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Strategic Delegation in a Multiproduct Mixed Industry

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We examine strategic delegation in a multiproduct mixed duopoly with nonprofit organization (NPO) and for-profit organization (FPO). We will demonstrate that the nonprofitable mission service can reduce both the interest conflicts between the NPO and FPO owners and those between the NPO owner and self-benefited manager. The profit orientation in the compensation schemes will vary with different relative costs. Although the NPO owner may have a different objective from the FPO owner, they all end up having their managers raise their prices and reducing competition in the profitable market. Moreover, as the regulated price of mission service increases, both firms will charge more for their profitable services, but the owner of NPO could still overcompensate her or his manager, when the indirect impact on increasing the conflict of interest is higher than the direct impact on price.

1. INTRODUCTION

This paper studies strategic delegation in a multiproduct mixed duopoly with a private nonprofit firm (nonprofit organization (NPO) and a private profit maximizing firm (for-profit organization (FPO). The altruistic concern of the NPO owner creates an interest conflict between the owner and self-benefit-oriented manager.[1] Previous research showed that the owner of the private firm will set the incentive contract to reduce market competition, whereas the owner of the public firm seeks to increase it (Barcena-ruiz, 2009). The main contribution of this paper is to demonstrate that, when providing multiple services (profitable and nonprofitable), the NPO owner may overcompensate or undercompensate the manager for profit in the managerial compensation scheme, but she or he will all end up having the managers behave less aggressively in the profitable market.

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Under a regular oligopoly framework, Fershtman and Judd (1987) pointed out that when firms compete in prices, the owners will overcompensate their managers at the margin for profits, thus inducing less aggressive prices than under the regular profit-maximization hypothesis. In other words, with ownership and control separated, the profit maximizing owner behaves like a Stackelberg leader vis-a-vis the other firm's manager, through choosing the profit orientation in the managerial compensation scheme.

Extending this discussion to mixed oligopolies is interesting, as there will be two kinds of interest conflicts: between the NPO and FPO owners and between the NPO owner and self-benefited manager. Given that the FPO owner will choose her or his compensation scheme to increase prices, will the NPO owner set a more aggressive incentive scheme to offset this strategic impact from the FPO owner, thus enlarging the interest conflict between the NPO owner and self-benefited manager? The existing literature has provided answers to this question. Under quantity competition, Barros (1995) showed that the owner of NPO firm would choose a higher weight on revenue. Goering (2007) showed that the NPO owners will commit their manager to a more aggressive course of action, which increases their market share and total output. Heywood and Ye (2009) extended Barros' setup by considering multiple private firms. They showed that the optimal incentive contract for a public firm may either increase or decrease welfare depending on the number of private firms and the exact nature of costs.

It seems that the aggressiveness in the product market is directly affected by the profit orientation in the managerial compensation. Under a regular oligopoly framework, both FPO owners *over*compensate (for profits) and both managers behave *less* aggressively (Fershtman and Judd, 1987); under a mixed oligopoly framework, the NPO owner chooses a *higher weight on revenue* and commits her or his manager to a *more* aggressive course of action, which increases their market share and total output (Barros, 1995; Goering, 2007). This linkage between managerial compensation and market performance, however, will become more complicated when we consider the provision of multiple services.

It is commonly seen that NPOs provide mission-related services such as charity service or community health education. As these services are usually nonprofitable, FPOs would not provide them.[2] Horwitz (2005) recorded that NPO hospitals often provide both profitable and mission services. In particular, Lindrooth and Weisbrod (2007) studied hospices and found out that people freely choose between the profitable and nonprofitable facilities. Troyer (2002) also pointed out that in nursing homes, patients often choose between self-insured and Medicaid programs.

We will demonstrate that the nonprofitable mission service will reduce both of the two interest conflicts in the mixed oligopolies, so that the NPO owner need not necessarily set a more aggressive incentive scheme to offset this strategic impact from the FPO owner. Moreover, because the manager will adjust his or her product mix to maintain cost efficiency, the NPO owner may overcompensate or undercompensate the manager for profits in the managerial compensation scheme. However, she or he will all end up having the manager behave less aggressively in the profitable market.

Specifically, we consider a mixed duopoly with an NPO and an FPO, and the NPO provides both a profitable mission service and a nonprofitable mission service. Following the literature on strategic delegation (Fershtman and Judd, 1987; Sklivas, 1987), it is assumed that both owners adopt a linear compensation scheme consisting of both profit and revenue. Different from the existing discussions on mixed oligopolies (Goering, 2007), we will demonstrate that providing the mission service gives the manager of NPO an opportunity to coordinate his or her service mix. When profitable service is cheaper than mission service, the manager of NPO will adjust his or her product mix to produce more profitable service for more profits. For the NPO owner with an altruistic concern, providing the mission service would give her or him leeway to reduce the interest conflict between the NPO owner and manager through an undercompensated scheme at the margin for profits. Moreover, as the price of mission service is often regulated and bounded above by an upper limit, our result will show that as this price limit increases, both firms will charge more for their profitable services, but the owner of NPO could still overcompensate her or his manager, when the indirect impact on increasing the conflict of interest is higher than the direct impact on price.

The remainder of this paper proceeds as follows. In Section 2, we present a mixed duopoly where an NPO provides both profitable and nonprofitable mission services and competes with an FPO only in the profitable service. The delegation process takes two stages. In the first stage, the owners of NPO and FPO simultaneously determine their compensation schemes. After observing these schemes, in the second stage, the two managers compete in the product market to maximize their compensation. In Sections 3 and 4, we characterize the subgame perfect equilibrium and discuss the equilibrium properties of the market prices and managerial compensation. Section 5 concludes the paper.

2. THE MODEL

We consider a mixed duopoly with an NPO and an FPO, and the NPO provides both a profitable mission service and a nonprofitable mission service. For example, Horwitz (2005) recorded that NPO hospitals often provide both profitable and mission services. In particular, Lindrooth and Weisbrod (2007) studied hospices and found out that people freely choose between the profitable and nonprofitable facilities. Troyer (2002) also pointed out that in nursing homes, patients often choose between self-insured and Medicaid programs.

To describe the fact that in a multiproduct mixed duopoly consumers can freely choose between profitable and mission services, we consider the following

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linear demand function with differentiated products (Dixit, 1979; Singh and Vives, 1984). Specifically, let 1 and 2 indicate the NPO and FPO, respectively. x denotes the profitable service, and y denotes the nonprofitable mission service. Moreover, let Q_i^k and p_i^k denote firm i's demand and price for the service k for $k = x, y$.

$$\begin{aligned} Q_1^x\left(p_1^x, p_2^x, p_1^y\right) &= A - p_1^x + ap_2^x + \delta p_1^y, \\ Q_2^x\left(p_1^x, p_2^x, p_1^y\right) &= A - p_2^x + ap_1^x + \delta p_1^y, \\ Q_1^y\left(p_1^x, p_2^x, p_1^y\right) &= \hat{A} - p_1^y + \delta p_1^x + \delta p_2^x. \end{aligned}$$

The term $A\ (\hat{A})$ indicates the market scale for the profitable (mission) service. Essentially, the service demand Q_i^k depends on the prices of all three services; firm i's profitable service is an imperfect substitute to firm j's profitable service and the NPO firm's mission service. For simplification, we assume a unit own-price effect for all three services (that is, the parameter of p_i^k is one in Q_i^k). To distinguish the competition between the two profitable services and between the profitable and mission services, we use a parameter a to denote the cross-price effect between the two profitable services and δ to denote the cross-price effect between the profitable and mission services. For simplification, we assume $0 < \delta < a < 1$.

For the supply side, assume that firm i's production cost for service k is a linear cost function $c_i^k Q_i^k$, for $i = 1, 2$ and $k = x, y$, where $0 < c_i^k < A, \hat{A}$.

Hence, firm i's revenue for service k, denoted by R_i^k, is given by

$$R_i^k = p_i^k Q_i^k\left(p_1^x, p_2^x, p_1^y\right), \quad \text{for } i = 1, 2 \text{ and } k = x, y,$$

and firm i's profit for service k is hence

$$\pi_i^k = \left(p_i^k - c_i^k\right) Q_i^k\left(p_1^x, p_2^x, p_1^y\right) \text{for } i = 1, 2 \text{ and } k = x, y.$$

With linear demand and cost functions, the profit function is concave in p_i^k.

2.1. Separation of Ownership and Control

Because of the separation of ownership and control, the owners of NPO and FPO will delegate the control right to managers. Although they are different in ownership, many evidences show that they both adopt financial performance-based managerial compensations (Lambert and Larcker, 1995; Brickley and Van Horn, 2002; Eldenburg *et al.*, 2004). In particular, Lambert and Larcker (1995) pointed out that NPO firms have increasingly begun to use performance-based compensation contracts to better align firm and managerial compensation. Brickley and Van Horn (2002) reported that both the turnover and compensation of CEOs in NPO firms are related to return on assets, and the turnover/performance relation appears to be stronger in nonprofit than in for-profit firms.

On the basis of these evidences, we assume that both NPO and FPO adopt a financial performance-based compensation scheme. Following Fershtman and Judd (1987) and Sklivas (1987), we consider a linear incentive contract that consists of both profit and revenue. This form is adopted by Barros (1995) and Goering (2007) to analyze the managerial compensation in a mixed duopoly with NPO and FPO firms. Both articles show that the delegation of control right can serve as a strategic variable that improves the competitiveness and social welfare in a mixed duopoly. In this paper, we will demonstrate that in a multiproduct context, the delegation of control right can motivate the NPO manager to arbitrage between the two services, ending up charging more for the profitable service.

The delegation process takes two stages. In the first stage, the owners of NPO and FPO simultaneously determine their compensation schemes. After observing these schemes, in the second stage, the two managers compete in the product market to maximize their compensation.

The Fershtman and Judd compensation scheme is a mixture of profit and revenue. The weight used in the scheme will be determined in equilibrium. As there is no restriction on the weight, we do not preclude the possibility that the owners choose the traditional compensation. Also, it is important to notice that there is no hidden action or information in the process. Our focus, like the other literature on strategic delegation, is to show that a firm's owner can write a contract with a manager that may advance the firm's strategy position beyond what could be achieved when the manager is instructed to maximize the firm's profit. Hence, the profit maximizing owners will never tell their managers to maximize profits. When the agency cost (hidden action or information) is taken into account, the qualitative properties of the equilibrium will sustain if the hidden action or information does not diverge the manager's preference too much.

Managerial scheme. As in Fershtman and Judd 1987), we will consider the following linear scheme for the self-benefited managers. Let β_i and $1 - \beta_i$, $i = 1, 2$, denote the weights for profit and revenue, respectively. The compensation schemes for managers 1 and 2 are given as follows.

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$$\max_{p_1^x, p_1^y} M_1\left(\beta_1, p_1^x, p_2^x, p_1^y\right) = \beta_1\left(\pi_1^x + \pi_1^y\right) + (1-\beta_1)\left(R_1^x + R_1^y\right),$$
$$\max_{\mathrm{p}^{2\mathrm{x}}} M_2\left(\beta_2, \mathrm{p}_1^{\mathrm{x}}, \mathrm{p}_2^{\mathrm{x}}, \mathrm{p}_1^{\mathrm{y}}\right) = \beta_2\pi_2^x + (1-\beta_2)\mathrm{R}_2^{\mathrm{x}}.$$

As the managers are self-benefited, both managers will choose prices to maximize their compensation. There is no restriction on β_i, so it is possible that in the equilibrium the owner will end up choosing the traditional compensation with $\beta_i = 1$.

Our main purpose is to demonstrate that the provision of the mission service will change both owners' decisions on β_i. This linear compensation scheme will suffice for us to demonstrate the multiproduct effect on managerial compensation. As hidden action or information is not considered in this format, a two-part tariff (consisting of fixed and variable components) will not add in too many insights to a risk neutral manager's decision, and the fixed component will be set to zero in equilibrium.

Literally, the price of nonprofitable or mission service will be restricted and bounded by an upper bound, say, $\bar{p}^y$. For completeness, we will discuss both of the cases when $\bar{p}^y$ is not binding and when it is binding.

Owner's objective. There is no universal setup for the objectives of NPOs. Empirically, early papers such as Newhouse (1970), Pauly and Redisch (1973), and Dusansky and Kalman (1974) have noticed that nonprofitable hospitals may have a different objective than profit maximization. Newhouse (1970) assumed that an NPO maximizes the total number of patients treated. Deneffe and Masson (2002) discovered that nonprofitable hospitals take both profits and outputs as objectives. Horwitz and Nichols (2007) showed that the Newhouse model is supported by the data with a mix of profitable and mission services. Therefore, the objective of NPO is assumed to be a mixture of profit and demand (quantity). This form is also adopted by Lakdawalla and Philipson (1998), Calem *et al*. (1999), Philipson and Posner (2009), Gaynor and Vogt (2003) and Harrison and Lybeckery (2005).

Specifically, let $0 < (1-\theta) < 1$ denote the NPO's 'altruistic' concern, so the objective of the NPO owner (owner 1) is

$$\max_{\beta_1} \theta\left(\pi_1^x + \pi_1^y\right) + (1-\theta)\left(Q_1^x + Q_2^x\right) - M_1.$$

For the owner of FPO (owner 2), the objective is

$$\max_{\beta_2} \pi_2^x - M_2.$$

As explained by Fershtman and Judd (1987), the linear compensation scheme will leave the owner to maximize its profit net of the manager's opportunity cost. Notice that the payment to the manager is often not done in the managerial incentive contract literature (as the contract can always be calibrated to equal the manager's opportunity cost and is therefore fixed in value). Barros (1995) and Shy (1996) used this aforementioned setting to describe the usual concept of 'salary'. The main idea is to show that the owner has an incentive to choose a β_i such that this net profit is positive.

By backward induction, we will solve the equilibrium product prices $\left(\left(p_1^x, p_1^y\right), p_2^x\right)$ first and then solve the weights (β_1, β_2) for the compensation schemes. We are interested in how the provision of nonprofitable mission service can affect the equilibrium prices of profitable services and the owners' decisions on their compensation schemes.

3. MARKET EQUILIBRIUM

Given (β_1, β_2), the two managers simultaneously choose their prices $\left(\left(p_1^x, p_1^y\right), p_2^x\right)$ to maximize $M_i\left(\beta_1, p_1^x, p_2^x, p_1^y\right)$ in the product market. Here, we repeat the NPO and FPO managers' maximization problems as follows.

$$\max_{p_1^x, p_1^y} \beta_1\left(\pi_1^x + \pi_1^y\right) + (1-\beta_1)\left(R_1^x + R_1^y\right),$$
$$\max_{p_2^x} \beta_2\left(\pi_2^x\right) + (1-\beta_2)\left(R_2^x\right).$$

In order to demonstrate the impact of price restriction on the mission service, we will present both of the two cases when the upper limit $\bar{p}^y$ is binding and when it is not binding. This upper limit $\bar{p}^y$ can measure the intensity of government intervention. p_1^y can be regulated or subsidized. The more the nonprofitable service is subsidized, the lower this upper limit is.

3.1. When p^y Is Not Binding

When $\bar{p}^y$ is not binding, the marginal conditions for the NPO's and FPO's maximization problems are

$$\begin{aligned}
\beta_1\left(\frac{\partial \pi_1^x}{\partial p_1^x} + \frac{\partial \pi_1^y}{\partial p_1^x}\right) + (1-\beta_1)\left(\frac{\partial R_1^x}{\partial p_1^x} + \frac{\partial R_1^y}{\partial p_1^x}\right) &= 0,\\
\beta_1\left(\frac{\partial \pi_1^x}{\partial p_1^y} + \frac{\partial \pi_1^y}{\partial p_1^y}\right) + (1-\beta_1)\left(\frac{\partial R_1^x}{\partial p_1^y} + \frac{\partial R_1^y}{\partial p_1^y}\right) &= 0,\\
\beta_2\frac{\partial \pi_2^x}{\partial p_2^x} + (1-\beta_2)\left(\frac{\partial R_2^x}{\partial p_2^x}\right) &= 0.
\end{aligned} \tag{1}$$

With multiple services, manager 1 needs to coordinate the prices of the two services, by taking into account

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the marginal cross-effects on the other service. The best replies for firms 1 and 2 are given by

$$\begin{aligned}
p_1^x\left(p_1^y, p_2^x\right) &= \frac{A + ap_2^x + 2\delta p_1^y + \beta_1\left(c_1^x - c_1^y\delta\right)}{2},\\
p_1^y\left(p_1^x, p_2^x\right) &= \frac{\hat{A} + 2\delta p_1^x + \delta p_2^x + \beta_1\left(c_1^y - c_1^x\delta\right)}{2},\\
p_2^x\left(p_1^x, p_1^y\right) &= \frac{A + ap_1^x + \delta p_1^y + \beta_2 c_2^x}{2}.
\end{aligned} \tag{2}$$

Notice first that the price of each service is positively related to the other two prices, indicating that the three services are strategic complements in price competition. The mission service has a slightly different impact from the others. First, p_1^y has a higher positive impact on p_1^x than on p_2^x (as $2\delta > \delta$). Manager 1's coordination between the two services also pushes up the price of firm 2's profitable service. Second, as a result of coordination, there is a cost reduction effect on each price ($c_1^y\delta$ and $c_1^x\delta$ for service x and y, respectively). Notice that the extent of such a cost reduction effect is related to β_i in the compensation scheme.

Let $\left(p_1^{x^*}, p_1^{y^*}, \text{ and } p_2^{x^*}\right)$ denote the equilibrium prices satisfying $p_1^{x^*} = p_1^x\left(p_1^{y^*}, p_2^{x^*}\right)$, $p_1^{y^*} = p_1^y\left(p_1^{x^*}, p_2^{x^*}\right)$, and $p_2^{x^*} = p_2^x\left(p_1^{x^*}, p_1^{y^*}\right)$ simultaneously. Proposition 1 summarizes the comparative statics on the profit orientation in the compensation schemes.

Proposition 1

(i) All equilibrium prices $\left(p_1^{x^*}, p_1^{y^*}, p_2^{x^*}\right)$ increase with β_2. (ii) The impacts of β_1 will depend on the relative sizes of c_1^x and c_1^y.

Proof

(i) From the best replies in Equation (2), as β_2 increases, the best reply of p_2^x shifts up. Because of strategic complementation, the prices of all three services will all increase. (ii) The impact of β_1 depends on the signs of $\left(c_1^x - c_1^y\delta\right)$ and $\left(c_1^y - c_1^x\delta\right)$. Notice that $\delta < 1$. There are three possibilities. If $c_1^y > \frac{c_1^x}{\delta}$, then $\left(c_1^x - c_1^y\delta\right) < 0$ and $\left(c_1^y - c_1^x\delta\right) > 0$. As β_1 increases, the best reply of p_1^x moves down and that of p_1^y shifts up. So p_1^{y*} will increase, but p_1^{x*} will decrease. Similarly, if $\delta c_1^x < c_1^y < \frac{c_1^x}{\delta}$, then both terms are positive. As β_1 increases, all prices will increase. Next, if $c_1^y < \delta c_1^x$, then as β_1 increases, the best reply function of p_1^x shifts up and that of p_1^y moves down. p_1^{x*} will increase, but p_1^{y*} will decrease. Finally, the case when $\left(c_1^x - c_1^y\delta\right) < 0$ and $\left(c_1^y - c_1^x\delta\right) < 0$ does not exist for $\delta < 1$. ■

To see why β_1 and β_2 have different impacts on the equilibrium prices, let us first rewrite M_2 as

$$R_2^x - \beta_2 c_2^x Q_2^x\left(p_1^x, p_2^x, p_1^y\right).$$

With this form, manager 2 is encouraged to increase the price as the effective cost increases with β_2. Likewise, the effective cost in M_1 is $\beta_1\left(c_1^x Q_1^x + c_1^y Q_1^y\right)$. However, as manager 1 can coordinate x and y services, she or he will produce more of the cheaper service and less of the expensive one. As x and y are imperfect substitutes, a unit of y service is equivalent to δ unit of x service. Hence, when β_1 increases and if c_1^y is relatively cheap (range I in Figure 1), firm 1 will produce less service x and more service y (corresponding to higher p_1^x and smaller p_1^y); if c_1^y is relatively expensive (range III), then p_1^x decreases and p_1^y increases; if c_1^y is in the intermediate range II, then both p_1^x and p_1^y will increase.

3.2. When p^y Is Binding

In this case, the second condition in Equation (2) no longer exists. The best replies for firm 1 and firm 2 are given by

$$\begin{aligned}
p_1^x\left(\bar{p}^y, p_2^x\right) &= \frac{A + ap_2^x + 2\delta\bar{p}^y + \beta_1\left(c_1^x - c_1^y\delta\right)}{2},\\
p_2^x\left(p_1^x, \bar{p}^y\right) &= \frac{A + ap_1^x + \delta\bar{p}^y + \beta_2 c_2^x}{2}.
\end{aligned} \tag{3}$$

Let $\left(\hat{p}_1^x, \hat{p}_2^x\right)$ denote the equilibrium prices that simultaneously satisfy $\hat{p}_1^x = \hat{p}_1^x\left(\hat{p}_2^x, \bar{p}^y\right)$ and $\hat{p}_2^x = \hat{p}_2^x\left(\hat{p}_1^x, \bar{p}^y\right)$, where

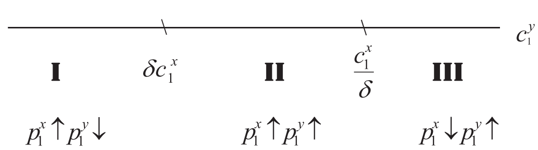

Figure 1. Different levels of c_1^y.

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$$\hat{p}_1^x = \frac{(2+a)A + (4+a)\delta\bar{p}^y + a\beta_2 c_2^x}{4-a^2} + \frac{2\beta_1\left(c_1^x - c_1^y\delta\right)}{4-a^2}, \tag{4}$$

$$\hat{p}_2^x = \frac{(2+a)A + (1+a)2\delta\bar{p}^y + a\beta_1\left(c_1^x - c_1^y\delta\right)}{4-a^2} + \frac{2\beta_2 c_2^x}{4-a^2}. \tag{5}$$

Proposition 2 summarizes the comparative statics on the profit orientation in the compensation schemes.

Proposition 2

(i) Both $\hat{p}_1^x$ and $\hat{p}_2^x$ increase with β_2. (ii) The impacts of β_1 will depend on the relative sizes of c_1^x and c_1^y.

Proof

The arguments for parts (i) and (ii) are similar to those in Proposition 1. ▪

In this case, manager 1 loses the freedom of adjusting sale through changing p_1^y. However, x and y are still imperfect substitutes, so when β_1 increases and if c_1^y is relatively cheap (range I in Figure 1), manager 1 will increase p_1^x, thus relatively increasing the sale for the y service although whose price is fixed at $\bar{p}^y$. The other two ranges in Figure 1 no longer matter, because p_1^y is now fixed and its strategic impact only occurs in range I.

Proposition 3

Increasing $\bar{p}^y$ has a higher positive effect on $\hat{p}_1^x$ than on $\hat{p}_2^x$.

Proof

Observe that as $\bar{p}^y$ increases, the best replies of p_1^x and p_2^x in Equation (3) both shift up, and the best reply of p_1^x shifts upward twice more than that of p_2^x. Hence, we have $0 < \frac{\partial \hat{p}_2^x}{\partial \bar{p}^y} < \frac{\partial \hat{p}_1^x}{\partial \bar{p}^y}$. ▪

Given that p_1^y has the same cross-price effect (δ) on $Q_1^x\left(p_1^x, p_2^x, p_1^y\right)$ and $Q_2^x\left(p_1^x, p_2^x, p_1^y\right)$, it is interesting to see why increasing $\bar{p}^y$ has a higher positive effect on $\hat{p}_1^x$. Again, this is due to the provision of multiple services. In M_1, manager 1 chooses p_1^x to maximize the sum: $\left(R_1^x + R_1^y\right) - \beta_1\left(c_1^x Q_1^x + c_1^y Q_1^y\right)$. Although p_1^y has the same cross-price effect on Q_1^x and Q_2^x, when determining p_1^x, manager 1 needs to take into account its impact on service y. Given that both x and y are imperfect substitutes, the impact on service y is equivalent to δ times the impact on service x. This explains why in Equation (3) the parameter of $\bar{p}^y$ in $p_1^x\left(\bar{p}^y, p_2^x\right)$ is 2δ and that in $p_2^x\left(\bar{p}^y, p_1^x\right)$ is δ.

Next, as firm 1 provides two services and the price for the mission good is restricted by $\bar{p}^y$, it is interesting to know if firm 1 will raise the price of the profitable service to compensate the loss or little profit from the mission good. That is, we ask if 'cross-subsidization' will happen in this case. The result in Proposition 3 has provided us a negative answer. This is because the mission service is a substitute to the profitable service. With $\delta > 0$, when the regulated price $\bar{p}^y$ is decreased, the degree of competition between the two profitable services also decreases, and hence both $\hat{p}_1^x$ and $\hat{p}_2^x$ will decrease. Cross-subsidization only happens when the mission service is a complement to profitable services (i.e., $\delta < 0$). Finally, as $\bar{p}^y$ can measure the intensity of government intervention, Proposition 3 says that this intervention in the mission good service can help reduce the degree of competition between the profitable services.

Overall, when providing multiple services, manager 1 can coordinate her or his product mix. When the price restriction on the mission service is not binding, manager 1 can strategically adjust both of the profitable and mission service prices, to take advantage of the cost (effective) difference between the two services. This partly reflexes the observation by Eldenburg and Kallapur (1997) and Hsu and Qu (2010) that firms under a dual payment system often change their patient mix and cost allocation as a tool for revenue management.

In particular, we showed that as β_1 increases, p_1^x can increase or decrease, depending on the relative size of c_1^y. Fershtman and Judd (1987) demonstrated that with price competition, managers will choose $\beta_i > 1$ to overcompensate for profit in the compensation scheme. The overcompensation for profit can also be interpreted as an owner's tax on the manager, which disciplines and prevents the manager from being too aggressive in his or her pricing strategy. In a multiproduct context of mixed duopoly, will the owners of NPO and FPO still overcompensate toward profit in the compensation schemes? Given the altruistic concern of NPO owner, will the owner undercompensate to increase competition and thus increase the total service? How does the intensity of government intervention (negatively related to $\bar{p}^y$) affect the decisions on β_i? We will provide answers to these questions by characterizing the owners' decisions on (β_1,β_2).

4. EQUILIBRIUM COMPENSATION SCHEME

Given the equilibrium prices in Section 3, we now characterize (β_1,β_2) in the compensation schemes. To

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simplify the analysis, we concentrate on the case when $\bar{p}^y$ is binding. Given $(\hat{p}_1^x, \hat{p}_2^x)$ in Equations (4) and (5), the NPO and FPO owners' maximization problems are repeated as follows.

$$\begin{aligned}&\max_{\beta_1} \theta(\pi_1^x + \pi_1^y) + (1-\theta)(Q_1^x + Q_1^y) - M_1,\\&\max_{\beta_2} \pi_2^x - M_2.\end{aligned} \tag{6}$$

Denote $\hat{\beta}_1$ and $\hat{\beta}_2$ as the equilibrium profit weights in the NPO's and FPO's compensation scheme, respectively. As the explicit forms of $\hat{\beta}_1$ and $\hat{\beta}_2$ are too complicated to have unambiguous insights, we will examine the properties of $\hat{\beta}_1$ and $\hat{\beta}_2$ in the following way.

First, notice that there are two terms in each owner's objective function: the owner's value and the managerial compensation. Second, as the owners and managers face the same market prices, if $(\hat{p}_1^x, \hat{p}_2^x)$ can maximize the owner's objectives in (6), then the following equations ought to be satisfied at $(\hat{p}_1^x, \hat{p}_2^x)$. Specifically, for firm 1:

$$\theta \frac{\partial(\pi_1^x + \pi_1^y)}{\partial p_1^x} + (1-\theta)\frac{\partial(Q_1^x + Q_1^y)}{\partial p_1^x} = 0, \tag{7}$$

$$\beta_1 \frac{\partial(\pi_1^x + \pi_1^y)}{\partial p_1^x} + (1-\beta_1)\frac{\partial(R_1^x + R_1^y)}{\partial p_1^x} = 0. \tag{8}$$

Equation (7) is the partial differentiation of owner 1's value, $\theta(\pi_1^x + \pi_1^y) + (1-\theta)(Q_1^x + Q_1^y)$, and Equation (8) is the partial differentiation of manager 1's compensation. Notice that Equation (8) is identical to the first line in Equation (1). Obviously, the second term at the left-hand side (LHS) of Equations (7) and (8) are not the same. To have them both satisfied at the same prices, we have to adjust β_1.

Similarly, for firm 2, we have

$$\frac{\partial(\pi_2^x)}{\partial p_2^x} + 0 = 0, \tag{9}$$

$$\beta_2 \frac{\partial(\pi_2^x)}{\partial p_2^x} + (1-\beta_2)\frac{\partial(R_2^x)}{\partial p_2^x} = 0. \tag{10}$$

Equation (9) is the partial differentiation of owner 2's value π_2^x , and Equation (10) is the partial differentiation of manager 2's compensation. Notice that Equation (10) is identical to the third line in Equation (1). As described, the second term at the LHS of Equations (9) and (10) are not the same, and one way to have both equalities satisfied is to modify β_2.

Determination of $\boldsymbol{\beta_1}$. Suppose temporarily that β_1 was set to be θ. Then the difference between Equations (7) and (8) is only on their second terms: $\frac{\partial(Q_1^x+Q_1^y)}{\partial p_1^x}$ and $\frac{\partial(R_1^x+R_1^y)}{\partial p_1^x}$. Notice first that $\frac{\partial Q_1^x}{\partial p_1^x} < \frac{\partial R_1^x}{\partial p_1^x} < 0$ from the demand function. So we have $\frac{\partial(Q_1^x+Q_1^y)}{\partial p_1^x} < \frac{\partial(R_1^x+R_1^y)}{\partial p_1^x}$. In other words, if β_1 was set to be θ, then the LHS of Equation (7) will be less than that of Equation (8). By the concavity of the objective function, the price satisfying Equation (8) is less than the price satisfying Equation (7).

One way to have both equalities satisfied at the same equilibrium prices is to modify β_1. However, whether β_1 ought to be set higher or lower than θ will depend on the relative sizes of c_1^x and c_1^y. From the discussion in Proposition 2, if the cost for the mission service is not too high (i.e., $c_1^x - c_1^y\delta > 0$), then the best reply of p_1^x will shift up with the increase of β_1. Given that the price satisfying Equation (8) is higher, owner 1 should set β_1 to be higher than θ, thus pushing up p_1^x.

If the cost for mission service is sufficiently high (i.e., $c_1^x - c_1^y\delta < 0$), then the best reply of p_1^x will shift downward with the increase of β_1. Given that the price satisfying Equation (8) is higher, owner 1 should set β_1 to be lower than θ, thus pushing up p_1^x.

Determination of $\boldsymbol{\beta_2}$. Notice that the difference between Equations (9) and (10) is on their second terms: 0 and $\frac{\partial(R_2^x)}{\partial p_2^x}$. With a linear demand function, we have $\frac{\partial(R_2^x)}{\partial p_2^x} < 0$. Hence, for all $0 < \beta_2 < 1$, the LHS of Equation (9) will be greater than that of Equation (10). By the concavity of the objective function, the price satisfying Equation (9) is less than the price satisfying Equation (10). As this is true for all $0 < \beta_2 < 1$, decreasing β_2 to push down p_2^x cannot let both equalities be satisfied at the same price. Alternatively, we can set $\beta_2 > 1$, in which case, both equalities can be satisfied simultaneously. Proposition 4 and Corollary 5 summarize our findings on the profit orientation in the compensation schemes.

Proposition 4

In the equilibrium, (i) $\hat{\beta}_1$ is greater or less than θ, depending on the relative sizes of c_1^x and c_1^y. (ii) $\hat{\beta}_2$ is greater than 1.

Part (i) of this proposition says that the owner of NPO can also overcompensate the manager, just as its FPO counterpart. Should not the NPO's altruistic concern lead the owner to set a $\hat{\beta}_1$ smaller than θ, so that there will be more outputs served at lower equilibrium prices? The key reason relies on the provision of multiple services. Remember from Proposition 1 that when β_1 increases and if the mission service is

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relatively expensive, then manager 1 will produce more service x and less service y (corresponding to smaller p_1^x and higher p_1^y). Now, from the derivation of β_1, in this case, owner 1 will actually set a β_1 lower than θ (a decrease from θ), thus pushing up p_1^x. On the other hand, if c_1^y is relatively cheap (range III), then manager 1 will produce less service x and more service y (corresponding to higher p_1^x and smaller p_1^y). Now, from the derivation of β_1, owner 1 will set a β_1 greater than θ (an increase from θ) and also push up p_1^x.

When the mission service is relatively expensive, owner 1 will *undercompensate* manager 1 for the profit in the compensation scheme, and when the mission service is relatively cheap, owner 1 will *overcompensate* manager 1 for the profit. In both cases, p_1^x will be pushed up. The NPO's altruistic concern has indeed restricted the choice of β_1 to be close to θ. The NPO owner knows that with multiple services, manager 1 will adjust his or her product mix to ensure the cost efficiency. The choice of β_1 is altered accordingly to reach the goal of increasing p_1^x. In other words, for the profitable services, the NPO owner behaves the same as the FPO owners qualitatively, that is, to reduce competition and enhance equilibrium prices. The choice of overcompensation or undercompensation in the compensation scheme will depend on the relative costs of the two services.

Corollary 5

Both $\hat{p}_1^x$ and $\hat{p}_2^x$ are higher than in the regular mixed duopoly (when $\beta_1 = \theta$ and $\beta_2 = 1$).

Proof

(i) From Equation (4), $\frac{\partial \hat{p}_1^x}{\partial \beta_1} \lesseqgtr 0$, depending on whether $c_1^x - c_1^y \delta \lesseqgtr 0$. But for both cases, $\hat{p}_1^x$ is higher than that for $\beta_1 = \theta$.(ii) From Equation (5), $\frac{\partial \hat{p}_2^x}{\partial \beta_2} > 0$. As $\hat{\beta}_2 > 1$, $\hat{p}_2^x$ is higher than that for $\beta_2 = 1$. ∎

When providing multiple services, the profit orientation in the compensation schemes will vary with different relative costs. However, they all end up having their managers raise their prices and reducing competition in the profitable market. Although the NPO owner may have a different objective from the FPO owner, their altitudes in the profitable market are the same. With multiple services, the manager can divert part of the interest conflict with the owner to the nonprofitable mission service.

With a single service, Barros (1995) considered strategic delegation in a mixed industry with the Cournot competition. It is demonstrated that the owner of the public firm encourages its manager to behave more aggressively than the owner of the private firm. Hence, the use of an optimal incentive contract for the public firm can increase welfare. Heywood and Ye (2009) extended Barros' setup by considering multiple private firms. They showed that the optimal incentive contract for a public firm may either increase or decrease welfare depending on the number of private firms and the exact nature of costs. When the number of private firms is large and the cost is small, 'the public firm actually produces less than a private firm. When the public owner uses an incentive contract, then its output increases and that of all other private firms decrease. The net effect is an increase in total output and hence welfare' (p. 77). Finally, in a mixed industry with heterogenous price competition, Barcena-ruiz (2009) showed that the owner of the private firm tries to *reduce* market competition, whereas the owner of the public firm seeks to *increase* it.

The following proposition describes the effect of decreasing the intensity of government intervention.

Proposition 6

As $\bar{p}^y$ increases, (i) $\hat{\beta}_1$ will increase or decrease, depending on the extent that $\bar{p}^y$ increases the conflict of interest between owner 1 and manager 1; (ii) $\hat{\beta}_2$ will decrease.

Proof

(i) Suppose temporarily that β_1 was set to be θ. The difference between Equations (7) and (8) is $\frac{\partial\left(R_1^x + R_1^y\right)}{\partial p_1^x} - \frac{\partial\left(Q_1^x + Q_1^y\right)}{\partial p_1^x}$, which is $Q_1^x + \frac{\partial Q_1^x}{\partial p_1^x}\left(p_1^x - 1\right) + \frac{\partial Q_1^y}{\partial p_1^x}(\bar{p}^y - 1)$. $\bar{p}^y$ has two effects. First, as $\frac{\partial Q_1^y}{\partial p_1^x} = \delta > 0$, by concavity of the objective function, the price satisfying Equation (8) is less than the price satisfying Equation (7). Let Φ denote the partial differentiation[3] of $\theta \frac{\partial\left(\pi_1^x + \pi_1^y\right)}{\partial p_1^x} + (1 - \theta)\frac{\partial\left(R_1^x + R_1^y\right)}{\partial p_1^x}$ with respect to p_1^x. The indirect price shortage caused by $\bar{p}^y$ is hence $\Phi^{-1}(\delta)$, where Φ^{-1} denotes the inverse of Φ. Second, as $\bar{p}^y$ increases, there is a direct positive effect on the market price $\hat{p}_1^x$. Namely, from Equation (3), $\frac{\partial \hat{p}_1^x}{\partial \bar{p}^y = \frac{(4+a)\delta}{4-a^2}}$. The impact on β_1 hence depends on the relative sizes of direct and indirect effects. If $\Phi^{-1}(\delta) > \frac{(4+a)\delta}{4+a^2}$, then β_1 should increase, thus eliminating the price shortage. On the other hand, if $\Phi^{-1}(\delta) > \frac{(4+a)\delta}{4+a^2}$, then β_1 should decrease, thus eliminating the excess positive effect on p_1^x.

(ii) For the effect on β^2, the difference between Equations (9) and (10) is $\frac{\partial\left(R_2^x\right)}{\partial p_2^x}$. Under linear demand

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function, we have $\frac{\partial(R_2^x)}{\partial p_2^x} < 0$. As $\frac{\partial(R_2^x)}{\partial p_2^x}$ increases with $\bar{p}^y$, the level of β^2 to offset the negative effect of $\frac{\partial(R_2^x)}{\partial p_2^x}$ will decrease. ▪

As the prices of the three services are strategic complements, as $\bar{p}^y$ increases, both p_1^x and p_2^x will increase. For the FPO owner, there is no need to push up p_2^x so much by increasing β^2, and hence, $\hat{\beta}^2$ will decrease with $\bar{p}^y$. For the NPO manager, there will be more space to adjust her or his product mix when $\bar{p}^y$ increases. As mentioned earlier, the altruistic concern in the NPO owner creates an interest conflict with the self-interest oriented manager. Increasing $\bar{p}^y$ will directly increase the equilibrium prices, as shown by Equation (3). It will also indirectly affect the equilibrium prices through increasing the conflict of interest between the owner and manager of NPO (i.e., $\frac{\partial(R_1^x+R_1^y)}{\partial p_1^x} - \frac{\partial(Q_1^x+Q_1^y)}{\partial p_1^x}$). The overall impact of increasing the upper limit of the price of mission service will depend on the relative sizes of these two effects. Proposition 5 says that when the indirect impact on increasing the conflict of interest between the owner and manager of NPO dominates the direct effect on price, the owner of NPO could still overcompensate her or his manager.

5. CONCLUDING REMARKS

We have examined strategic delegation in a multiproduct mixed duopoly with NPO and FPO. Obvious examples for this framework are the medical markets, which feature the coexistence of NPOs and FPOs, and the provision of nonprofitable mission services. We demonstrated that this nonprofitable mission service can reduce both the interest conflicts between the NPO and FPO owners and between the NPO owner and self-benefited manager. Hence, the NPO owner need not necessarily set a more aggressive incentive scheme to offset this strategic impact from the FPO owner.

When providing multiple services, the profit orientation in the compensation schemes will vary with different relative costs. Although the NPO owner may have a different objective from the FPO owner, their altitudes in the profitable market are the same. They all end up having their managers raise their prices and reducing competition in the profitable market. With multiple services, the manager can divert part of the interest conflict with the owner to the nonprofitable mission service. Moreover, as the regulated price of mission service increases, both firms will charge more for their profitable services, but the owner of NPO could still overcompensate her or his manager, when the indirect impact on increasing the conflict of interest is higher than the direct impact on price. This paper contributes to the increasing discussions on managerial compensation in the medical markets (Roomkin and Weisbrod, 1999; Brickley and Van Horn, 2002; Ballou and Weisbrod, 2003; Cornell, 2004; Fisman and Hubbard, 2005; Core *et al*., 2006).

ENDNOTES

1. Note that as argued in Fama and Jensen (1983), there is also conflict of interest in FPOs.
2. The price of unprofitable service is often constrained to be less than its marginal cost to prevent entry by FPOs.
3. This is Equation (6) temporarily replaced by θ.

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