

# Controversial Role of GPOs in Healthcare-Product Supply Chains

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This paper examines the controversial role that Group Purchasing Organizations (GPOs) play in the supply chains for healthcare products. Among the controversies, perhaps the most fundamental one is whether or not GPOs reduce purchasing costs for their members. However, the fiercest controversy is around the “contract administration fees (CAFs)” that GPOs charge to manufacturers. We examine these and other controversies using a Hotelling duopoly model. Among our conclusions: GPOs increase competition between manufacturers and lower prices for healthcare providers. However, GPOs reduce manufacturers’ incentives to introduce innovations to existing products. We also demonstrate that the existence of lower off-contract prices is not, per se, evidence of anticompetitive behavior on the part of GPOs. Indeed, we demonstrate that, under certain circumstances, the presence of a GPO lowers off-contract prices. We also examine the consequences of eliminating the “safe harbor” provisions that permit healthcare GPOs to charge CAFs to manufacturers, and conclude that it would not affect any party’s profits or costs.

*Key words:* healthcare product supply chain; GPOs; CAFs; on-contract; off-contract

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## 1. Introduction

GPOs play a very significant—and very controversial—role in the supply chains for healthcare products. A 2005 study conducted for the Health Industry Group Purchasing Association (HIGPA) reported that 72–80% of every healthcare dollar (in an acute-care setting) is acquired through group purchasing. More recently, Burns and Lee (2008) reported that nearly 85% route 50% or more of their commodity-item spending through GPOs, and 80% route 50% or more of their pharmaceutical spending through GPOs.

Moreover, GPO purchasing power is highly concentrated: According to a 2003 GAO (Government Accountability Office) study (GPO Report: GAO-03-998T), the seven largest GPOs account for over 85% of hospital purchases made through GPO contracts, and the two largest GPOs account for approximately two-thirds of total GPO purchasing volume for all medical products. In 2007, *Modern Healthcare* reported that the largest GPO, Novation, contracted for over 2,400 hospitals and 30,000 alternative sites, with 2006 purchasing volume of over \$33 billion.

What makes the role of GPOs controversial, however, is neither the significance of the role they play in healthcare-product supply chains nor the concentration of their purchasing power, per se. Instead, the controversies involve the fees GPOs charge to manufacturers, some of the business practices they employ, and, ultimately, whether GPOs promote or stifle competition in the markets for healthcare products.

In this paper, we briefly describe the role of GPOs in healthcare-product supply chains and summarize some of the criticisms about them. Then, we examine these criticisms using the Hotelling model. Our analysis concludes that healthcare GPOs promote competition in some ways but stifle competition in others.

We believe that our model is the first to include contract administration fees (CAFs), and the first to address questions relevant to healthcare-product supply chains. Like all other models of GPOs, ours is highly stylized. Nonetheless, the insights our model provides must be interpreted in view of the gaps between the simplicity of our model and the complexity of the real world of GPOs. We provide some interpretations in section 9.

Group purchasing organizations (GPOs) negotiate the prices that their “provider-members” pay for products they purchase “on contract.” The rationale for healthcare providers belonging to a GPO is that they will incur lower total costs by purchasing “on contract” through a GPO than they might obtain for themselves. GPOs position themselves to offer lower total purchasing costs through a combination of product expertise over a wide range of products (e.g., quality and technology assessment) and the combined buying power of their members.

GPOs display a wide range of ownership structures and operating modes. The two largest, Premier and Novation, operate as membership alliances, and, as such, return a high percentage of the revenues col-

lected in excess of costs to their members. Hence, in our analysis we represent GPOs as not-for-profit organizations that which want to maximize their owners/members' surplus. Subsequently, we discuss the implications if the GPO wants to maximize its own profit.

GPOs earn revenue from several sources: CAFs charged to manufacturers, membership fees charged to provider-members, administrative fees charged to distributors authorized to distribute products to provider-members on-contract, and miscellaneous fees for services. The most common, most significant, and most controversial source of GPO revenue is the CAF, which is nominally set at 3% of each manufacturer's contracted sales.

Although revenue-sharing contracts or payments are commonly used elsewhere (e.g., real estate, mutual funds), such revenue-sharing in healthcare had been specifically outlawed under the "anti-kickback" statute of the Social Security Act. However, in 1987, partly to facilitate the growth of GPOs, the Social Security Act was amended to create "safe-harbor provisions" that protect healthcare GPOs from prosecution under the anti-kickback statute. In brief, these provisions require GPOs to limit CAFs to an average of 3% or, in the case of exceptions, to inform members in detail about them.

Many of the criticisms about healthcare GPOs are linked to CAFs. For example, manufacturers complain that they are forced to charge higher prices for all products—whether they are sold on- or off-contract—in order to recover the CAFs they pay to GPOs for on-contract sales. Others assert that the elimination of the "safe-harbor" provisions would yield large cost savings to providers and/or payers. Here are two excerpts.

The elimination of the safe harbor would be revenue neutral under the most conservative assumptions; and would generate large savings for the federal government under more realistic assumptions. Singer (2006)

According to Sethi (2006),

Based on our analysis of the total revenue generated by the GPOs, their operating margins, and a careful assessment of their expenses, it is estimated that GPOs generate excess annual revenue in the range of \$5 billion to \$6 billion, which legitimately belongs to their member hospitals since they are the ones who actually paid for it.

Another criticism about GPOs revolves around whether or not GPOs' on-contract prices are, in fact, the lowest prices available. A pilot study on GPO

(GPO report: GAO-02-690T) prices conducted for the US Senate Subcommittee on Antitrust, Competition, and Business and Consumer Rights concluded that a hospital's use of a GPO contract did not guarantee that the hospital saved money: GPOs' prices were not always lower but often higher than prices paid by hospitals negotiating with vendors directly.

Yet another is about product innovation and quality; i.e., that the contract relationship between GPOs and manufacturers blocks or slows the innovation or improvement of existing products.

The GPO industry takes these criticisms seriously, and has responded with a series of commissioned reports and white papers, arguing that GPOs reduce prices and are procompetitive. Recently, Burns and Lee (2008) conducted an independent survey of GPO members and concluded that GPOs do help contain rising healthcare costs by reducing product prices in two ways: (1) through pooled purchasing leverage of hospitals buying products on nationwide contracts and (2) through the establishment of price ceilings beneath which hospitals negotiate on their own.

To date, the "cases" either for and against GPOs have been based either on surveys or macro-economic scenario analysis. Using these as background, in what follows we develop and analyze several stylized economic models involving GPOs, manufacturers, and providers to address the controversial roles of the GPO. Our analysis leads to the following insights:

- The existence of a GPO increases competition between the manufacturers and lowers costs for healthcare providers except in the case of a monopolist manufacturer.
- Asymmetry in providers' preference for similar products does not affect the results summarized above.
- However, by intensifying price competition, GPOs lower the manufacturers' incentive to introduce innovation to their existing products.
- If the manufacturers can choose to sell on-contract or off-contract, then two equilibria may arise: both sell on-contract, or one manufacturer sells on-contract and the other sells off-contract. In the latter case, the off-contract price might be lower than the on-contract price. Hence, our analysis indicates that the availability of lower off-contract prices is not, in and of itself, evidence of anticompetitive GPO practices.
- Eliminating CAFs and having providers pay for GPOs' contracting services instead of manufacturers would have no effect on any party's profit or cost.

These results are the same whether the GPO operates for profit or not for profit. In particular, the prices

that members pay using a for-profit GPO are the same as if using a not-for-profit GPO. However, for-profit GPOs reduce manufacturers' profits. Our analysis also indicates that for-profit GPOs have an incentive, not shared with not-for-profit, to reduce their own contracting costs.

The remainder of this paper is organized as follows: section 2 introduces related literature, section 3 presents the basic model, section 4 studies whether the presence of the GPO lowers the prices, section 5 endogenizes the manufacturers' decision on whether to sell off-contract or on-contract, section 6 explores whether the presence of GPO promotes or hinders product innovation, section 7 examines whether removing the "safe harbor" provisions improves any party's profits or costs, and section 8 examines extensions. Finally, section 9 discusses the gaps between the simplicity of our model and the complexity of the real world of GPOs and suggests future research.

## 2. Literature

To date, the published literature on healthcare-product GPOs has been descriptive (Burns 2002; Schneller & Smeltzer 2006), focused on the advantages and disadvantages of GPOs (Nollet and Beaulieu 2005; Schneller 2005), and provider surveys regarding GPOs (Burns and Lee 2008). The economics literature includes several models of GPOs, but not necessarily healthcare GPOs.

There is a vast body of operations/supply-chain management literature on contracting—see Cachon (2003), for example—but very little involves GPOs or other contracting intermediaries. Wang et al. (2004) discuss channel performance when a manufacturer sells its goods through a retailer using consignment contracts with revenue sharing.

Assuming a monopoly manufacturer who offers a linear quantity discount, Chen and Roma (2008) identify conditions under which the competing retailers will form a GPO. In contrast, in our model healthcare providers do not compete on quantity and their requirements are inelastic to price. Our paper captures these characteristics of healthcare providers.

Another stream of research concerns the allocation of alliance benefits back to its members, the fairness of allocation, and the stability of the alliance. In particular, Schotanus et al. (2008) and Nafarajan et al. (2008) study how GPOs can allocate cost savings. The latter further discusses the stability of the GPO under different allocation rules.

One strand of economics literature examines the effects of competition among manufacturers when buyers form a GPO to commit to purchasing exclusively from one of the manufacturers. O'Brien and

Shaffer (1997) show that buyers can obtain lower prices through both nonlinear pricing and sole sourcing, which intensify competition between the rival suppliers. Dana (2003) extends O'Brien and Shaffer (1997) by endogenizing the decisions of buyers to form groups. He shows that if the GPO commits to purchasing exclusively from one supplier, then the buyers obtain a lower price that is equal to the suppliers' marginal costs. Marvel and Yang (2008) study a similar problem, assuming that: (1) the GPO's interests are aligned with the buyers and thus seeks to minimize the buyers' total purchasing costs; and, that (2) the sellers have the bargaining power, offering take-or-leave it nonlinear pricing tariffs to the GPO. Different from Dana (2003), their GPO cannot identify individual providers' utility value. They demonstrate that the competition-intensifying effect of the nonlinear tariff, not the GPO's bargaining power, lowers the GPO's purchasing price since the sellers have the bargaining power in their model. However, none of these models include CAFs, and none of them address questions specific to healthcare-products.

Like Marvel and Yang (2008), we employ the Hotelling model. However, in recognition of the purchasing power of healthcare GPOs, we model the GPO as the Stackelberg leader. Like Marvel and Yang (2008), we show that the GPO intensifies the competition between the rival manufacturers, and, therefore, lowers prices. In addition, our model captures the transaction efficiency enabled by GPOs: an important rationale for the existence of GPOs in U.S. healthcare-product supply chain. As Marvel and Yang (2008), we prove that asymmetry in preferences do not affect the price advantage of the GPO. However, because the bargaining power is in the GPO instead of in the manufacturers, the manufacturers' profits in our models are smaller than those in Marvel and Yang (2008); and as a result, the providers' costs in our model are smaller than those in Marvel and Yang (2008).

We draw the opposite conclusion of Marvel and Yang (2008) on the effect of the GPOs on innovation: the presence of the GPO stifles the manufacturers' incentives to innovate. This contrasting result is caused by the different power structure that we assume. In Marvel and Yang (2008), the manufacturers employ nonlinear pricing to negotiate with the GPO and act as the Stackelberg leader and therefore can set higher prices for an innovative product. In contrast, in our model, the GPO acts as the Stackelberg leader and will charge a higher CAF, thus the manufacturers cannot benefit from innovation although they can sell at a higher price. O'Brien and Shaffer (1997) and Dana (2003) also model the GPO as the leader.

### 3. The Model

We employ the Hotelling model of horizontal differentiation. Two manufacturers offer competing but not identical products. A continuum of healthcare providers are distributed uniformly with density 1 along the interval  $[0, 1]$ , with manufacturer 1 located at 0 and manufacturer 2 located at 1. All providers are assumed to be willing to pay  $v > 0$  for a single unit of the product if that product exactly matches the provider's requirement. This willingness to pay is reduced by  $t > 0$  per unit distance for a product whose characteristics do not match. It is worth noting that the qualitative results would not change as long as the providers purchase the equal amount of products. We assume the distribution of the providers is common knowledge, but the manufacturers cannot identify any individual provider's preference. This information constraint prevents manufacturers from engaging in price discrimination when selling directly to the providers.

#### 3.1. Contracting Costs

Our model is designed to represent four types of contracting costs: (1) product-search cost (i.e., what alternatives are available?), (2) product-assessment cost (i.e., which is best?), (3) contract-negotiation cost (i.e., what price for what quantity?), and (4) transaction-processing (i.e., buying and selling) cost. Correspondingly, if a provider purchases directly from (i.e., contracts directly with) a manufacturer, then it incurs all four types of cost per contract. The manufacturer contracting directly with each provider incurs contract-negotiation and transaction-processing costs. Under a GPO contract, the GPO incurs the product-search, product assessment, and contract-negotiation costs for its members. GPOs reduce contracting costs because the negotiation process is performed by only one organization, instead of many (Rozemeijer 2000). Consider a manufacturer such as Johnson & Johnson. By negotiating with Novation, Johnson & Johnson avoids negotiating with Novation's thousands of individual members, and Novation's product-search and product assessment costs are spread over Novation's members. No numbers are available on the manufacturer's savings. However, Schneller (2005) estimates that provider's average cost avoidance is \$1,367 per contract. To put this saving into context, note that the average acute hospital purchases thousands of different items from hundreds of different manufacturers.

The manufacturer and the provider experience contracting costs whether or not they contract through a GPO. However, for the reasons given above, we assume that these contracting costs are less for both when contracting through a GPO than when contracting directly with one another. For simplicity of notation, we normalize these contracting costs to zero.

If the manufacturers and providers contract directly, let the providers have common contracting cost,  $c_p$  per contract and  $c_m$  be the manufacturers' common contracting cost per contract. Let  $c_d = c_m + c_p$ . If the contracting costs of the manufacturers and providers when using a GPO were not normalized to zero, then  $c_d$  would be increased by the incremental costs to both from contracting directly. We represent the contracting cost incurred by the GPO as  $c_g$  per contract; and, because of the economies of scale described above, assume that  $c_g < c_d$ . Define  $\Delta = c_d - c_g > 0$ . Hence, if products are sold through a GPO, then the total contracting cost is  $c_d - \Delta$  per contract, where  $0 < \Delta < c_d$ , and it is borne by the GPO.

Let  $p_i$  be manufacturer  $i$ 's price. The manufacturers' unit production costs are normalized to zero. The qualitative results of our analysis would not change although the formulae would be more complicated if any normalized cost were explicitly modeled.

It is worth mentioning that our model assumes that each provider orders one unit of product. So the total per unit cost is  $p_i + c_g$  if a provider buys from manufacturer  $i$  through a GPO; otherwise, its total per unit cost is  $p_i + c_d$  if it buys directly from manufacturer  $i$ .

#### 3.2. Market Share

A provider located at  $x$  on the interval receives a utility of  $v - tx - p_1 - c_p$  if purchasing directly from manufacturer 1, and a utility of  $v - (1 - x)t - p_2 - c_p$  if purchasing directly from manufacturer 2. Given  $p_1$  and  $p_2$ , in the absence of a GPO, each manufacturer's demand  $D_i$  ( $i = 1, 2$ ) can be obtained by solving

$$v - tx - p_1 - c_p = v - (1 - x)t - p_2 - c_p.$$

Hence,

$$\begin{aligned} D_1 &= x = \frac{1}{2} + \frac{p_2 - p_1}{2t}, \\ D_2 &= 1 - x = \frac{1}{2} + \frac{p_1 - p_2}{2t}. \end{aligned} \quad (1)$$

Note that the manufacturers' market shares do not depend on contracting cost but only on the preference characteristic parameter  $t$  and the prices. This market-share distribution remains the same when the goods are sold through the GPO.

Suppose that providers in the market have the option to form a single GPO. The GPO incurs unit contracting cost  $c_g = c_d - \Delta$ , described above. As a Stackelberg leader, the GPO offers a take-or-leave-it contract to each manufacturer, stipulating a CAF: for each unit of product that is sold at price  $p_i$ , manufacturer  $i$  receives  $\lambda_i p_i$  and the GPO receives  $(1 - \lambda_i) p_i$  where  $0 < \lambda_i < 1$ . If the manufacturers decline the offer, the game is over, and they receive zero profit. If the manufacturers accept the offer, they engage in a price-

ing game, each getting a share of the market and sales revenue.

If the providers do not form a GPO and purchase directly from the manufacturers, then the contracting costs  $c_m$  and  $c_p$  are borne by the manufacturers and the providers, respectively. The manufacturers engage in pricing game and receive 100% of the revenues from their respective share of market. If the GPO is formed, then the nominal profit of the GPO is  $\Pi_{GPO} = \sum_{i=1}^2 [(1 - \lambda_i)p_i - c_g D_i]$  where  $(1 - \lambda_i)$  is the CAF charged to the manufacturer by the GPO,  $p_i$  is the contracted price,  $c_g$  is the GPO's contracting cost, and  $D_i$  is manufacturer  $i$ 's market share.

## 4. Will the GPO be Formed?

### 4.1. Symmetric Preference

We first assume that two identical manufacturers compete for business from the providers, each located at the two end points of the interval  $[0, 1]$  of the Hotelling model. At the first stage, the providers decide whether or not to form a GPO. If a GPO is formed, anticipating the duopoly pricing game between the manufacturers, it specifies  $\lambda_i$ , the CAF, charged to each manufacturer so that its contracting costs are recovered. Later we discuss the implications if the GPO is for-profit. At the second stage, the manufacturers compete on pricing and each obtains a market share. We solve the game backward by examining the pricing subgame between the manufacturers first, assuming the GPO is formed or is absent, respectively.

If the providers do not form a GPO at the first stage, they contract directly with the manufacturers. Manufacturer  $i$  chooses  $p_{id}$  to maximize its profit,  $\pi_{id}$ :

$$\pi_{id} = (p_{id} - c_m)D_i = (p_{id} - c_m) \left( \frac{1}{2} + \frac{p_{jd} - p_{id}}{2t} \right) \quad (2)$$

$(i, j = 1, 2; i \neq j).$

Let  $p_{id}^*$  be the equilibrium prices without the GPO and  $\pi_{id}^*$  be the manufacturer's profit at equilibrium. The first-order condition (FOC) of (2) with respect to  $p_{id}$  yields

$$t + (p_{jd} - p_{id}) - (p_{id} - c_m) = 0.$$

Therefore, at equilibrium,  $p_{1d}^* = p_{2d}^* = p_d^* = t + c_m$ ,  $D_1 = D_2 = 1/2$ , and each manufacturer earns  $\pi_{1d}^* = \pi_{2d}^* = \pi_d^* = t/2$ . In order to ensure full market coverage, the provider located at the center of the unit interval must have a nonnegative utility at the equilibrium. That is,  $v - p_d^* - c_p - t/2 \geq 0$ , which is equivalent to  $v \geq 3t/2 + c_d$ .

Let  $s_d^*$  be the providers' total costs without the GPO; then

$$\begin{aligned} s_d^* &= \int_0^x (p_d^* + c_p + t\varepsilon)d\varepsilon + \int_0^{1-x} (p_d^* + c_p + t\varepsilon)d\varepsilon \\ &= 5t/4 + c_d. \end{aligned}$$

The first component represents the utility loss of buying a less-desirable product; the second term is the total channel contracting costs. Thus, the channel contracting costs are all borne by the providers in the absence of the GPO. The total channel surplus is

$$v - s_d^* + 2\pi_d^* = v - t/4 - c_d.$$

The following lemma summarizes the results.

LEMMA 1. *In the absence of the GPO, at the pricing subgame equilibrium,*

- (a) *Each manufacturer sells to 1/2 of the market at price  $t + c_m$  and earns  $t/2$ .*
- (b) *The providers' total costs are  $5t/4 + c_d$ .*
- (c) *The total channel surplus is  $v - t/4 - c_d$ .*

Note that the selling price is increasing in  $c_m$ , a well-known result that unit production costs soften Bertrand–Nash competition under linear pricing.

Now we assume that at the first stage the providers form a GPO and contract through the GPO, who provides contracting service to the providers and the manufacturers, but requires a CAF payment from each manufacturer. Then, the manufacturers decide whether to accept the offer and, if so, then engage in pricing competition for a market share. Let superscript  $g$  represent that products are sold through the GPO. Let  $\lambda_i$  be manufacturer  $i$ 's CAF,  $\pi_{ig}$  be manufacturer  $i$ 's profit from selling its product through the GPO, and  $p_{ig}$  be manufacturer  $i$ 's on-contract price. In the duopoly game, manufacturer  $i$  chooses  $p_{ig}$  to maximize  $\pi_{ig}$  where

$$\pi_{ig} = \lambda_i p_{ig} D_i = \lambda_i p_{ig} \left( \frac{1}{2} + \frac{p_{jg} - p_{ig}}{2t} \right). \quad (3)$$

The FOC of (3) with respect to  $p_{ig}$  yields

$$t + p_{jg} - 2p_{ig} = 0 \quad (i, j = 1, 2; i \neq j).$$

Let  $p_{ig}^*$  and  $\pi_{ig}^*$  be the equilibrium prices and profit, respectively. Solving above equations yields  $p_{1g}^* = p_{2g}^* = p_g^* = t$  and  $D_1 = D_2 = 1/2$ . As a result, the GPO's nominal profit,  $\pi_{GPO}$ , is

$$\pi_{GPO} = \sum_{i=1}^2 [p_g^* (1 - \lambda_i) - c_g] D_i. \quad (4)$$

The GPO chooses  $\lambda_i$  such that it breaks even, namely,  $\pi_{GPO} = 0$ :

$$\lambda_1 = \lambda_2 = \lambda = [p_g^* - c_g]/p_g^* = (t - c_g)/t.$$

Substituting  $\lambda$  into (3) yields

$$\pi_{1g}^* = \pi_{2g}^* = \pi_g^* = (t - c_g)/2.$$

The providers' aggregated costs, denoted by  $s_g^*$  are as follows:

$$s_g^* = \int_0^x (p_g^* + t\varepsilon)d\varepsilon + \int_0^{1-x} (p_g^* + t\varepsilon)d\varepsilon = 2 \int_0^{1/2} (t + t\varepsilon)d\varepsilon = 5t/4.$$

The total channel surplus is

$$v - s_g^* + 2\pi_g^* = v - t/4 - c_g.$$

The results are summarized as follows.

**LEMMA 2.** *In the presence of the GPO, at the subgame equilibrium,*

- Each manufacturer sells to 1/2 of the market at price  $t$  and earns  $(t - c_g)/2$ .
- The providers' total purchasing costs are  $5t/4$ .
- The total channel surplus is  $v - t/4 - c_g$ .

Comparing the equilibrium points with and without the GPO leads to the following conclusions.

**PROPOSITION 1.** *In the presence of the GPO,*

- Each manufacturer's price decreases by  $c_m$ , and its profit decreases by  $c_g/2$ ;
- The providers' total costs decrease by  $c_d$ . Therefore, the providers will form a GPO at the first stage;
- The total channel surplus increases by  $\Delta$ .

It is well known that production cost, here contracting cost, softens the Bertrand–Nash competition with linear prices. The CAF contract induces the manufacturers to compete more intensively because their contracting costs are lower. As a result, contracting costs are shifted upward along the supply chain to the manufacturers. In contrast, without the GPO, as stated in Lemma 1, all the contracting costs are borne by the providers. The total channel surplus increases because of the efficiency gain through the GPO.

#### 4.2. Asymmetric Preference

In many settings, providers' preferences for products are asymmetric, whether one product is functionally superior to another or not. For example, physicians may prefer one manufacturer's product to the other's, some manufacturers may have a longer relationship with providers, thus having "brand" advantage over its competitors. This asymmetry is particularly likely to happen in hospital settings, for so-called "physician

preference" items. To capture such situations, we now generalize our models to deal with cases wherein providers' preferences are shifted in favor of one of the two competing manufacturers.

As in section 4.1, the providers remain uniformly distributed over the unit interval, but their willingness to pay for the product of manufacturer 1 is increased by a factor  $\delta/2 > 0$ , and for the products of manufacturer 2 is decreased by  $\delta/2$ . Manufacturer 1 can be seen as the more established firm, while manufacturer 2 is a new entrant. So  $v + \delta/2$  is the reservation price for manufacturer 1's product for a provider located at  $x = 0$ , and  $v - \delta/2$  is the reservation price for manufacturer 2's product for a provider located at  $x = 1$ .

As in section 4.1, the market shares can be derived as follows: a provider located at  $x$  on the unit interval is indifferent to buying a product from either manufacturer:

$$v + \delta/2 - tx - c_p - p_{1d} = v - \delta/2 - (1 - x)t - c_p - p_{2d}, \quad (5)$$

hence

$$D_1(p_{1d}, p_{2d}) = x = \frac{1}{2} + \frac{p_{2d} - p_{1d} + \delta}{2t},$$

$$D_2(p_{1d}, p_{2d}) = 1 - x = \frac{1}{2} + \frac{p_{1d} - p_{2d} - \delta}{2t}.$$

If the providers contract through a GPO, then  $c_p$  disappears from both sides of (5). Hence, the market-share distribution remains the same. As in section 4.1, in the subsequent analysis, we examine the subgames under which the GPO is absent or present, respectively.

If the GPO is not formed, then each manufacturer  $i$  chooses  $p_{id}$  to maximize its expected profit  $\pi_{id}$  where

$$\pi_{1d} = D_1(p_{1d} - c_m) = \left(\frac{1}{2} + \frac{p_{2d} - p_{1d} + \delta}{2t}\right)(p_{1d} - c_m), \quad (6)$$

$$\pi_{2d} = D_2(p_{2d} - c_m) = \left(\frac{1}{2} + \frac{p_{1d} - p_{2d} - \delta}{2t}\right)(p_{2d} - c_m). \quad (7)$$

Solving the FOCs of above equations yields equilibrium prices  $p_{id}^*$  with

$$p_{1d}^* = t + c_m + \delta/3 \quad p_{2d}^* = t + c_m - \delta/3. \quad (8)$$

So the equilibrium market shares are

$$D_1 = x = \frac{1}{2} + \frac{\delta}{6t},$$

$$D_2 = 1 - x = \frac{1}{2} - \frac{\delta}{6t}. \quad (9)$$

Hence, for manufacturer 2 to obtain a market share, i.e.,  $D_2 > 0$ ,  $\delta < 3t$  must hold. The manufacturers' expected profit, denoted by  $\pi_{id}^*$  at equilibrium are

$$\pi_{1d}^* = \frac{(3t + \delta)^2}{18t},$$

$$\pi_{2d}^* = \frac{(3t - \delta)^2}{18t}.$$

The favored manufacturer charges a higher price and obtains a larger market share and, therefore, reaps a greater profit than its rival. The manufacturers' total profits are

$$t + \frac{\delta^2}{9t}.$$

The providers' total costs are

$$\begin{aligned} s_d^* &= \int_0^x (p_1 + t\varepsilon + c_p - \delta/2)d\varepsilon + \int_0^{1-x} (p_2 + t\varepsilon + c_p + \delta/2)d\varepsilon \\ &= \int_0^{\frac{1}{2} + \frac{\delta}{6t}} (t + c_d - \frac{\delta}{6} + t\varepsilon)d\varepsilon + \int_0^{\frac{1}{2} - \frac{\delta}{6t}} (t + c_d + \frac{\delta}{6} + t\varepsilon)d\varepsilon \\ &= \frac{5t}{4} - \frac{\delta^2}{36t} + c_d. \end{aligned}$$

The total channel surplus is

$$\pi_{1d}^* + \pi_{2d}^* + v - s_d^* = v - \frac{t}{4} + \frac{\delta^2}{12t} - c_d.$$

Compared with the symmetric game, the providers' costs decrease by  $\delta^2/(12t)$ , manufacturer 1's profit increases by  $\delta/3 + \delta^2/(18t)$ , and manufacturer 2's profit decreases by  $\delta/3 - \delta^2/(18t)$ . The profit gain of manufacturer 1 is due to its competitive advantage against manufacturer 2 because of the increase of the providers' willingness to pay for its product. Surprisingly, the total channel surplus increases by  $\delta^2/(12t)$  compared with the symmetric game. The results are summarized as follows.

LEMMA 3. *In the absence of the GPO, at the subgame perfect equilibrium,*

- Manufacturer 1 sells to  $\frac{1}{2} + \frac{\delta}{6t}$  of the market at the price  $t + c_m + \delta/3$  and earns  $\frac{(3t + \delta)^2}{18t}$ .
- Manufacturer 2 sells to  $\frac{1}{2} - \frac{\delta}{6t}$  of the market at the price  $t + c_m - \delta/3$  and earns  $\frac{(3t - \delta)^2}{18t}$ .
- The providers' total costs are  $\frac{5t}{4} - \frac{\delta^2}{36t} + c_d$ .
- The channel total surplus is  $v - \frac{t}{4} + \frac{\delta^2}{12t} - c_d$ .

Suppose now that the providers form a GPO, who offers a take-or-leave-it CAF contract to each manufacturer. Let  $\lambda_i$  be manufacturer  $i$ 's share of its own

sales revenue. Then the manufacturers' expected profits are

$$\pi_{1g} = \lambda_1 p_{1g} \left( \frac{1}{2} + \frac{p_{2g} - p_{1g} + \delta}{2t} \right), \quad (10)$$

$$\pi_{2g} = \lambda_2 p_{2g} \left( \frac{1}{2} + \frac{p_{1g} - p_{2g} - \delta}{2t} \right). \quad (11)$$

Solving the FOCs with respect to  $p_{ig}$  yields

$$\begin{aligned} p_{1g}^* &= t + \delta/3, \\ p_{2g}^* &= t - \delta/3. \end{aligned} \quad (12)$$

So the equilibrium prices do not depend on the revenue shares but only on  $t$  and  $\delta$ . The market share distribution remains the same as (9).

For the GPO to break even, the following equation must hold

$$[(1 - \lambda_1)p_{1g}^* - c_g]D_1 + [(1 - \lambda_2)p_{2g}^* - c_g]D_2 = 0. \quad (13)$$

Since under  $\delta < 3t$ , each manufacturer takes a positive share of the market. The GPO can charge the same or different CAFs to the manufacturers. We will first examine the latter case.

**Different CAFs.** Here we assume that the GPO charges different CAFs to the manufacturers. Under  $\delta < 3t$ , each manufacturer takes a positive market share, i.e.,  $D_1 > 0$  and  $D_2 > 0$ . Thus for (13) to hold, the following must also hold

$$\begin{aligned} \lambda_1 &= \frac{p_{1g}^* - c_g}{p_{1g}^*} = 1 - \frac{3c_g}{3t + \delta}, \\ \lambda_2 &= \frac{p_{2g}^* - c_g}{p_{2g}^*} = 1 - \frac{3c_g}{3t - \delta}. \end{aligned} \quad (14)$$

Observe that

$$\frac{1 - \lambda_1}{1 - \lambda_2} = \frac{p_{2g}^*}{p_{1g}^*}.$$

The proportion of the GPO's revenue shares from the manufacturers' revenue is the reciprocal of their selling prices. That is, the GPO collects a lower share of revenues from the favored manufacturer who sells at a higher price. In order to guarantee manufacturer 2 a market share, i.e.,  $\lambda_2 > 0$ , (14) implies that  $3(t - c_g) > \delta$ .

The manufacturers' expected profits at equilibrium are

$$\pi_{1g}^* = \frac{(3t + \delta)^2}{18t} \left( 1 - \frac{3c_g}{3t + \delta} \right), \quad (15)$$

$$\pi_{2g}^* = \frac{(3t - \delta)^2}{18t} \left(1 - \frac{3c_g}{3t - \delta}\right). \quad (16)$$

Both manufacturers make less profit than if the GPO is not formed. The two manufacturers' total expected profits are

$$\pi_{1g}^* + \pi_{2g}^* = t + \frac{\delta^2}{9t} - c_g.$$

Thus, the manufacturers' total expected profits decrease by  $c_g$  with the GPO.

**Uniform CAFs.** Here we assume that the GPO offers the same CAF to each manufacturer. Since the equilibrium prices and market-share distribution are independent of the revenue shares, letting  $\lambda_1 = \lambda_2 = \lambda$  in (13) leads to

$$1 - \lambda = \frac{9tc_g}{9t^2 + \delta^2}.$$

Therefore, the manufacturers' expected profits at equilibrium are

$$\tilde{\pi}_{1g}^* = \frac{(3t + \delta)^2}{18t} \lambda = \frac{(3t + \delta)^2}{18t} \left(1 - \frac{9tc_g}{9t^2 + \delta^2}\right), \quad (17)$$

$$\tilde{\pi}_{2g}^* = \frac{(3t - \delta)^2}{18t} \lambda = \frac{(3t - \delta)^2}{18t} \left(1 - \frac{9tc_g}{9t^2 + \delta^2}\right). \quad (18)$$

**Comparison.** Interestingly, the total profits of the manufacturers are the same under either CAF scheme proposed above:

$$\tilde{\pi}_{1g}^* + \tilde{\pi}_{2g}^* = \pi_{1g}^* + \pi_{2g}^* = t + \frac{\delta^2}{9t} - c_g.$$

To compare  $\tilde{\pi}_{1g}^*$  and  $\tilde{\pi}_{2g}^*$ , one only needs to compare the second term in the square brackets of (15) and (17).

$$\frac{9tc_g}{9t^2 + \delta^2} \frac{3t + \delta}{3c_g} = \frac{9t^2 + 3t\delta}{9t^2 + \delta^2} > 1,$$

because  $3t > \delta$ . Therefore,  $\tilde{\pi}_{1g}^* < \pi_{1g}^*$ . Since the manufacturers' total profits are the same, manufacturer 1 is worse off under the uniform CAFs, manufacturer 2 must be better off. Hence, if the manufacturers have options to choose between the two schemes, manufacturer 1 would favor the differentiated CAF scheme over the uniform CAF scheme. Under the differentiated CAFs, manufacturer 1 obtains a larger share of the revenue than its competitor. However, the uniform CAF scheme forces manufacturer 1 to

share the gain from its more favorable product with its competitor.

Because the manufacturers' total profits and the selling prices are the same under either scheme, the providers' total purchasing costs are also the same:

$$\begin{aligned} s_g^* &= \int_0^x (p_{1g}^* + t\varepsilon - \delta/2)d\varepsilon + \int_0^{1-x} (p_{2g}^* + t\varepsilon - v + \delta/2)d\varepsilon \\ &= \int_0^{\frac{1}{2} + \frac{\delta}{6t}} (t - \frac{\delta}{6} - \delta + t\varepsilon)d\varepsilon + \int_0^{\frac{1}{2} + \frac{\delta}{6t}} (t + \frac{\delta}{6} + t\varepsilon - v)d\varepsilon \\ &= \frac{5t}{4} - \frac{\delta^2}{36t}. \end{aligned}$$

The providers' "traveling costs" are the same as those without the GPO. However, the providers who purchase from manufacturer 1 obtain an additional utility of  $\frac{\delta}{2} + \frac{\delta^2}{36t}$  because manufacturer 1's product is more appealing. The total channel surplus under either CAF scheme is

$$v + \pi_{1g}^* + \pi_{2g}^* - s_g^* = v - \frac{t}{4} + \frac{\delta^2}{12t} - c_g.$$

Above results are summarized in the following lemma.

**LEMMA 4.** *In the presence of the GPO, at the equilibrium of the asymmetric subgame,*

- Under either CAF scheme, manufacturer 1 sells to  $\frac{1}{2} + \frac{\delta}{6t}$  of the market at the price  $t + \frac{\delta}{6}$ , manufacturer 2 sells to  $\frac{1}{2} - \frac{\delta}{6t}$  of the market at the price  $t - \frac{\delta}{6}$ .*
- Under the differentiated CAF scheme, manufacturer 1's profit is  $\frac{(3t+\delta)^2}{18t}(1 - \frac{3c_g}{3t+\delta})$  and manufacturer 2's profit is  $\frac{(3t-\delta)^2}{18t}(1 - \frac{3c_g}{3t-\delta})$ ; under the uniform CAF scheme, manufacturer 1's profit is  $\frac{(3t+\delta)^2}{18t}(1 - \frac{9tc_g}{9t^2+\delta^2})$  and manufacturer 2's profit is  $\frac{(3t-\delta)^2}{18t}(1 - \frac{9tc_g}{9t^2+\delta^2})$ ;*
- The providers' total cost is  $\frac{5t}{4} - \frac{\delta^2}{36t}$  under either scheme;*
- The channel's total surplus under either scheme is  $v - \frac{t}{4} + \frac{\delta^2}{12t} - c_g$ .*

Based on Lemmas 3 and 4, purchasing through the GPO reduces the providers' total purchasing cost by  $c_d$  as in the symmetric game. Therefore, as in the symmetric game, the providers will form a GPO at the first stage. In addition, whether the GPO is formed or not, the total channel surplus is increasing in  $\delta$ . This increase is because manufacturer 1, whose product provides a greater utility value, earns a



larger market share. The results are summarized as follows.

PROPOSITION 2. *Compared with the equilibrium without the GPO,*

- (a) *Under either CAF scheme, the manufacturers' market shares are the same, but each manufacturer's selling price decreases by  $c_m$ .*
- (b) *Under the differentiated CAF scheme, manufacturer 1's profit decreases by  $\frac{c_g}{2} - \frac{c_g \delta}{6t}$ , and manufacturer 2's profit decreases by  $\frac{c_g}{2} - \frac{c_g \delta}{6t}$ .*
- (c) *Under the uniform CAF scheme, manufacturer 1's profit decreases by  $\frac{c_g}{2} + \frac{3t\delta c_g}{9t^2 + \delta^2}$ , and manufacturer 2's profit decreases by  $\frac{c_g}{2} - \frac{3t\delta c_g}{9t^2 + \delta^2}$ .*
- (d) *The manufacturers' total profits decrease by  $c_g$  under either scheme.*
- (e) *Manufacturer 1 prefers the differentiated CAF scheme to the uniform one, while the opposite holds for manufacturer 2. The providers are indifferent between the two schemes;*
- (f) *The providers' costs decrease by  $c_d$  under either scheme and therefore they will form a GPO at the first stage.*
- (g) *The total channel surplus increases by  $\Delta$  under either scheme.*

Although we do not model market entry directly, a comparison of the manufacturers' profits implies that the GPO would make the prospect of entry less attractive, assuming that manufacturer 2 is a new entrant who has yet to establish a preference for its product. As the weaker rival in the market, manufacturer 2 charges a lower price and obtains a smaller market share. The forming of the GPO further reduces its profit, thus creating a more intimidating environment than in the symmetric case analyzed in section 4.1.

The presence of the GPO lowers the manufacturers' total profits by  $c_g$ , a constant independent of  $\delta$ . Thus, one may conjecture that if  $\delta$  is a decision variable, the forming of the GPO, at best, will not change, if not lower, the value of  $\delta$  at equilibrium. This conjecture leads us to the innovation game in section 6.

## 5. Can Off-Contract Price be Lower Than On-Contract Price?

Despite the "contract" terminology, GPO provider-members are not necessarily under an obligation to purchase products under the terms of the GPO-negotiated contract. The extent to which a provider-member purchases a contracted product (instead of its off-contract equivalent) is called "compliance." GPOs benefit from higher levels of compliance, since

higher compliance means larger market share, more purchasing power for the GPO, and, potentially, lowers prices for the provider-members. This section examines a common charge against GPOs: GPOs don't benefit providers because off-contract prices are sometimes lower than on-contract prices. We will show below that under certain conditions, it is the presence of the GPO that lowers the off-contract price. Therefore, one cannot criticize GPOs simply based on the fact that providers can obtain lower price buying off-contract than on-contract. This result is consistent with Burns and Lee (2008).

Suppose now that each manufacturer is, first, able to choose to sell through the GPO or directly to the providers. The providers who buy from the manufacturer who sells directly pay an off-contract price. Then, at the second stage, the manufacturers engage in pricing competition. Three cases are possible: both sell off-contract; both sell on-contract, or one of the manufacturers, taken arbitrarily to be manufacturer 1, sells off-contract and manufacturer 2 sells on-contract. The first two cases have been examined in section 4.1. In the following analysis, we examine the hybrid case: manufacturer 1 sells off-contract and manufacturer 2 sells on-contract.

### 5.1. On-Contract Selling Competes with Off-Contract Selling

The market-share distribution is obtained by solving

$$v - p_{1d} - tx - c_p = v - p_{2g} - (1 - x)t.$$

The left side of above equation is the surplus of the provider located at  $x$  if it buys from manufacturer 1 and its right side is its surplus if it buys from manufacturer 2. Note that buying directly from manufacturer 1 incurs unit contracting costs  $c_p$ , while buying through the GPO does not. So

$$\begin{aligned} D_1 = x &= \frac{1}{2} + \frac{p_{2g} - p_{1d} - c_p}{2t}, \\ D_2 = 1 - x &= \frac{1}{2} - \frac{p_{2g} - p_{1d} - c_p}{2t}. \end{aligned} \quad (19)$$

Manufacturer 1 chooses  $p_{1d}$  to maximize its profit,  $\pi_{1d}$ , where

$$\pi_{1d} = (p_{1d} - c_m) \left( \frac{1}{2} + \frac{p_{2g} - p_{1d} - c_p}{2t} \right).$$

Similarly, manufacturer 2 selects  $p_{2g}$ , to maximize its profit,  $\pi_{2g}$ , where

$$\pi_{2g} = \lambda p_{2g} \left( \frac{1}{2} - \frac{p_{2g} - p_{1d} - c_p}{2t} \right).$$

and  $\lambda$  is the revenue share of manufacturer 2 from sales. The FOCs of above equations yield the equilibrium prices,  $p_{1d}^*$  and  $p_{2g}^*$  where

$$p_{1d}^* = t + \frac{2c_m - c_p}{3},$$

$$p_{2g}^* = t + \frac{c_m + c_p}{3}.$$

At the hybrid equilibrium of this subgame, the equilibrium prices depend on both the contracting costs of the manufacturer and the providers. Here, manufacturer 1's decision to sell directly allows manufacturer 2 to raise its price from  $t$  to  $t + \frac{c_d}{3}$ . Manufacturer 1's price, however, is higher than  $t$  if and only if  $2c_m < c_p$ . Moreover, the off-contract price  $p_{1d}^*$  is lower than the on-contract price  $p_{2g}^*$  if  $c_m < 2c_p$ . In addition, manufacturer 2's revenue share,  $\lambda = 1 - c_g/p_{2g}^*$ .

A comparison of the equilibrium prices is very revealing. If both manufacturers contract through the GPO, then the manufacturers are forced to compete more intensively because their contracting costs are lower, thus driving down the equilibrium prices (that are independent of  $c_m$  and  $c_p$ ). However, if one manufacturer sells directly, both  $c_m$  and  $c_p$  affect the equilibrium prices. Manufacturer 1's contracting costs soften the pricing competition, with its own price increasing at the constant rate  $2/3$  relative to  $c_m$  and its rival's price increasing at the lower rate,  $1/3$ . The provider's contracting cost  $c_p$  drives manufacturer 1 to lower its price at the constant rate  $1/3$ . Responding strategically, manufacturer 2 raises its price at the rate  $1/3$  with respect to  $c_p$ .

Substituting  $p_{1d}^*$  and  $p_{2g}^*$  into (19) yields

$$D_1 = x = \frac{1}{2} - \frac{c_m + c_p}{6t},$$

$$D_2 = 1 - x = \frac{1}{2} + \frac{c_m + c_p}{6t}.$$

Note that manufacturer 1 takes a greater market share than its competitor. To ensure manufacturer 1 a positive market share requires that  $3t > c_d$ . The manufacturers' profits at equilibrium are

$$\pi_{1d}^* = \frac{(3t - c_d)^2}{18t}, \quad (20)$$

$$\pi_{2g}^* = \frac{1}{18t}(3t + \Delta)(3t + c_d) > \frac{t}{2}. \quad (21)$$

The providers' total costs are

$$\begin{aligned} & \int_0^x (p_{1d}^* + c_p + t\varepsilon)d\varepsilon + \int_0^{1-x} (p_{2g}^* + t\varepsilon)d\varepsilon \\ &= \int_0^{\frac{1}{2} - \frac{c_d}{6t}} \left( t + \frac{2}{3}c_d + t\varepsilon - v \right) d\varepsilon + \int_0^{\frac{1}{2} + \frac{c_d}{6t}} \left( t + \frac{1}{3}c_d + t\varepsilon - v \right) d\varepsilon \\ &= \frac{5t}{4} + \frac{1}{2}c_d - \frac{1}{36t}c_d^2. \end{aligned}$$

The total channel surplus is

$$\begin{aligned} & \pi_{1d}^* + \pi_{2g}^* - \left( \frac{5t}{4} + \frac{1}{2}c_d - \frac{1}{36t}c_d^2 \right) + v \\ &= v - \frac{t}{4} - \frac{2c_d}{3} + \frac{c_d^2}{12t} + \frac{\Delta}{6} + \frac{\Delta c_d}{18t}. \end{aligned}$$

By Lemma 1, the equilibrium price without the GPO is  $t + c_m$  and the providers' surplus is  $v - 5t/4 - c_d$ . Hence, the GPO improves the providers' surplus in the hybrid game if and only if

$$\frac{t}{4} - \frac{c_d}{2} - \frac{c_d^2}{36t} = \frac{1}{36t}[3(t - c_d)^2 - 10c_d^2] < 0.$$

Solving the inequality yields  $t < (\frac{\sqrt{10}}{3} + 1)c_d$ . The conclusions are summarized as follows.

**PROPOSITION 3.** *If one manufacturer sells off-contract, while its competitor sells on-contract, then at equilibrium,*

- The off-contract price is lower than the on-contract price if  $c_m < 2c_p$ .*
- The presence of the GPO improves the providers' surplus if and only if  $t < (\frac{\sqrt{10}}{3} + 1)c_d$ .*

Recall that the criticism about GPO pricing is bolstered by the evidence that on-contract prices are not necessarily the lowest available; indeed, off-contract prices are sometimes lower. We have shown here that off-contract price could be lower than on-contract price, as demonstrated above, if  $c_m < 2c_p$  because of the presence of the GPO. Without the GPO, the off-contract price would be higher.

## 5.2. Equilibrium Contract Types

We demonstrate that if the manufacturers are able to choose to sell on or off contract, then only two equilibria exist: Either both sell on-contract or one sells on-contract and the other sells off-contract. We also show that the manufacturers' total profits are larger in the latter case.

Using Lemmas 1, 2 and Proposition 4, the first-stage game between the manufacturers, selling off contract or on-contract, can be expressed by a  $2 \times 2$  matrix as shown in Table 1.

If, for each manufacturer, selling on-contract is the best response, given that the competing manufacturer sells on-contract, then the symmetric equilibrium arises: both manufacturers sell on-contract. Equivalently, using Table 1, the following inequality must hold:

$$\frac{t - c_g}{2} > \left( \frac{t}{2} + \frac{c_d^2}{18t} - \frac{c_d}{3} \right),$$

**Table 1** Selling On-Contract or Off-Contract

Manufacturer 1	Manufacturer 2	
	On-contract	Off-contract
On-contract	$\left(\frac{t-c_g}{2}, \frac{t-c_g}{2}\right)$	$\left(\frac{(3t+c_d)(3t+\Delta)}{18t}, \frac{(3t-c_d)^2}{18t}\right)$
Off-contract	$\left(\frac{(3t-c_d)^2}{18t}, \frac{(3t+c_d)(3t+\Delta)}{18t}\right)$	$\left(\frac{t}{2}, \frac{t}{2}\right)$

which can be simplified as

$$\Delta > \frac{c_d^2}{18t} + \frac{2c_d}{3}. \quad (22)$$

For the asymmetric equilibrium to arise, the following two equalities must hold:

$$\Delta < \frac{c_d^2}{18t} + \frac{2c_d}{3} \quad (23)$$

and

$$\frac{(3t+c_d)(3t+\Delta)}{18t} > \frac{t-c_g}{2},$$

which always holds.

The equilibrium in which both manufacturers sell off-contract cannot arise because

$$\frac{(3t-c_d)^2}{18t} - \frac{t}{2} < 0,$$

due to  $c < 3t$ . Above inequality also implies that the off-contract selling manufacturer 1's profit is lower when competing with an on-contract selling rival than when competing with an off-contract selling rival. Using (20) and (21), the manufacturers' total profits at the equilibrium of the hybrid game are

$$t - \frac{c_d}{6} + \frac{\Delta}{6} = t - \frac{c_g}{6}.$$

From Lemma 2, at the equilibrium where both manufacturers sell on-contract, their total profits are  $t - c_g$ . Hence, the manufacturers' total profits are greater in the asymmetric equilibrium than in the symmetric one.

Note that Since  $\Delta < c_d$  and  $t < c_d/3$ , so it is more likely that (22) does not hold. In particular, if  $\Delta < 2c_d/3$ , then (22) does not hold with certainty. Then, as a result, only the asymmetric equilibrium can arise.

**PROPOSITION 4.** *If each manufacturer can choose to sell off-contract or on-contract, at equilibrium,*

- If  $\Delta < \frac{c_d^2}{18t} + \frac{2c_d}{3}$ , the hybrid equilibrium arises in which one manufacturer sells on-contract, the other sells off-contract. Otherwise, both manufacturers will choose to sell through the GPO.
- The total profits of the manufacturers are greater at the asymmetric equilibrium than at the symmetric equilibrium in which both sell on-contract.

The results provide the following insights into the controversies about on- and off-contract buying. First, the presence of GPOs might lower off-contract price. Second, off-contract buying is not, in and of itself, evidence that GPOs are anti-competitive. Instead, this represents an equilibrium that maximizes the manufacturers' total profits.

In addition, we could study an asymmetric case as in section 4, letting providers favor one manufacturer's product over another's. The qualitative results will remain. However, the explicit condition for a hybrid equilibrium to arise will differ from (23).

## 6. Do GPOs Help or Hinder Innovation?

Here we will examine whether the presence of GPO promotes or stifles innovation of existing products. Our analysis proceeds as in section 4.2 except here we endogenize  $v_1$  and  $v_2$ . Suppose that the base value of either manufacturer's product to a provider is  $v$ , but each manufacturer can choose to increase the base value by  $\delta_{ik}$  ( $k = d, g$ ) at a cost  $c(\delta_{ik})$ , where  $c(\cdot)$  is increasing and strictly convex. So  $v_i = v + \delta_{ik}$ . Each manufacturer chooses  $\delta_{ik}$  first and then sets its price.

Working backward, we first obtain the pricing subgame, and then the equilibrium of the innovation game. If the GPO is not formed, the equilibrium prices are similar to (8), with  $\delta$  being replaced by  $\delta_{1d} - \delta_{2d}$  for  $p_{1d}$  and  $-\delta$  being replaced by  $\delta_{2d} - \delta_{1d}$ ,

$$p_{id} = t + c_m + \frac{\delta_{id} - \delta_{jd}}{3} \quad (i, j = 1, 2; i \neq j) \quad (24)$$

and using (9), manufacturer  $i$ 's market share is

$$\begin{aligned} D_i(p_{id}, p_{jd}) &= \frac{1}{2} + \frac{p_{jd} - p_{id} + \delta_{id} - \delta_{jd}}{2t} \\ &= \frac{1}{2} + \frac{\delta_{id} - \delta_{jd}}{6t} \quad (i, j = 1, 2; i \neq j). \end{aligned} \quad (25)$$

Using (24) and (25) yields manufacturer  $i$ 's expected profit with

$$\begin{aligned} \pi_{id}^* &= (p_{id} - c_m)D_i = \frac{(3t + \delta_{id} - \delta_{jd})^2}{18t} - c(\delta_{id}) \\ &\quad (i, j = 1, 2; i \neq j). \end{aligned} \quad (26)$$

The FOC of (26) with respect to  $\delta_{id}$  yields

$$\frac{1}{3} + \frac{\delta_{id} - \delta_{jd}}{9t} = c'(\delta_{id}). \quad (27)$$

In the symmetric equilibrium,  $\delta_{1d}^* = \delta_{2d}^* = \delta_d^*$ . So at the equilibrium of the innovation game,

$$\frac{1}{3} = c'(\delta_d^*).$$

If the GPO is formed, using (10) and (11) leads to the equilibrium price  $p_{ig}^*$

$$p_{ig}^* = t + \frac{\delta_{ig} - \delta_{jg}}{3}$$

and the market shares do not change with the presence of the GPO where

$$D_i = \frac{1}{2} + \frac{\delta_{ig} - \delta_{jg}}{6t}.$$

We proved in section 4.2 that the manufacturer whose product is more appealing prefers the differentiated CAFs to the uniform CAFs. For the GPO to break-even,

$$\lambda_i = 1 - \frac{c_g}{t + \frac{\delta_{ig} - \delta_{jg}}{3}}.$$

So manufacturer  $i$ 's expected profit is

$$\begin{aligned} \pi_{ig} &= \lambda_i p_i \left( \frac{1}{2} + \frac{p_{jg} - p_{ig} + \delta_{ig} - \delta_{jg}}{2t} \right) - c(\delta_{ig}), \\ &= \lambda_i \left( t + \frac{\delta_{ig} - \delta_{jg}}{3} \right) \left( \frac{1}{2} + \frac{\delta_{ig} - \delta_{jg}}{6t} \right) - c(\delta_{ig}), \\ &= \left( t + \frac{\delta_{ig} - \delta_{jg}}{3} - c_g \right) \left( \frac{1}{2} + \frac{\delta_{ig} - \delta_{jg}}{6t} \right) - c(\delta_{ig}). \end{aligned}$$

The FOC of  $\pi_{ig}$  with respect to  $\delta_{ig}$  yields

$$\frac{1}{3} + \frac{\delta_{ig} - \delta_{jg}}{9t} - \frac{c_g}{6t} = c'(\delta_{ig}).$$

In a symmetric equilibrium,  $\delta_{1g}^* = \delta_{2g}^* = \delta_g^*$ , where  $\delta_g^*$  satisfies

$$\frac{1}{3} - \frac{c_g}{6t} = c'(\delta_g^*).$$

So  $c'(\delta_g^*) \leq c'(\delta_d^*)$ .

The convexity of  $c(\cdot)$  yields  $\delta_g^* \leq \delta_d^*$ . For the symmetric equilibrium, the same  $\delta_g^*$  can be achieved if the GPO employs the uniform CAF scheme. Therefore, the introduction of a GPO does dampen demand-enhancing activities, whether it is promotion or product innovation.

**PROPOSITION 5.** *Contracting through the GPO lowers the manufacturers' incentives to introduce innovations to existing products.*

Some theoretical models concur with our results. Inderst and Wey (2003) argue that buyers' purchase group dampens a seller's incentive to innovate.

## 7. Should "Safe Harbor" Provisions for GPOs be Eliminated?

In this section we examine the most controversial issue of all: whether or not the "safe harbor" provisions, which permit GPOs to charge CAFs, should be withdrawn, thereby eliminating CAFs. We assume that GPOs would continue to exist because of the contracting efficiencies they provide, but their provider

members instead of the manufacturers would pay the CAFs as a percentage of their purchase.

Let  $\lambda$  be the CAF charged to the providers. All other settings are the same as in section 4.1. Then the market-share distribution can be determined by solving

$$p_{1g} + \lambda p_{1g} + tx = p_{2g} + \lambda p_{2g} + t(1 - x).$$

Hence,

$$\begin{aligned} D_1 = x &= \frac{1}{2} + \frac{(1 + \lambda)(p_{2g} - p_{1g})}{2t}, \\ D_2 = 1 - x &= \frac{1}{2} - \frac{(1 + \lambda)(p_{2g} - p_{1g})}{2t}. \end{aligned}$$

And manufacturer 1's profit is

$$p_{1g}x = p_{1g} \left[ \frac{1}{2} + \frac{(1 + \lambda)(p_{2g} - p_{1g})}{2t} \right].$$

Its FOC condition is

$$\frac{1}{2} + \frac{(1 + \lambda)(p_{2g} - p_{1g})}{2t} - p_{1g} \frac{1 + \lambda}{2t} = 0.$$

Let  $p_{1g}^*$  be the equilibrium price, then

$$p_{1g}^* = p_{2g}^* = \frac{t}{1 + \lambda} = \frac{t}{1 + \frac{c_g}{p_{1g}^*}} < t,$$

if  $\lambda > 0$ . Solving above equation leads to

$$p_{1g}^* = p_{2g}^* = t - c_g \quad \lambda = \frac{c_g}{t - c_g},$$

where  $\lambda < 1$ ,  $t > 2c_g$ . Note that for every unit of the product that the providers purchase, their actual unit costs are  $(1 + \lambda)p_{1g}^* = t$ . Although the providers' nominal purchasing price decreases, their total purchasing costs are the same as those in section 4.2, i.e.,  $5t/4 - v$ . In addition, each manufacturer sells to one half of the market at the price  $t - c_g$ , but it does not need to pay the CAFs to the GPO. As a result, it also earns  $(t - c_g)/2$ , the same as its counterpart in section 4.2. One can also verify that shifting the CAF from the manufacturers to the providers will induce a lower level of innovation-promotion than if the CAF is charged to the manufacturers. Hence, merely shifting the CAF does not alter any party's profit or cost.

## 8. Extensions

In the preceding sections we assumed two manufacturers competing with similar, but not identical products and represented GPOs as not-for-profit organizations. In our first extension we examine a monopolist manufacturer; e.g., a manufacturer of a medical device or pharmaceutical for which there is no substitute. Here, in contrast to the duopoly results, we will demonstrate that forming a GPO hurts providers. In our second extension we discuss the

impact of a profit-seeking GPO in the original duopoly market.

### 8.1. Monopoly

Suppose that manufacturer 1 is the monopolist, and manufacturer 2 does not exist. In a similar way as in the duopoly, the optimal prices, market coverage, and the providers' surplus can be calculated. Let  $p_{md}^*$  and  $p_{mg}^*$  be the monopolist's price in the absence and presence of the GPO, respectively. The results are summarized as follows.

**PROPOSITION 6.** *Suppose that  $v \geq \max\{2t, 2t + c_p - c_m\}$ , then  $p_{md}^* = v - t - c_p$  and  $p_{mg}^* = v - t$ .*

The condition  $v \geq \max\{2t, 2t + c_p - c_m\}$  ensures that the interval is covered so that we can compare the monopoly case with the duopoly fairly. Proposition 6 implies that  $p_{mg}^* \leq p_{md}^*$  if  $c_p \geq 0$ . Hence, forming a GPO hurts the providers. Contracting through the GPO lowers the providers' contracting cost and allows the monopolist to charge a higher price! In contrast, in the duopoly, lowering the providers' contracting costs does not permit the manufacturers to raise prices because each manufacturer attempts to augment its market share through low prices at the margin. Thus, each manufacturer's ability to extract surplus is now limited by its rival's aggressive pricing. As a result, neither  $c_p$  nor  $v$  plays a role in the manufacturers' Bertrand–Nash game in the duopoly game. However,  $c_m$  does allow the manufacturers to charge a higher price when the GPO is not formed. When the GPO is formed in the duopoly, as indicated in Lemma 2, the equilibrium price is independent of  $c_m$ ,  $c_p$ , and  $v$ . The forming of the GPO further intensifies the Bertrand–Nash competition between the manufacturers by reducing the manufacturers' contract cost and thus leading to the equilibrium price  $t$ .

### 8.2. For-Profit GPO?

Given a GPO's nominal profit, (4), a for-profit GPO can generate profit in four different ways: charging a CAF,  $(1 - \lambda)$ , in excess of the breakeven specified above; by charging its provider-members for contracting services; by reducing its own contracting cost,  $c_g$ ; or by operating profit-generating businesses in conjunction with its contracting services.

Although it seems trivial for a profit-maximizing GPO to increase its CAF—in the extreme, so that it captures all of the revenue from product sales—the safe-harbor provisions of the Social Security Act limit  $(1 - \lambda)$  to average 3% and requires GPOs to report all exceptions, in detail, to its provider members. In view of the controversies about them, GPOs generally limit CAFs to the 3%. Regardless, note that the providers' equilibrium price is unaffected by the size of the CAF. In other words, to the extent that a GPO can generate

profits through CAFs, these profits are extracted from the manufacturers' profits, not the providers' surplus.

Another possible source of revenue (or cost recovery) for GPOs is to charge their provider-members a fixed contracting fee. Some GPOs do so. Our analysis indicates that as long as the total membership fees are lower than  $c_d$ , the providers still benefit from forming a GPO, and they will pay the same equilibrium prices. In addition, GPOs offer a wide range of additional business services to their members that can be used either to generate profit or to offset contracting costs.

Finally, given a nominal profit, (4), it is clear, given the pervasiveness of the 3% CAF, that for-profit GPOs have an incentive to reduce their own contracting costs,  $c_g$ , compared with their not-for-profit counterparts.

In summary, whether a GPO operates on a profit or not-for-profit basis, the result for providers is the same.

## 9. Discussion

Before discussing our major results, we summarize them:

- Purchasing through GPOs lowers prices for providers (except in the case of a monopolist manufacturer) by lowering transactions costs for providers and manufacturers and by intensifying price competition between the manufacturers. Asymmetry in preference does not affect this result.
- The existence of lower off-contract prices is not, in and of itself, evidence of anticompetitive behavior on the part of the GPO. Indeed, we provide conditions under which a GPO lowers off-contract prices, again, by intensifying competition.
- By increasing price competition, GPOs reduce the manufacturers' incentives to introduce innovations to existing products.
- Eliminating the "Safe Harbor" provisions will not change any party's profit or cost. Nor will it resolve the innovation dampening effect of the GPO.

Although these results are mathematically unambiguous, they must be interpreted in view of the gaps between the simplicity of our model and the complexity of the real world of GPOs. We believe that most of our results will hold if these complexity gaps are narrowed in subsequent research, and we provide some reasons below. However, confirmation requires more research. We organize this discussion around assumptions about providers, assumptions about manufacturers, and other artifacts of our analysis.

We assume a single GPO acting as a Stackelberg leader. In fact, there are hundreds of GPOs; it is our understanding that the price competition is intense among them. Hence, we believe that if it were possible to include several competing GPOs in our model, this competition would provide even lower prices to providers. With respect to the contracting process, our understanding is that on-contract prices are negotiated, with neither the manufacturer nor the GPO as leader. Although we are, so far, unable to model this negotiation, in a forthcoming paper (Hu et al. 2009), we have developed a similar model with the manufacturer as Stackelberg leader, and obtained similar results: the presence of a GPO lowers prices for providers.

Another simplifying assumption of our model is that although the GPO enjoys economies of scale in transactions cost/contract compared with manufacturers and providers, our model doesn't account for economies of scale as a function of the number of members that belong to a GPO, or, better still, the total dollars a GPO has under contract. The dominance of a few large GPOs in the marketplace suggests that these economies of scale might be very significant. Within the context of our model, such economies of scale would decrease  $c_g$ , which, as implied by Lemma 2, will enable the GPO to charge a larger CAF, increase the manufacturers' profit, but not change providers' costs.

As noted, our results hold regardless of whether the GPO is run for-profit or not-for-profit, since GPOs' profits, if any, are extracted from the manufacturers' profits, not from the providers. However, this does not imply that for-profit and not-for-profit GPOs are the same. Similarly, our results indicate that our results do not change if CAFs were simply transferred from the buyer side to the seller side of a GPO's business. However, there are other methods that GPOs might use to replace CAF revenue from manufacturers (e.g., membership fees). Hence, this result, too, requires further analysis. More generally, we have not addressed non-price mechanisms that GPOs use to attract and retain members.

Our model assumes a continuum of providers, all of the same size. In fact, in the United States, there are a few dozen very large providers, hundreds of large providers, and thousands of small providers. Very large providers are in a position to enjoy their own economies of scale in transactions cost, and, because of large volumes, are sometimes in a position to negotiate substantial discounts when buying direct from manufacturers. (According to Burns and Lee (2008), such very large providers still belong to GPOs, but use GPO on-contract prices as a starting point for negotiating directly with manufacturers.) On the other hand, small providers may simply be incapable of contracting directly with manufacturers. Hu et al. (2009) capture this issue.

Our model also assumes that providers are shopping for a single product, whereas a typical acute-care hospital buys literally thousands of different products. GPOs take advantage of this fact by grouping products into bundles of products, often from different competitors. By carefully selecting the bundles and prices of the products in them, GPOs are able to increase demand (and compliance) for otherwise less-preferred products or for products whose ordinary on-contract price is not competitive. These characteristics of the marketplace also remain to be examined.

Finally, it should be noted that our results indicate that providers will purchase all of their requirements either on-contract or off-contract; and, similarly, that manufacturers will sell all their products either direct or through a GPO. Although such behavior is observed for some providers and/or manufacturers, mixed sourcing and supply are also observed. The analysis of this phenomenon waits for sophisticated models.

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