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Pool Revenue Sharing, Team Investments, and Competitive Balance in Professional Sports
A Theoretical Analysis

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Using a contest model of a professional sports league, we show that pool revenue sharing has a negative effect on total expenditure for player talent. There are ''moral hazard'' problems with lower revenue teams in that they may pocket the money they receive from the pool without increasing talent investments. Based on four alternative measures of competitive balance, we find that pool revenue sharing increases the variance of expected winning percentages for a match and thus reduces the degree of competition in the league. Policy recommendations that combine pool revenue sharing with the requirement of a minimum payroll on players are shown to be procompetitive.

Keywords: *pool revenue sharing; competitive balance; professional sports league*

1. Introduction

In the economic analysis of professional team sports leagues, considerable attention has been focused on two important and closely related issues. One concerns whether revenue sharing in a league is able to enhance the league's competitive balance. As indicated by Rottenberg (2000) and others, a sporting competition is more entertaining and of higher quality when the game's outcome is more unpredictable. The other issue concerns how a revenue-sharing scheme affects team owners' investment decisions on player talent and how the resulting distribution of player talent affects the winning percentages of teams in the league. Treating a game in professional team sports as a ''contest'' and using the Nash noncooperative

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solution concept, Szymanski (2003, 2004) and Szymanski and Késenne (2004) examine gate revenue sharing under which home and visiting teams split the gate revenue for each match. These authors find that gate revenue sharing has a negative effect on talent investments by team owners in a professional sports league. Szymanski and Késenne (2004, p. 173) further remark that pool revenue sharing is distinct in structure and thus deserving of separate study. Under pool revenue sharing, each team in a sports league contributes a certain percentage of its locally generated revenue to a pool that is then redistributed equally to all teams. This form of revenue sharing was implemented by Major League Baseball (MLB), with permission from Congress, in 1997. In subsequent years, there has been much speculation as to how the plan influences competitive balance in MLB, player salaries and disparities thereof, and the incentives of small market teams.

In this study, we present a contest model of a professional sports league to analyze issues related to pool revenue sharing. We find that the sharing of pooled revenues within a professional sports league negatively affects total investment in playing talent by team owners in the league. Using four alternative measures of competitive balance, we show that pool revenue sharing also reduces the degree of competition in the league. This finding stands in contrast with the argument that pool revenue sharing enhances competitive balance in professional team sports to justify an exemption from the antitrust laws.

An interesting observation is that the MLB Players' Association (MLBPA) has consistently sought to limit the level of pool revenue sharing in MLB. Such actions indicate that pool revenue sharing is democratically good for teams but bad for players on net. Based on the model of sports contest considered herein, we also find the effect of a policy that combines pool revenue sharing with a minimum team payroll requirement to be procompetitive. Such a policy mix has been considered in recent Major League Baseball Basic Agreements (2002, 2006). However, the latter policy has not been implemented.

The remainder of the article is organized as follows. Section 2 first presents Nash models of talent investments by team owners in a professional sports league with and without the sharing of team revenues. Section 3 presents a graphical analysis to compare equilibrium levels of talent investments in the sharing and nonsharing cases. Section 4 uses an example to illustrate the effect of pool revenue sharing on the competitive nature of a match, using alternative measures of competitive balance. In Section 5, we discuss policy recommendations for enhancing competitive balance in a professional sports league. Section 6 concludes.

2. The Analytical Framework

We consider a simple setting in which a sports league has two types of teams. The first type (denoted as 1) is a higher revenue team whose expected revenue exceeds the average revenue of the league. The other type (denoted as 2) is a lower revenue

team whose expected revenue falls short of the league average. As usual in the sports economics literature, we assume that team owners are profit maximizers. In maximizing profit, each owner of team type $i(i = 1, 2)$ independently and noncooperatively determines his investment in player talent (denoted as t_i). It is plausible to assume that the level of player talent on a team determines the team's quality or strength. Talent (or skill) as the primary input for each team is assumed to be infinitely divisible and common knowledge to all teams. As in many past studies, we assume that the player talent market within a sports league is competitive. The average cost of talent investment t_i for team type i is assumed to be constant at c. This is a tractability assumption made necessary by the complexity of the model's contest success functions and is not realistic when a league enforces restrictions on free agency. In the case of MLB, Vrooman (1996, 1997) notes that restrictions on free agency apparently cause teams to face increasing marginal costs of talent. Clubs employ monopsonized nonveteran players at a low cost, then seek competitively priced talent from the veteran free agent market.

As in previous literature, we treat a sporting competition as a ''contest'' that links the probability of a team's success to its investment in player talent. Furthermore, each team's financial revenue depends not only on its probability of success but also on the level of attendance (i.e., market size) in sports games. Specifically, we assume that the expected revenue for team type 1 is $\sigma R_1(w_1(t_1, t_2))$, where the parameter σ is positive and greater than one, $w_1(t_1, t_2)$ is the team type's expected winning percentage in a match, $\partial R_1/\partial w_1 > 0$, and $\partial^2 R_1/\partial w_1^2 \leq 0$. The expected revenue for team type 2 is $R_2(w_2(t_2, t_1))$, where $w_2(t_2, t_1)$ is the team type's expected winning percentage, $w_2(t_2, t_1) = 1 - w_1(t_1, t_2), \partial R_2/\partial w_2 > 0$, and $\partial^2 R_2/\partial w_2^2 \leq 0$. These assumptions imply that each team type's expected revenue is an increasing but concave function of its expected winning percentage. We use σ to parameterize the ''market size differential'' between the two team types in the league (Quirk & Fort, 1992). Another interpretation of the parameter σ is that type 1 is a ''strong drawing'' team whereas type 2 is a ''weak drawing'' team (Szymanski & Késenne, 2004). We employ a canonical ''contest success function'' to characterize the expected winning percentage of a sports team. The probabilities that team type 1 and team type 2 win in a match are given, respectively, as

$$w_1(t_1, t_2) = \frac{t_1}{t_1 + t_2} \text{ and } w_2(t_2, t_1) = \frac{t_2}{t_1 + t_2}. \tag{1}$$

The expected winning probabilities specified above are in a simple additive form and have been widely used in many fields of economics. It is easy to verify that the expected winning percentages satisfy the following conditions:

$$\frac{\partial w_i}{\partial t_i} > 0; \frac{\partial^2 w_i}{\partial t_i^2} < 0; \frac{\partial w_i}{\partial t_j} < 0; \frac{\partial}{\partial t_j}\left(\frac{\partial w_i}{\partial t_j}\right) = \frac{(t_i - t_j)}{(t_i + t_j)^3} > 0 \text{ if } t_i > t_j, \tag{2}$$

where $i = 1, 2$, $j = 1, 2$, and $i \neq j$. That is, expected winning percentage of a team type increases with its own talent investment, where this effect is subject to diminishing returns. However, the expected winning percentage of team type i decreases with the level of talent investment by team type j, where this effect is subject to diminishing returns if $t_i > t_j$. With no sharing of team revenues, the two teams' profit functions are

$$\Pi^N = \sigma R_1(w_1(t_1, t_2)) - ct_1 \text{ and } \pi^N = R_2(w_2(t_2, t_1)) - ct_2. \qquad (3)$$

The first-order conditions (FOCs) for the teams are given, respectively, as

$$\Pi^N_{t_1} = \left(\sigma \frac{\partial R_1}{\partial w_1} \frac{\partial w_1}{\partial t_1} \right) - c = 0 \text{ and } \pi^N_{t_2} = \left(\frac{\partial R_2}{\partial w_2} \frac{\partial w_2}{\partial t_2} \right) - c = 0, \qquad (4)$$

where $\Pi^N_{t_1} \equiv \partial \Pi^N / \partial t_1$ and $\pi^N_{t_2} \equiv \partial \pi^N / \partial t_2$. The FOCs indicate that each team demands for player talent up to the point at which marginal revenue from talent investment equals marginal cost. These optimality conditions determine the Nash equilibrium levels of skill investment for the two team types, which are denoted as $\{t_1^N, t_2^N\}$. We will use this ''nonpooling Nash equilibrium'' as a benchmark to evaluate alternative outcomes.

Next, we examine the case where teams pool their revenues. MLB adopts the so-called ''straight pool plan'' under which each team contributes a certain percentage of its locally generated revenue to a pool that is then redistributed equally to all teams. With such a pooling scheme, the profit functions for the two team types become

$$\Pi^S = (1 - \theta)[\sigma R_1(w_1(t_1, t_2))] + \frac{\{\theta[\sigma R_1(w_1(t_1, t_2))] + \theta R_2(w_2(t_2, t_1))\}}{2} - ct_1, \qquad (5a)$$

$$\pi^S = (1 - \theta)R_2(w_2(t_2, t_1)) + \frac{\{\theta[\sigma R_1(w_1(t_1, t_2))] + \theta R_2(w_2(t_2, t_1))\}}{2} - ct_2, \qquad (5b)$$

where θ is the share of pooled revenues that each team type contributes and $0 < \theta < 1$. The second term in Equation (5a) or (5b) captures an equal distribution of the MLB Commissioner's Pool.

The profit functions in Equations (5a) and (5b) can easily be rewritten as

$$\Pi^S = \sigma R_1(w_1(t_1, t_2)) - \theta \left[\sigma R_1(w_1(t_1, t_2)) - \frac{\sigma R_1(w_1(t_1, t_2)) + R_2(w_2(t_2, t_1))}{2} \right] - ct_1, \quad (5a')$$

$$\pi^S = R_2(w_2(t_2, t_1)) + \theta \left[\sigma R_1(w_1(t_1, t_2)) - \frac{\sigma R_1(w_1(t_1, t_2)) + R_2(w_2(t_2, t_1))}{2} \right] - ct_2. \quad (5b')$$

These profit functions have interesting implications for the straight pool plan. The higher revenue team is required to transfer a portion θ of its revenue above the league average to the lower revenue team type. The second term in Equation (5a') shows the

''luxury tax'' that team type 1 is required to pay. Symmetrically, the second term in (5b′) shows the ''luxury subsidy'' that team type 2 receives. Pool revenue sharing thus involves a redistribution of locally generated revenues between the two team types in terms of the luxury tax (or subsidy). The tax (or subsidy) rate is the revenue-pooling share θ. Under the current Major League Baseball Basic Agreement (2002, 2006), revenue sharing consists of a base plan and a central fund component. The base plan pools 31% of each team's net local revenue, while the central fund component pools centrally generated operating revenues from activities like broadcasting agreements. Together, these two pooling mechanisms act as a ''48% straight pool plan'' (MLB Basic Agreement, 2006, p. 106). In other words, the currently observed level of θ in MLB is equal to 0.48 for both payer and payee teams.

It follows that the FOCs for the two team types are given, respectively, as

$$\Pi_{t_1}^S = (1 - \frac{\theta}{2})(\sigma \frac{\partial R_1}{\partial w_1} \frac{\partial w_1}{\partial t_1}) + \frac{\theta}{2} (\frac{\partial R_2}{\partial w_2} \frac{\partial w_2}{\partial t_1}) - c = 0, \tag{6a}$$

$$\pi_{t_2}^S = (1 - \frac{\theta}{2})(\frac{\partial R_2}{\partial w_2} \frac{\partial w_2}{\partial t_2}) + \frac{\theta}{2} (\sigma \frac{\partial R_1}{\partial w_1} \frac{\partial w_1}{\partial t_2}) - c = 0. \tag{6b}$$

The FOCs indicate that each team demands player talent up to the level at which the weighted sum of marginal revenues from both team types equals the marginal cost of talent, the weights being equal to $(1 - \theta)/2$ and $\theta/2$. Under such a revenue-sharing scheme, the two team types' Nash equilibrium talent investments must satisfy the FOCs in Equations (6a) and (6b).

Equation (6a) implicitly defines team 1's reaction function of talent investment, $t_1 = t_1(t_2; \theta, \sigma)$. The slope of this reaction function is

$$\frac{\partial t_1}{\partial t_2} = -\frac{\Pi_{t_1 t_2}^S}{\Pi_{t_1 t_1}^S}, \tag{7}$$

where $\Pi_{t_1 t_1}^S \equiv \partial^2 \Pi^S / \partial t_1^2 < 0$ and $\Pi_{t_1 t_2}^S \equiv \partial(\partial \Pi^S / \partial t_1) / \partial t_2$. It is easy to verify that, ceteris paribus, an increase in talent investment by team 2 increases the marginal profit of talent investment for team 1. That is, $\Pi_{t_1 t_2}^S > 0$. It follows from Equation (7) that team 1's reaction function is upward sloping $(\partial t_1 / \partial t_2 > 0)$. In response to an increase in team 2's investment, team 1 also finds it optimal to increase its investment.

It is then interesting to see how team 1 adjusts its talent investment in response to the implementation of pool revenue sharing or to a change in the revenue-pooling share (θ), all else being equal. Using the FOC in Equation (6a), we derive the following partial derivative:

$$\frac{\partial t_1}{\partial \theta} = -\frac{1}{\Pi_{t_1 t_1}^S} [-\frac{\sigma}{2} (\frac{\partial R_1}{\partial w_1} \frac{\partial w_1}{\partial t_1}) + \frac{1}{2} (\frac{\partial R_2}{\partial w_2} \frac{\partial w_2}{\partial t_1})] < 0. \tag{8}$$

The negative sign follows directly from the assumptions in Equation (2) and the second-order sufficient condition for profit maximization. Equation (8) indicates that an increase (a decrease) in the revenue-pooling share θ lowers (raises) talent investment by team 1.

Similarly, the FOC in Equation (6b) implicitly defines team 2's reaction function of talent investment, $t_2 = t_2(t_1; \theta, \sigma)$. The slope of this reaction function is

$$\frac{\partial t_2}{\partial t_1} = -\frac{\pi^S_{t_2 t_1}}{\pi^S_{t_2 t_2}}, \tag{9}$$

where $\pi^S_{t_2 t_2} \equiv \partial^2 \pi^S / \partial t_1^2 < 0$ and $\pi^S_{t_2 t_1} \equiv \partial^2 \pi^S / \partial t_1 \partial t_2$. It should be noted that the sign of $\pi^S_{t_2 t_1}$ cannot be determined unambiguously, however. If marginal profit of talent investment for team 2 increases when team 1's investment increases, that is if $\pi^S_{t_2 t_1}$ is positive, then $\partial t_2 / \partial t_1$ is positive. In this case, team 2's reaction function is upward sloping. However, if $\pi^S_{t_2 t_1}$ is negative, instead, then team 2's reaction function turns out to be downward sloping. Thus, in response to an increase in talent investment by team 1, ceteris paribus, team 2 may or may not increase its investment in player talent.

To see how team 2 adjusts its talent investment in response to a change in θ, we have from the FOC in Equation (6b) the following partial derivative:

$$\frac{\partial t_2}{\partial \theta} = -\frac{1}{\pi^S_{t_2 t_2}} \left[-\frac{1}{2} \left(\frac{\partial R_2}{\partial w_2} \frac{\partial w_2}{\partial t_2} \right) + \frac{\sigma}{2} \left(\frac{\partial R_1}{\partial w_1} \frac{\partial w_1}{\partial t_2} \right) \right] < 0. \tag{10}$$

The negative sign follows directly from the assumptions in Equation (2) and the second-order sufficient condition for profit maximization. Equation (10) indicates that, all else being equal, an increase (a decrease) in the revenue-pooling share lowers (raises) talent investment by team 2. Denote $\{t_1^S, t_2^S\}$ as the Nash equilibrium levels of skill investment for the two team types under pool revenue sharing. As in game theory, the stability of the Nash equilibrium requires that the following condition be satisfied: $\Pi^S_{t_1 t_1} \pi^S_{t_2 t_2} - \Pi^S_{t_2 t_1} \pi^S_{t_1 t_2} > 0$. We assume this condition holds.

3. A Graphical Analysis of Talent Investments

In what follows, we use a graphical approach to compare talent investments in the sharing and nonsharing cases. Figure 1 presents the situation where team 2's reaction function is downward-sloping. In the absence of revenue pooling, the two teams' reaction functions are given by the curves RF_1^N and RF_2^N, respectively. The nonpooling Nash equilibrium occurs at E^N, where talent investments by the two teams are t_1^N and t_2^N. The implementation of pool revenue sharing (or an increase in the share of pooled revenues) shifts team 1's reaction function RF_1^N leftward, say to RF_1^S,

Figure 1
The Case of a Downward-Sloping Reaction Function for a Low-Revenue
Team Type
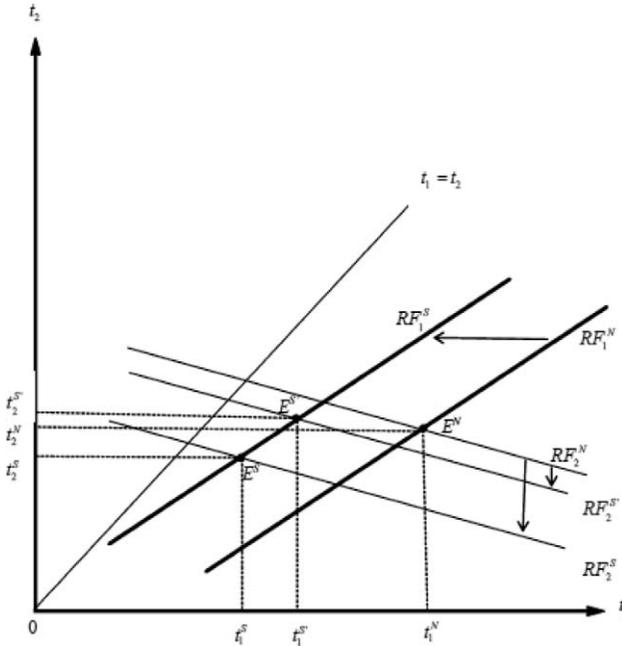
according to Equation (8). In the meanwhile, the sharing scheme shifts team 2's reaction function RF_2^N downward according to Equation (10). Figure 1 shows two possible scenarios, depending on the downward shift in team 2's reaction function.

(1)   When team 2's reaction function shifts to $RF_2^{S'}$, Nash equilibrium occurs at $E^{S'}$. As a result, team 1's investment decreases and team 2's investment increases. That is, $t_1^S < t_1^N$ and $t_2^{S'} > t_2^N$. However, this increased investment is more than offset by the decrease in investment by team 1, that is, $t_1^S + t_2^{S'} < t_1^N + t_2^N$. For the stability of the Nash equilibrium, team 2's reaction function must be flatter than team 1's. Consequently, aggregate investment in player talent decreases.

(2)   When team 2's reaction function shifts downward further to RF_2^S, the revenue-pooling Nash equilibrium occurs at E^S. Both team owners find it optimal to reduce their investments, because $t_1^S < t_1^N$ and $t_2^S < t_2^N$. Consequently, total investment decreases.

Figure 2
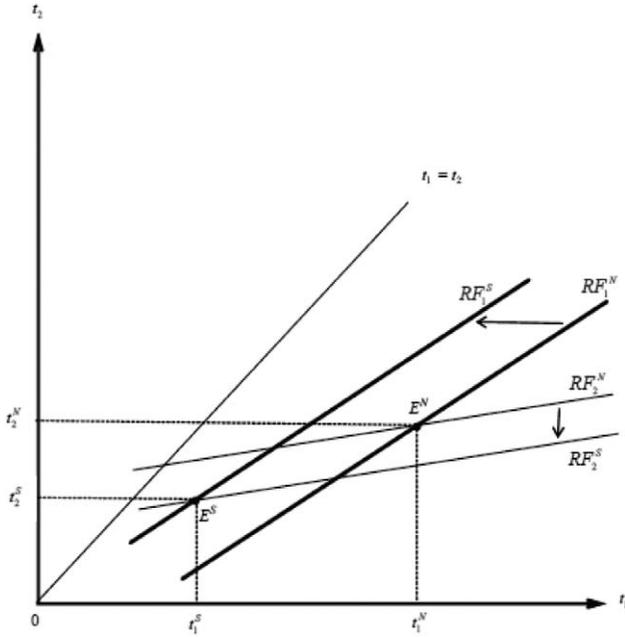**The Case of an Upward-Sloping Reaction Function for a Low-Revenue Team Type**

Figure 2 illustrates an alternative case where team 2's reaction function is upward sloping. The stability condition of the Nash equilibrium is satisfied because the slope of team 1's reaction function is greater than that of team 2's. An increase in the revenue-pooling share causes team 1's reaction function to shift leftward, say to RF_1^S, and team 2's reaction function to shift downward, say to RF_2^S. The pooling Nash equilibrium occurs at E^S. As a result, both teams reduce their talent investments to t_1^S and t_2^S, respectively. We thus have $t_1^S < t_1^N$ and $t_2^S < t_2^N$, which imply that aggregate investment in player talent decreases.

The FOCs of team 2's reaction function are unknown in theory and practice. It is perhaps the role of advanced empirical analysis to shed light on the issue. We can say that an upward-sloping reaction function for team 2 implies that revenue sharing invites moral hazard on the part of low-revenue teams. A downward-sloping reaction function for team 2 implies that a sufficient level of revenue sharing will invite moral hazard on the part of low-revenue teams, whereas a relatively low level of revenue sharing will actually induce such a team to invest more in player talent. In a more

sophisticated setting (i.e., reality), this indeterminacy may shed light on why not all low-revenue teams are blamed for engaging in moral hazard with net revenue-sharing receipts. One might think of two types of low-revenue clubs, each present in Major League Baseball, where one faces a downward-sloping reaction function and another faces either a more gradually downward-sloping reaction function or an upward-sloping reaction function. In response to the same new revenue-sharing plan, these two low-revenue team types may go different directions in terms of player investment. Indeed, Ray (2007) notes that moral hazard is not apparent among all low-revenue teams:

> The Rockies used all of the $16 million they received in 2006 revenue-sharing dollars to increase their payroll in 2007, and that certainly helped the team win this year's National League pennant. The Detroit Tigers are another success story. They used revenue-sharing dollars to attract free agents Ivan Rodriguez and Magglio Ordonez, and those players helped the Tigers climb from a team that won just 43 games in 2002 to a club that won the American League pennant last year . . . . The two biggest abusers of the system are the Florida Marlins and the Tampa Bay Rays . . . . Teams get the money and simply use it as they please. Some spend it on payroll and watch their teams improve. Others pocket the cash and watch their teams continue to [not be good].

The preceding analysis results in the following proposition:

Proposition 1: Consider the case in which (1) a higher revenue team type pays into the pool a proportion of each revenue dollar it gains in excess of the league average and (2) a lower revenue team type takes out of the pool a proportion of each revenue dollar by which it falls short of the league average. Assuming the stability of the Nash equilibrium in a sporting contest, an increase in the revenue-pooling share leads the higher revenue team type to lower its investment in player talent. The lower revenue team type may or may not increase its investment. Nevertheless, the league's total investment in player talent decreases.

The economic implications of *Proposition 1* are straightforward. Pool revenue-sharing affects the incentive structure of team investments. In determining investment in player talent, the higher revenue (or strong drawing) team type is required to pay a ''winning tax,'' whereas the lower revenue (or a weak drawing) team type receives a ''losing subsidy'' within the league. The higher revenue team that pays the luxury tax lowers its talent investment; the lower revenue team that receives the luxury subsidy has the limited financial capability to sufficiently increase its investment. The worst case scenario is when the lower revenue team pockets the money they receive from the pool without reinvesting in their players. There thus exists a potential ''moral hazard'' problem associated with skill investment by the lower revenue team type. This constitutes a major problem for MLB as pointed out by the Blue Ribbon Panel and various MLB team owners. *Proposition 1* predicts that pool revenue sharing causes the league's total expenditure for player talent to decline. Our analysis of pool revenue sharing in MLB complements the model of gate revenue

sharing in soccer or football as developed by Szymanski and Késenne (2004). The findings of these two models stand in contrast with the standard analysis of a professional sports league, which exhibits the ''invariance principle'' for gate revenue sharing (El-Hodiri & Quirk, 1971; Fort & Quirk, 1995; Vrooman, 1995). Sanderson and Siegfried (2006, p. 597) remark that ''Rottenberg recognized the possible effect of revenue sharing on the incentives to win.'' Rottenberg (1956, p. 256) himself states

> Let the total revenues of all teams in the major leagues be pooled and shared equally by all teams . . . . All teams will then be equal in capacity to bid for talent. There will be no incentive, however, for any single team to win or to assemble a winning combination. Win or lose, play badly or well, it will receive its equal slice of pie . . . . No team will be willing to spend if it cannot be assured that others will also do so . . . . A rule of equal sharing of revenue leads to the equal distribution of mediocre players among teams and to consumer preference for recreational substitutes.

Szymanski (2004) argues that the standard model of talent demand by team owners in a professional sports league is, in essence, based on the assumption of ''joint profit'' maximization. As a consequence, the optimal decisions on talent choices for team owners are independent of gate revenue transfers among teams in the sports league. Moreover, Szymanski (2004) shows that the invariance principle for gate-revenue sharing does not hold at the Nash equilibrium, in which team owners determine their optimal levels of player talent independently and noncooperatively. In analyzing the economic designs of sports competition, Szymanski (2003) proposes the use of Nash equilibrium to characterize the independent decisions of talent choice for profit-maximizing team owners in professional sports leagues.

4. Is Pool Revenue Sharing Procompetitive?

It has been widely recognized that competitive balance in a professional sports league is vital to the success of the league. Teams would have difficulties in attracting fans if they were constantly losing. Moreover, games in which two competing teams match better are likely to generate more revenues than when they do not match at all. In this section, we wish to show that competitive balance in a league depends crucially on the distribution of player talent which, in turn, depends on the incentive structure of team investments in player talent. Examining what factors determine the distribution of player talent among the competing teams in a league is of vital interest. Smaller market teams may argue that they cannot compete because their low revenue does not allow them for hiring talented players hired by larger market teams. In response to this, league authorities may decide to implement a policy that redistributes revenues among the higher and lower revenue teams. The aim of such a policy is to alter the redistribution of player talent among the teams. As shown in Section 2,

a revenue-pooling scheme may lead both team types to lower their investments in player talent. To characterize explicitly effects of pool revenue sharing on competitive balance, we adopt an example in the subsequent analysis.

4.1. Talent Investments by Team Owners

For ease of illustration, we assume that the revenue functions of the two team types under pool revenue sharing are given, respectively, by

$$R_1(\sigma w_1(t_1, t_2)) = \sigma \frac{t_1}{t_1 + t_2} \text{ and } R_2(w_2(t_2, t_1)) = \frac{t_2}{t_1 + t_2}, \tag{11}$$

and that their cost functions are $C_i = ct_i$ for $i = 1, 2$. Applying these functions to the profit-maximization models in Equations (5a) and (5b), we solve for the Nash equilibrium skill investments

$$t_1^S = \frac{(2 - \theta - \theta\sigma)(2\sigma - \theta - \theta\sigma)^2}{8(1-\theta)^2(1+\sigma)^2 c} \text{ and } t_2^S = \frac{(2 - \theta - \theta\sigma)^2(2\sigma - \theta - \theta\sigma)}{8(1-\theta)^2(1+\sigma)^2 c}. \tag{12}$$

Note that $(2 - \theta - \theta\sigma)$ and $(2\sigma - \theta - \theta\sigma)$ must be positive for t_1^S and t_2^S to be positive, where the market size parameter is strictly greater than one ($\sigma > 1$) and the revenue-pooling share is positive but is less than one ($0 < \theta < 1$). The league's total investment in player talent is

$$t_1^S + t_2^S = \frac{(2 - \theta - \theta\sigma)(2\sigma - \theta - \theta\sigma)}{4(1-\theta)(1+\sigma)c}. \tag{13}$$

The effects of an increase in θ on talent investments by the two teams and the league are

$$\frac{\partial t_1^S}{\partial \theta} = -\frac{[(2 - \theta - \theta\sigma)(1-\theta)(\sigma+1) + 2(\sigma-1)^2](2\sigma - \theta - \theta\sigma)}{8(1-\theta)^3(\sigma+1)^2 c} < 0,$$

$$\frac{\partial t_2^S}{\partial \theta} = -\frac{(1-\theta)(1+\sigma)(2 - \theta - \theta\sigma)^2 + 2(\sigma-1)(2 - \theta - \theta\sigma)(2\sigma - \theta - \theta\sigma)}{8(1-\theta)^2(1+\sigma)^2 c} < 0,$$

$$\frac{\partial(t_1^S + t_2^S)}{\partial \theta} = -\frac{(2 - \theta - \theta\sigma)(2\sigma - \theta - \theta\sigma) + 2(\sigma-1)^2}{4(1-\theta)^2(1+\sigma)c} < 0,$$

all of which are unambiguously negative. These findings confirm *Proposition 1* that pool revenue sharing has a disincentive effect on the distribution of player talent. As discussed by Szymanski (2004), the conventional model of talent choice in the sports literature is based on the assumption that total supply of talent to a league is fixed. This assumption implies that, in equilibrium, total demand for talent by the two teams is equal to the total supply of talent (denoted as T). That is, $t_1^S + t_2^S = T$.

Substituting t_1^S and t_2^S in Equation (12) into this equilibrium condition and solving for the ''market-clearing price'' of talent yields

$$c^S = \frac{(2\sigma - \theta - \theta\sigma)(\sigma - \theta - \theta\sigma)}{4(1 - \theta)(\sigma + 1)T}.$$

The league's total expenditure on player talent and the effect of a change in θ on the expenditure are given, respectively, as follows:

$$c^S T = \frac{(2\sigma - \theta - \theta\sigma)(\sigma - \theta - \theta\sigma)}{4(1 - \theta)(\sigma + 1)}; \frac{\partial(c^S T)}{\partial \theta} = -\frac{(2\sigma - \theta - \theta\sigma)(\sigma - \theta - \theta\sigma) + 2(\sigma - 1)^2}{4(1 - \theta)^2(\sigma + 1)} < 0.$$

Thus, despite the standard assumption that total supply of player talent to a league is fixed, pool revenue sharing has a negative effect on the total expenditure for talent.

We now examine how relative market sizes affect competitive balance. Regardless of whether we use the ratio or the difference measures of expected winning percentages, we find that the market size differential has a negative effect on competitive balance, ceteris paribus. To verify these results, we have from Equations (17) and (18) that

$$\frac{\partial}{\partial \sigma}\left(\frac{w_1^S}{w_2^S}\right) = \frac{4(1 - \theta)}{(2 - \theta - \theta\sigma)^2} > 0 \text{ and } \frac{\partial(w_1^S - w_2^S)}{\partial \sigma} = \frac{2}{(1 - \theta)(1 + \sigma)^2} > 0.$$

We can also show a negative effect on competitive balance by examining how market size differential affects the variance of expected winning percentages. It follows from Equation (19) that

$$\frac{\partial V}{\partial \sigma} = \frac{(\sigma - 1)}{(1 - \theta)^2(1 + \sigma)^3} > 0.$$

The findings of the analyses lead to the following proposition:

Proposition 2: For the case in which financial revenues of teams in a professional sports league are concave functions of their expected winning percentages (see Equation (11)), an increase in the revenue-pooling share not only lowers talent investments of all team owners in the league but also reduces its competitive balance, ceteris paribus. In terms of qualitative results, an increase in market size differential has the same effect as the increased pool revenue sharing.

4.2. Expected Winning Percentages and Alternative Measures of Competitive Balance

Next, we examine what effects pool revenue sharing has on competitive balance. It follows from Equation (12) that the expected winning percentage for team 1 is

$$w_1^S = \frac{t_1^S}{t_1^S + t_2^S} = \frac{(2\sigma - \theta - \theta\sigma)}{2(1-\theta)(1+\sigma)}. \tag{14}$$

Interestingly, an increase in the revenue-pooling share increases the expected winning percentage for team 1 as the following derivative demonstrates:

$$\frac{\partial w_1^S}{\partial \theta} = \frac{(\sigma - 1)}{2(1-\theta)^2(1+\sigma)} > 0. \tag{15}$$

As for the expected winning percentage of team 2, we have from Equation (12) that

$$w_2^S = \frac{t_2^S}{t_1^S + t_2^S} = \frac{(2 - \theta - \theta\sigma)}{2(1-\theta)(1+\sigma)}. \tag{16}$$

An increase in θ lowers w_2^S because

$$\frac{\partial w_2^S}{\partial \theta} = -\frac{(\sigma - 1)}{2(1-\theta)^2(1+\sigma)} < 0.$$

It is instructive to examine alternative measures of competitive balance. The first one, which is also adopted by Szymanski and Késenne (2004), measures the ratio of the expected winning percentages between the two team types. Other things (e.g., market size, labor management relations) being equal, an increase in the expected winning percentage ratio represents a decrease in competitive balance. It follows from Equations (14) and (16) that

$$\frac{w_1^S}{w_2^S} = \frac{(2\sigma - \theta - \theta\sigma)}{(2 - \theta - \theta\sigma)} \text{ and } \frac{\partial}{\partial \theta}\left(\frac{w_1^S}{w_2^S}\right) = \frac{2(\sigma + 1)(\sigma - 1)}{(2 - \theta - \theta\sigma)^2} > 0. \tag{17}$$

Pool revenue sharing lowers competitive balance because the winning percentage ratio increases.

The second measure of competitive balance is determined by the difference between the expected winning percentages of the two team types. Other things being equal, an increase in the expected winning percentage differential represents a decrease in competitive balance. It then follows from Equations (14) and (16) that

$$w_1^S - w_2^S = \frac{(\sigma - 1)}{(1-\theta)(1+\sigma)} > 0 \text{ and } \frac{\partial(w_1^S - w_2^S)}{\partial \theta} = \frac{(\sigma - 1)}{(1-\theta)^2(1+\sigma)} > 0. \tag{18}$$

Pool revenue sharing thus reduces competitive balance because the winning percentage differential increases. How does pool revenue sharing affect the variance (standard deviation) of winning percentages for the two teams? Answers to this question would have policy implications to the administrators of professional team sports leagues. Other things equal, the lower the variance in expected winning percentage, the greater the level of competitive balance in a sports league. Rottenberg (2000) remarks that ''The highest degree of uncertainty occurs when the probability that any

given team will win in any given (two-team) game is .5'' (p. 11). To answer the previous question, we first calculate the variance of expected winning percentages:

$$V = \frac{1}{2}\left[\left(\frac{t_1^S}{t_1^S + t_2^S} - .5\right)^2 + \left(\frac{t_2^S}{t_1^S + t_2^S} - .5\right)^2\right] = \frac{(\sigma - 1)^2}{4(1 - \theta)^2(\sigma + 1)}. \tag{19}$$

It follows from Equation (19) that the effect of an increase in θ on V is

$$\frac{\partial V}{\partial \theta} = \frac{(\sigma - 1)^2}{2(1 - \theta)^3(\sigma + 1)^2} > 0.$$

By this measure, pool revenue sharing unambiguously dampens competitive balance.

Another useful measure of competitive balance that has frequently been applied to professional sports leagues is the Hirfindahl-Hirschman index (HHI). This index reflects the concentration of market shares of ''strong drawing'' teams in a sports league. For the purpose of our article, we measure HHI in terms of market revenue shares of the two teams. The value of the HHI ranges from $^{1/2}$ to 1. Other things being equal, an increase (a decrease) in the HHI indicates a decrease (an increase) in the degree of competition. Using Equations (11), (12), (14), and (16), we calculate the market revenue shares $\mathrm{MRS}_i = R_i^S / (R_1^S + R_2^S)$ for the two teams as follows:

$$\mathrm{MRS}_1 = \frac{\sigma(2\sigma - \theta - \theta\sigma)}{\sigma(2\sigma - \theta - \theta\sigma) + (\sigma - \theta - \theta\sigma)}; \mathrm{MRS}_2 = \frac{(\sigma - \theta - \theta\sigma)}{\sigma(2\sigma - \theta - \theta\sigma) + (\sigma - \theta - \theta\sigma)}.$$

The resulting HHI index is

$$\mathrm{HHI} = \sum_{i=1}^{2} (\mathrm{MRS}_i)^2 = \frac{\sigma^2(2\sigma - \theta - \theta\sigma)^2 + (\sigma - \theta - \theta\sigma)^2}{[\sigma(2\sigma - \theta - \theta\sigma) + (\sigma - \theta - \theta\sigma)]^2},$$

and the effect of an increase in θ on the HHI is unambiguously positive because

$$\frac{\partial(\mathrm{HHI})}{\partial \theta} = \frac{4\sigma(2 - \theta)(\sigma + 1)^2(\sigma - 1)^2}{[\sigma(2\sigma - \theta - \theta\sigma) + (\sigma - \theta - \theta\sigma)]^3} > 0.$$

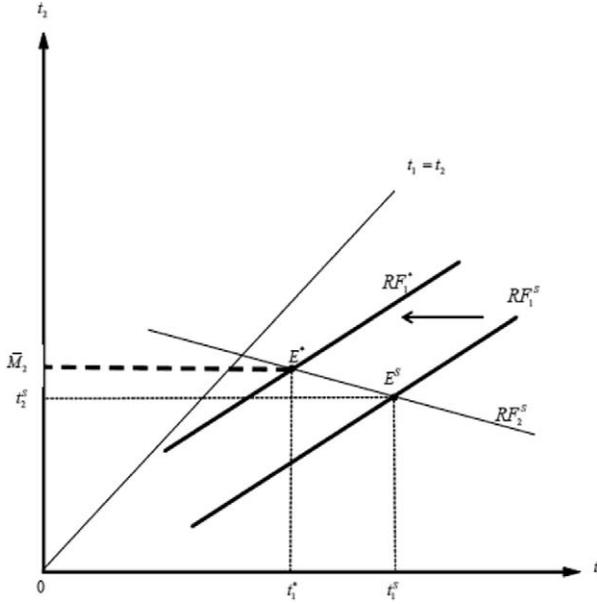Pool revenue sharing thus reduces competitive balance, as the HHI increases.

We thus have shown that the distribution of player talent in a sports league plays a crucial role in affecting the league's competitive balance which, in turn, affects the revenues of its teams. The findings of *Proposition 2* have several interesting implications. First, pool revenue sharing is not an effective policy instrument to improve the performance of a sports league (in terms of the alternative measures of competitive balance). Second, pool revenue sharing, allegedly designed to improve the performance of teams in lower revenue markets, may on the contrary hurt these teams in terms of competitive balance. Third, in empirically estimating whether pool revenue sharing has significant effects on the distribution of player talent and the degree of competitive balance, it is necessary to control for market size differential.

Differences in the sizes of sports markets may also contribute to reducing competitive balance in a league, especially when team revenues are pooled.

5. Policy Recommendations for Enhancing Competitive Balance

We have shown that pool revenue sharing is not procompetitive because the incentive structure of player skill investments is negatively affected. Recent Major League Baseball Basic Agreements (2002, 2006) indicate that the League understands the moral hazard problem underlying this outcome. The current (2002, 2006) Basic Agreement summarizes the preceding Agreement in stating, '' . . . each club shall use its revenue-sharing receipts . . . in an effort to improve its performance on the field. Each payee club, no later than April 1, shall report on the performance-related uses to which it put its revenue-sharing receipts in the preceding revenue-sharing year. Consistent with his authority under the Major League Constitution, the Commissioner may impose penalties on any club that violates this obligation.'' (p. 112). This statement advises clubs aided by revenue sharing to use the additional revenues toward additional player investment. Despite suggestive language regarding the latter policy, the subsequent two Basic Agreements have failed to effect a minimum payroll policy. In the absence of a minimum payroll, there are several examples of small market teams receiving more, in terms of revenue-sharing receipts, than they paid out to players. In 2006, the Florida Marlins cut their payroll drastically to US$14.9 million and received US$31 million in revenue-sharing receipts en route to an MLB-leading US$43 million profit. Furthermore, the Tampa Bay Devil Rays averaged US$32 million in revenue-sharing receipts between 2002 and 2006 on an average payroll of US$27 million (Ray, 2007). Many large market teams argue that such clubs are behaving in a morally hazardous manner in the anticipation of future revenue-sharing checks. We use our framework of sports contest to evaluate the effect of a mixed policy incorporating both pool revenue sharing and the requirement of a minimum team payroll. Figures 3 and 4 illustrate two cases in which the lower revenue has a negative or positive slope for its reaction function of talent investment. First, league cooperation through the redistribution of team revenues works as an implicit ''competitive balance tax'' on a higher revenue team such that its reaction function of talent investment shifts to the left (say from RF_1^S to RF_1^*). Second, team 2 receives a competitive balance subsidy and is required to increase its investment under a minimum payroll requirement. Assuming full compliance, we use $\bar{M}_2$ to reflect the minimum payroll (see Figures 3 and 4). Note that the exogenously determined amount of minimum payroll on players is given by $c\bar{M}_2$. Without the binding payroll constraint, the owner of a low-revenue team does not increase or may even reduce his investment in player talent as analyzed in Sections 2 and 3. In response to the imposition of $\bar{M}_2$, the owner of team 1 chooses to invest t_1^*.

Will the expected winning percentage of a lower revenue team type increase under the mixed policy? A comparison of expected winning percentages with and without the policy reveals that

$$\frac{\bar{M}_2}{t_1^* + \bar{M}_2} > \frac{t_2^S}{t_1^S + t_2^S}, \tag{20}$$

where $\bar{M}_2 > t_2^S$ and $t_1^* < t_1^S$. It follows that we have

Proposition 3: A league policy that combines pool revenue sharing among teams and a minimum team payroll requirement may increase the level of competitive balance in the league.

The policy mix considered thus exhibits a dual purpose. First, the minimum payroll requirement on players for each team serves as a ''leveling mechanism'' to reduce competitive imbalance resulting from the disincentive effect on investments by owners of low-revenue teams. Second, the pool revenue-sharing arrangement

Figure 4
Competitive Balance Tax and a Minimum Team Payroll (When Team Type 2's Reaction Function Is Upward Sloping)
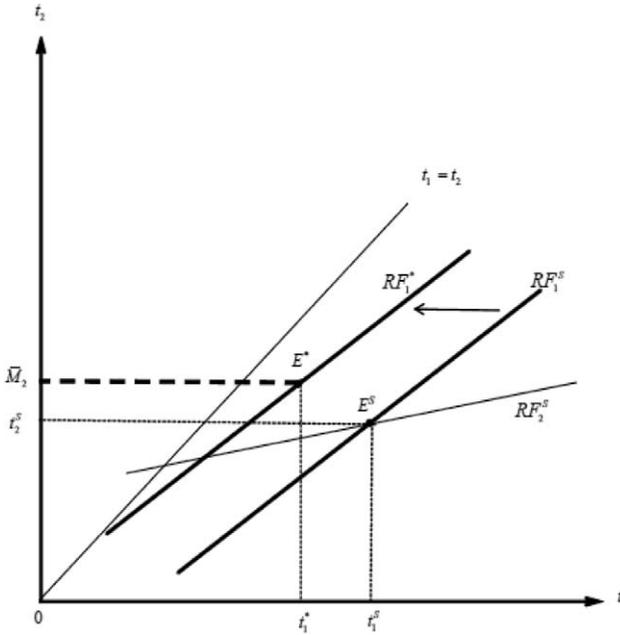
serves as a ''financing mechanism'' in that it collects funds from high-revenue teams and then transfers the funds to low-revenue teams.

6. Concluding Remarks

In this article, we present a stylized contest model to show how pool revenue sharing affects team investments in player talent within a professional sports league. Pool revenue sharing alone is found to have a negative effect on total expenditure on talent. This is due to the fact that the pooling of team revenues acts to dilute returns from talent investment. The higher revenue team that pays a winning tax lowers its investment, whereas the lower revenue team that receives a losing subsidy does not proportionately increase its investment in player talent. We further show that pool revenue sharing negatively affects the competitive balance in the league because the variance of expected winning percentages for a match increases.

We find that competitive balance in a sports league cannot be isolated from the mechanism that redistributes revenues among its teams. Revenues and hence profits serve as incentives to elicit team investment in player talent. The theoretical findings of the article have interesting implications for pool revenue sharing. It may be in the democratic interest of team owners to pool their revenues, but such a sharing arrangement unambiguously lowers total league expenditure on player talent. The trade-off between player and team interests, therefore, is an important consideration for legislators who must decide the overall appropriateness of pool revenue sharing in a sports league. Pool revenue sharing dampens the competitive nature of the sports industry as the competing teams' winning percentages diverge rather than converge. The argument that pool revenue sharing enhances the competitive balance in professional team sports to justify an exemption from the antitrust laws lacks a theoretical underpinning.

We further use the simple framework of sports contest to discuss the effects of a policy that incorporates both pool revenue sharing and a minimum team payroll requirement. Within our model, such a policy mix is found to be helpful in curbing disincentive problems resulting from pool revenue sharing. The policy mix appears to be procompetitive. However, some other problems remain. It is not clear how the revenue-pooling share (i.e., the luxury tax/subsidy) and the amount of a minimum team payroll are determined. This is an interesting issue for future research. Like any tax or price floor policy, there involves efficiency problems with the luxury tax and a minimum team payroll. There also involves compliance problems on the part of team owners in lower revenue markets. Lower revenue teams may simply pocket the money they receive from the pool without undertaking adequate investment in player talent (i.e., there are moral hazard problems). These issues on efficiency and compliance in the presence of a policy mix are beyond the scope of the present article and are presently subject to debate in literature and everyday discussion.

Notes

1. That is, the MLBPA wanted to lower the amount of revenue sharing that occurs between teams. The most notable of such attempts came in 2002, when revenue-sharing issues threatened to cause a player strike (Mackinder, 2002).

2. When θ equals zero, the profit functions in Equations (5a) and (5b) reduce to those in Equation (3).

3. This type of reaction is always true for a high-revenue team, regardless of whether revenue pooling takes place.

4. Team rivalry for revenues in a league is analogous to sibling rivalry for parental transfers within a family. Parental transfers can generate a negative effect on the supply of effort by siblings (see, e.g., Chang & Weisman, 2005).

5. Vrooman (1996) discusses the possibility that pool revenue sharing discourages team investment in player talent.

6. See, for example, Schmidt and Berri (2001) for discussions on issues related to competitive balance.

7. Schmidt and Berri (2005, 2006) examine, among other things, the evolution of baseball. They find evidence that people care more about winning and less about ''loyalty'' to their teams in the later part of the 20th century. Therefore, sport has become ''one of profit-maximizing business'' (2006, p. 222).

8. Szymanski and Késenne (2004) use these functions to analyze the case of gate revenue sharing. Revenue for a smaller market team is normalized to one times the team's expected winning percentage.

9. This is not to be confused with the current (2007–2011) Major League Baseball Collective Bargaining Agreement's official ''Competitive Balance Tax,'' which openly seeks to improve competitive balance.

10. In terms of game theory, the imposition of the constrained condition on payroll makes the owner of a low-revenue team type a ''passive'' player (i.e., a follower) in determining its investment expenditure on player talent.

11. An anonymous referee notes that teams may have an incentive to collude under the policy mix. That is, low-revenue teams may not compete with high-revenue teams in the free agent market in the presence of a payroll minimum and revenue sharing. Viewing the payroll minimum as a sunk cost, they may instead overpay low-ability free agents to meet the payroll minimum in a manner that does not greatly improve the team's talent level. Such a move would allow the team to maintain revenue-sharing flows but would fail to improve competitive balance.

12. The implementation of a minimum payroll on players is analogous to the imposition of a minimum wage for workers. For analyses on the latter topic, see, for example, Ashenfelter and Smith (1979) and Chang and Ehrlich (1985).

13. Rosen and Sanderson (2001) indicate that ''excess incentives to win can create negative externalities.'' They observe that policies such as payroll caps and revenue sharing help correct these externalities subject to a cost.

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