragement of generic prescribing which maximize the PBM's ability to move brand share. There are no transaction fees to divert PBM's attention to volume maximization. An optimal rebate pass-through rate focuses the PBM on the rebate elicitation task.

The Health Benefit maximizing Pareto optimal contracts differ by scenario but have the following common elements: 1) encouragement to physicians to prescribe the generic drug at maximum when the generic is of high quality, and at minimum when it is of lower quality; 2) maximum discouragement of unpreferred brand prescribing so that physicians do not write prescriptions that will face a low fill rate; 3) low copayment requirements to ensure higher fill rates; 4) high rebate pass-through rate that still provides incentive for the PBM to obtain rebates; 5) transaction fees only used when the brands offer higher quality than the generic but do not have enough demand to become preferred without transaction fees, as in the Low Pull Symmetric Brands scenario.

Table 12 The average normalized Employer Cost, *Health Benefit* and OOP by Scenario

	High pull symmetric brands	Low pull symmetric brands	Asymmetric brands	Strong generic	Grand total
Average of employer cost	1.15	0.93	1.01	0.91	1.00
Average of *Health Benefit*	1.11	0.91	0.98	1.00	1.00
Average of Avg OOP	1.03	0.99	1.02	0.97	1.00

Notice that the generic share or rebate maximizing contracts are not the same as Employer Cost minimizing contracts.

To guide employer contracting with PBMs, we summarize some common characteristics of Pareto optimal contracts that we observe across all scenarios and runs in our numerical experiment.

a) All Pareto optimal contracts observed require the PBM to exert influence to dissuade physicians from prescribing unpreferred brands in the formulary.
b) Most Pareto optimal contracts involve high patient copayment requirement for unpreferred brand(s). This feature induces the pharma brands to offer higher rebates (to obtain preferred status), while reducing patient fill rates for unpreferred brands, thereby decreasing the employer's overall cost.
c) Very few Pareto optimal contracts use transaction fees.
d) Low *Employer Cost* -focused Pareto optimal contracts typically are those that allow no rebate incentive for the PBM (i.e., Pass=1); while high *Health Benefit*-focused contracts allow the PBM to retain a proportion of the rebate dollars and motivate it to act more favorably towards the higher quality brands.
e) Contracts with higher copayment requirements for the generic and preferred brand tend to lower the *Employer Cost* but also the *Health Benefit*.

6 Conclusions

This paper models a very important player in US pharmaceutical markets, namely, the Pharmacy Benefit Manager, for the first time in the health care management literature. It provides insights into how a profit maximizing PBM's behavior can be directed, using the contract conditions, in the presence of rebates from competing pharma brands. The proposed modeling framework permits valuable simulation analyses of the effect of a policy on the outcomes of a very complex system comprised of actors who zealously guard against the release any of their actual data for analysis by outside researchers. While this framework employs simple representations of employer, PBM, and pharmaceutical company objective functions that account for physician and patient behaviors, it is capable of capturing very complex interactions among these actors in the system.

The analysis of the model generated insights into brand rebate and PBM tier assignment behaviors.

- First, the brands do not offer rebates unless some portion of these rebate dollars are kept by the PBM and contribute to its own profits.
- Second, the brands pay for the PBM's ability to move prescription share between brands but reduce rebates

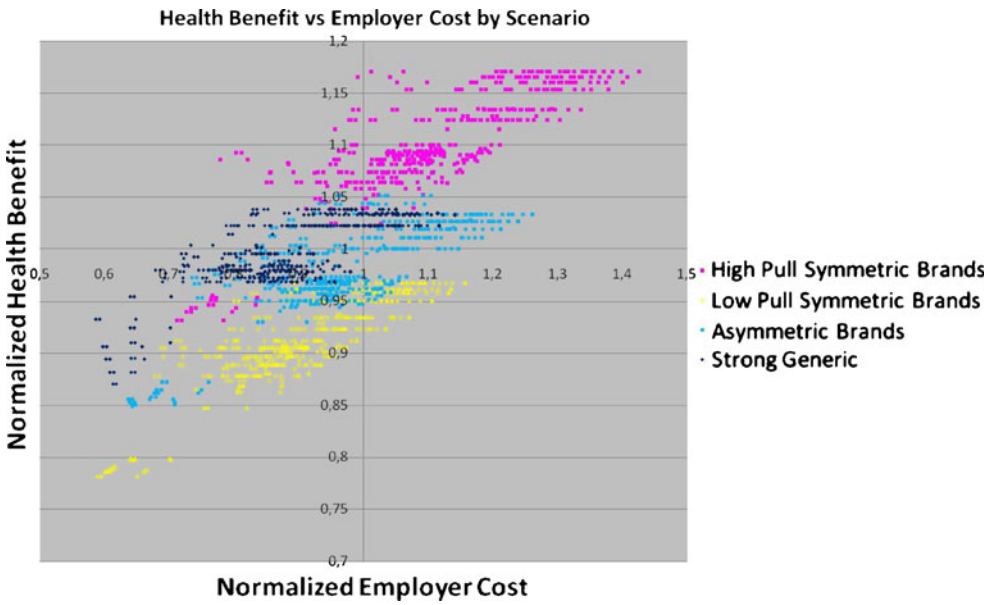

Fig. 1 Normalized *Health Benefit* versus *Employer Cost* of all contracts by Scenario

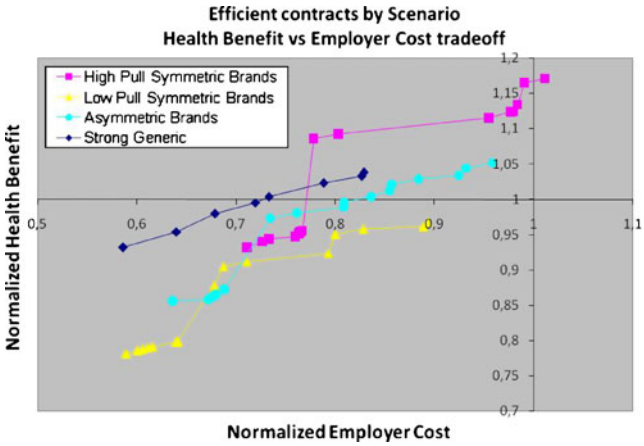

Fig. 2 The efficient frontier consisting of Pareto optimal contracts by Scenario

when the PBM's policy is aimed at channeling physcians' prescriptions towards the competing generic drug.

- However, even when rebates from the pharma brands do not contribute to its profits, the PBM can assign a brand to preferred status provided (a) there is enough demand for this brand as a result of its quality and pull marketing efforts; and (b) the PBM's influence against physician prescribing of unpreferred brands is weak.
- Also, symmetric brands in rebate competition end up paying for access to the employer's pool of patients without gaining an advantage relative to each other.

The analysis of the employer outcomes has pointed out that the environmental conditions play a large role in determining the Employer Cost and the Health Benefit, and that higher Health Benefits tend to come with higher Employer Cost. Examining the Pareto optimal contracts that provide the highest *Health Benefit* for a given *Employer Cost* budget for the employer, the following managerial implications were identified for the employer contracting with a PBM:

- Ensure maximum discouragement of physician prescribing of unpreferred brands, and keep the patient copayment requirement for the unpreferred brands high. Based on the severity of the health condition treated with the drugs in this therapeutic area, determine the desired position on the efficient frontier of the Employer Cost—Health Benefit tradeoff.
  - For life-style categories eliminate the rebate incentive for the PBM, and maximally encourage physicians to prescribe the generic drug, and keep the copayment requirements high.
  - For categories providing significant *Health Benefit*s, provide a share of the rebates to the PBM that will be enough to give incentive to pursue rebates over transaction volume and spread income, and keep the copayment requirements for the preferred brand and generic low. Lastly, encourage physicians to prescribe generics if they have high efficacy and low side effects, but not otherwise.

Another managerial implication is that the performance measures of employer and patient outcomes should account for the relative quality and pull marketing of the drugs in the therapeutic market as they can have a very large impact on the employer outcomes.

Our analysis has several limitations that suggest interesting directions for future research. First, we have had to rely on simulation analyses using several plausible fixed values of parameters of our model due to the lack of availability of actual financial data on PBM contracts, revenues, and pharma company rebate offers. It would obviously be beneficial to reestimate and reexamine our results using actual data from these organizations as and when that becomes available. Second, while rebate decisions and data are difficult to obtain

Table 13 Pareto optimal contracts that represent the four common employer strategies

		Plan design			PBM incentive	
Strategy	Scenario specific	TierInf1	TierInf3	Copays	Pass	Trans_Fee
Employer Cost minimizing	All	High	High	10, *,40	100%	0
Generic share maximizing	All	High	High	5, 20, 40	100%	0
Rebate maximizing (% of Employer Cost)	High pull symmetric	Medium	High	10, 20, 40	75%	0
	Low pull symmetric	Low	High	10, 20, 40	75%	0
	Asymmetric brands	Low	High	10, 20, 40	75%	0
	Strong generic	Low	High	5,10,20	75%	0
Health Benefit maximizing	High pull symmetric	Low	High	5,10,40	75%	0
	Low pull symmetric	Low	High	5,10,20	75%	5
	Asymmetric brands	Low	High	5,10,20	75%	0
	Strong generic	High	High	5,10,20	75%	0

by external analysts such as ourselves, our implicit assumption in our model is that actors within the system, e.g., the pharma companies' salespeople who negotiate with the buyers and managers of PBMs, do pick up knowledge of their rivals' offers to the PBM as well as the latter's contractual obligations to employers from their day-to-day contacts. Allowing for partial information or uncertainty among the players is not within the scope of this study but would be a worthwhile direction for future research. Third, we have assumed a PBM operating a three-tier formulary, and a three-drug market in this research. However, other types of formularies and more competitive market structures exist. Therefore, an interesting future research area is comparison of different formulary structures or number of drugs in the market in terms of the impact on brand and PBM behaviors and employer outcomes. Lastly we have kept employer-PBM contract elements and pharma brand marketing mix scenarios as exogenous factors in our three-stage sequential game. Future research may make these choice variables, e.g., allow optimization of pharma companies' marketing mix including the rebates and the pull marketing elements.

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Appendix—Fixed model parameter values

We consider the PBM to be located in a geographic area equal to that of the average U.S. state containing 1/50th of the US population displaying the average prevalence for high cholesterol levels [17], i.e. N=6 million.

For setting patient response parameters, we rely on two secondary data sources: the surveys conducted and published by the *Prevention Magazine* for six consecutive years [18] and the research by Goldman et al. [19] estimating copayment impact on prescription drug utilization. We fit a quadratic regression to the total DTC spend and DTC awareness figures over years 1997–2001, provided by *Prevention Magazine* surveys, and accordingly set $\alpha quad_{DTC}$=−0.7 and αlin_{DTC}=1.24. Survey results on high cholesterol sufferers who talked about their condition to their physician for the first time because of the ads they have seen, and their awareness of the corresponding ads are used to set $P0_{vis}$=0.5 and γ_{visDTC}=0.153. DTC sensitivity of patient probability to fill the prescription is estimated based on the net proportion of patients indicating that seeing a DTC ad makes it more likely that they will fill a prescription for a medicine that they are currently taking, hence $\gamma_{fillDTC}$=0.05.

We approximate the constant elasticity relationship between drug utilization and OOP spending in the lipid lowering market estimated by Goldman et al. [19] with a piecewise linear function in the OOP range of $5–$40, and use the trend to set $\gamma_{fillcost}$=−0.006.

The coefficient for quality in the physician choice model, β_q, is set at 100. The detailing effect coefficient, is set by assuming that the top quality brand with 1/3 of the maximum detailing would have the same chance of being prescribed as a brand with maximum detailing and half the quality, β_{det}=75.

Based on 2005 average gross profit (GP) margins of branded and generic manufacturer pharmaceutical companies, the brands are assumed to have a GP margin of 80% [20]. Lastly, we use $3 for the spread from brands, and $11 from the generic drug, based on the reports that spread, may run up to 10–16% for brands and 40–65% for the generics [14].

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