Revenue Sharing as an Incentive in an Agency Problem: An Example from the National Football League

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Revenue sharing as an incentive in an agency problem: an example from the National Football League

Scott E. Atkinson*
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and
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We consider a professional sports league’s use of a well-defined incentive mechanism, revenue sharing, to encourage the desired behavior of teams in the league. The incentive mechanism works by internalizing externalities that arise across agents (the team owners). We find revenue sharing to be a potentially powerful incentive scheme because in this setting it encourages an optimal distribution of resources among agents. Its effectiveness is mitigated, however, by agents who enjoy private, nonmonetary benefits that are not shared. Using data from the National Football League, we examine how well the propositions explain observed behavior in this relationship.

1. Introduction

Many problems involving incentive structures have been studied within a principal-agent framework. The literature consists primarily of theoretical derivations of optimal incentives, given varying assumptions on risk behavior and information asymmetries.1 Typically, the principal receives output from an agent in his employ, and the agent possesses better information than the principal about production. The principal’s problem is to design incentives that will encourage the agent to maximize output from given resources. Less studied has been the extension of this basic agency problem to the case of many agents. Externalities now become important if an agent’s output is affected by the output of others. With enforceable contracts the problem would disappear, since the principal could simply force actions to be taken by agents, and in this way, internalize the externalities that arise among agents. Enforcement is often unworkable, however, because the principal cannot

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1 A survey of the literature can be found in Arrow (1986).
observe the agents or does not have the information possessed by agents. Then, to paraphrase Arrow (1986, p. 1191), the question is: Without enforcement, can the principal devise some incentive scheme that will induce the agents to maximize total output?

Holmström (1982) examines the many-agents case and describes devising an incentive scheme as a moral-hazard problem that can arise even in the absence of uncertainty in output. He shows that if output is fully shared among noncooperative agents, then some form of enforcement by the principal is needed to avoid inefficient outcomes. In this article we examine professional team sports as a specific example of Holmström's model. We reformulate the theory to capture the institutional peculiarities of sports leagues and then econometrically examine several propositions that emerge from this theory. Data limitations usually prohibit empirical analysis of principal-agent theory, but for the National Football League (NFL) we are able to identify the necessary data on output, costs, revenues, and sharing rules.

The agency problem in professional team sports can be described as follows. The principal is the league comprising its member teams. A commissioner is hired by the owners to work for the league's best interests and to police certain activities of the owners. The owners, when acting apart from the league, are the agents. Each owner hires playing talent, and the total talent hired, along with its distribution across teams, determines profit. The league establishes a sharing rule that fully allocates the league's revenue among the owners.

In Holmström's formulation, there is a private, nonmonetary cost of taking action that is realized by each agent but not shared. Analogously, for the owner of a sports team there is a private, nonmonetary benefit: the enjoyment and prestige of winning contests, which is distinct from the profit that winning may generate. Holmström also discusses the principal's inability either to enforce agents' actions through direct contracts or to observe the actions. In professional team sports the league cannot directly enforce talent distribution without jeopardizing the integrity of the league and likely violating antitrust laws: noncooperative behavior among teams is essential to maintain fan interest. In addition, there is likely to be asymmetric or conflicting information among the league and owners. One owner may possess information about the level of a player's talent or how the talent contributes to his team's productivity, and the information may not be divulged to other owners for strategic reasons. The importance of strategy will increase with the private, nonmonetary benefits associated with winning. Since winning is a zero-sum game, direct attempts by the league to enforce a particular talent distribution to maximize the league's profit will fail if the private benefits of winning are large.

We proceed as follows. In Sections 2 and 3 we develop a theory of a professional sports league. To test for profit-maximizing behavior by the owners, we initially model them as profit maximizers and ignore the private, nonmonetary benefits of winning. This does not alleviate the externality problem discussed above. Increased wins of one team generate more revenue for that team, but may lower revenues of those teams that lose to it. The degree to which owners associate winners with greater profits, and hence the motivation to win, will depend on the form of the sharing rule. We examine revenue sharing, the sharing rule used by sports leagues, in Section 3 and contrast our result on the efficiency of this rule with Holmström's result on the impossibility of efficient sharing rules.

In Section 4 we explore the usefulness of this theory by estimating two distinct marginal

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2 The league does require some measure of authority simply to establish schedules and contest rules and to enforce the sharing rule voted by the owners.

3 Most other studies of professional sports leagues have considered profit-maximizing behavior. For examples, see El Hodiri and Quirk (1971), Quirk and El Hodiri (1974), Demmert (1973), and Canes (1974). El Hodiri and Quirk develop an illuminating optimal control model. They do consider briefly the possibility that utility might depend on winning, but do not favor this approach. In an analysis of the English Football League (soccer), Sloane (1971) develops a utility-maximization model but does not test it. In Section 4 we test the profit-maximization assumption.
revenue products for professional football players in the NFL.\textsuperscript{4} First, we estimate the current marginal revenue products of players to their teams under revenue sharing as currently practiced. Second, we estimate projected marginal revenue products of players to their teams that represent what the teams would realize in the absence of revenue sharing. Our results show that revenue sharing has been an effective incentive mechanism in the NFL. But we also find that owners do not behave as pure profit maximizers, and this negates some of revenue sharing’s potential benefit. Section 5 contains a brief discussion of our results with comments on how they might apply to other principal-agent problems.

2. A theory of professional sports leagues

We assume that a league comprises $n$ teams, each under separate ownership. The owners participate in a noncooperative game in which each owner chooses a level of talent to maximize his team’s profit, and the league cannot directly enforce talent levels on the owners. Profit for the $i$th team is given by total revenue received minus total cost:

$$\pi^i = TR^i - TC^i.$$  

Throughout, superscripts will denote the team, and $i = 1, \ldots, n$. The revenue generated by the $i$th team, which derives from three main sources—gate receipts and national and local broadcasting receipts—\textsuperscript{5} is given by

$$R^i(w(i), A^i).$$  

Here $w(i)$ is a vector of all teams’ total number of wins, $(w^1, \ldots, w^n)$, $t$ is a vector of all teams’ talents, $(t^1, \ldots, t^n)$, and $A^i$ is the population of the $i$th team’s home city. The function $R^i(\cdot)$ is assumed to be strictly concave in $t$. The revenue received, $TR^i$, differs from $R^i$ because of revenue sharing as explained below. We assume that talent is a homogeneous input that contributes to a team’s wins. Although the type of talent differs across positions, we assume that these different types of talent can be aggregated.\textsuperscript{6}

Revenue generated by the $i$th team depends not only on its performance, but also on the performance of all other teams that it plays. We assume that $t$ is continuous, and the revenue function is twice continuously differentiable, with first partials given as:

$$\frac{\partial R^i}{\partial w^j} > 0, \quad \frac{\partial R^i}{\partial A^i} > 0.$$  

Winning\textsuperscript{7} and greater population increase a team’s revenues. Also

$$\frac{\partial R^i}{\partial w^j} \leq 0, \quad j = 1, \ldots, n, \quad j \neq i,$$

because this measures both the closeness of the contest and the performance of the opposing team. If the fans’ enjoyment of a contest increases with closely matched teams, then when $w^j$ is greater than $w^i$, increasing $w^j$ may decrease team $i$’s revenue. But $R^i$ may increase with $w^j$ if individuals are interested in watching a winning team, whether it be the home

\textsuperscript{4} Scully (1974) was the first to measure marginal revenue products of professional athletes in his study of monopoly power in baseball. Beyond the sports literature (cf. Casing and Douglas, 1980; Raimondo, 1983; Scott, Long, and Somppi, 1985; Sommers and Quinlon, 1982), the only other attempt that we are aware of to estimate marginal revenue products directly is in Frank (1984), who examines salespeople and professors. Ours is the first attempt to include the effects of revenue sharing.

\textsuperscript{5} We omit all other revenues, including revenues from concessions and parking. For the average NFL team these other revenues are about 8–9% of total revenue. Institutional details on the importance of different receipts, revenue-sharing arrangements, free agency, and so on for the major sports leagues can be found in Stanley (1985).

\textsuperscript{6} This assumption is standard in the literature. See El Hodiri and Quirk (1971), Quirk and El Hodiri (1974), Demment (1973), and Canes (1974).

\textsuperscript{7} We assume that lowering the uncertainty of outcome by increasing wins will not make $\frac{\partial R^i}{\partial w^j}$ negative: fans want their team to win.
or opposing team; the desire to see a good team may outweigh the desire to see a close contest.

We allow for revenue sharing by having each team retain a fraction $\alpha$ of its own revenues, where $0 \leq \alpha \leq 1$, and then receive $1/n$ of a revenue pool made up of all teams' revenues, net of what each retains. Using (2) and taking into account this revenue sharing, we substitute for $TR^i$ in (1) to obtain the profit for team $i$, which becomes

$$
\pi^i = \alpha R^i(w(t), A^i) + \frac{1 - \alpha}{n} \sum_{j=1}^{n} R^j(w(t), A^j) - ct^i,
$$

(5)

where the variable costs, $ct^i$, depend on the amount of talent hired by the owner at wage $c$ per unit. The parametric wage is determined in the market for talent described below. We omit any fixed costs of administration, training, managing, staging a game, and depreciation of player contract acquisition costs.\(^8\) Note that we do not attempt to model any bargaining that may occur between owners and players.

The $i$th owner's problem is to choose $t^i$ to maximize (5), where all other $t$'s are fixed. The first-order condition for a maximum is

$$
\alpha \sum_{j=1}^{n} \frac{\partial R^i}{\partial w^j} \frac{\partial w^j}{\partial t^i} + \frac{1 - \alpha}{n} \sum_{j=1}^{n} \sum_{k=1}^{m} \frac{\partial R^j}{\partial w^k} \frac{\partial w^k}{\partial t^j} - c = 0.
$$

(6)

Condition (6) implies that the $i$th owner will hire a stock of playing talent whose marginal cost is equal to its marginal revenue product.

The owner imparts control over the technical aspects of building the team to the team's coach, whose objective is to maximize the team's winning percentage. Each coach has his own philosophy for producing a winning team, and this is depicted as a production process where wins are the output and the talents at each of $m$ positions are the inputs. Let wins be represented by a twice-differentiable, strictly quasi-concave production function,

$$
w^i = w^i(t^{i_1}, \ldots, t^{i_m}),
$$

(7)

where $t^{ik}$ is the talent of the $i$th team at position $k$, ($k = 1, \ldots, m$), and

$$
\sum_{k=1}^{m} \theta^k t^{ik} = t^{i*}.
$$

(8)

The $\theta^k$ are conversion factors that allow talent to be aggregated across positions, and $t^{i*}$ is the solution to the owner's problem. The coach takes the talent of the other teams as given, and these talents are suppressed in (7). We assume that the marginal products at each position are positive and decreasing. This production function, which we estimate in Section 4, is permitted to vary across coaches so that the value of a particular player who possesses a fixed amount of talent may vary across coaches. The $i$th coach maximizes (7) over $t^{ik}$ subject to (8). The maximum is achieved when marginal products, normalized by the conversion factors, are equated across all positions.

Next, we show how the wage rate, $c$, is determined. We can write owner $i$'s demand for talent as

$$
t^i = t^i(c, \alpha, A^i, n).
$$

(9)

\(^8\) This assumes that all revenues are shared in the same proportion. This is a simplification. The NFL splits gate receipts 60%-40% between the home and away teams, but national television revenues, almost 75% of the total, are split equally among all teams. We account for this difference in the empirical section.

\(^9\) In actuality, for tax purposes, player costs are treated differently from labor costs of other businesses. The acquisition costs of player contracts (aside from salary costs) are capitalized and depreciated over the useful lives of the contracts. See Weistart and Lowell (1979) for details on taxation of professional sports teams.
Summing (9) across teams yields the market demand. We assume that each team hires the maximum number of players, \( p \), allowed by league rules. This seems to be universally true in sports leagues. The market supply curve relates the talent of any pool of \( np \) players to the wage rate. Under the assumption of no competing leagues, the curve is horizontal at talent’s reservation wage, since the reservation wage per unit of talent should vary insignificantly among the groups of \( np \) players.\(^{10}\) It then becomes vertical at the total talent of the best available \( np \) players, \( T \), provided that the very best \( np \) players offer their talent in the player market. We expect this to occur because of the efficient filtering system for players from grade school to the professional ranks, and because once players are drafted, they invariably pursue the opportunity to play. The intersection of the market demand and market supply curves determines the wage per unit of talent and the total league talent hired. If this intersection occurs along the vertical section of the supply curve, the best \( np \) players will be hired by the league, and the wage will be at least the reservation wage.

3. Revenue sharing as an incentive mechanism

- Since the primary incentive scheme used in sports leagues is revenue sharing, we evaluate its properties. First, define \( MRP^i \) as the total marginal revenue product generated by \( t^i \), and \( MRP^j_i \) as the portion of \( MRP^i \) realized by team \( j \). From (6), \( MRP^j_i \) with no revenue sharing (\( \alpha = 1 \)) is

\[
\sum_{j=1}^{n} \frac{\partial R^i}{\partial w^j} \frac{\partial w^j}{\partial t^i} ;
\]

(10)

\( MRP^j_i \) with equal revenue sharing (\( \alpha = 0 \)), after slight rearranging, is

\[
\frac{1}{n} \sum_{j=1}^{n} \frac{\partial R^i}{\partial w^j} \frac{\partial w^j}{\partial t^i} + \frac{1}{n} \sum_{j^k=i} \sum_{k=1}^{n} \frac{\partial R^j}{\partial w^k} \frac{\partial w^k}{\partial t^i} ;
\]

(11)

and \( MRP^i \) is

\[
\sum_{j=1}^{n} \frac{\partial R^i}{\partial w^j} \frac{\partial w^j}{\partial t^i} + \sum_{j^k=i} \sum_{k=1}^{n} \frac{\partial R^j}{\partial w^k} \frac{\partial w^k}{\partial t^i} .
\]

(12)

Expression (12) is realized by the league regardless of the degree of revenue sharing.

Expression (10) reflects the own effect on the revenue team \( i \) generates by hiring talent, while (12) includes this own effect and the external effects on the rest of the league. Revenue sharing internalizes these external effects. Expression (11) shows that the own and external effects are weighted equally under equal revenue sharing. Expression (10) also suggests that in the absence of revenue sharing, there is likely to be a positive relationship between the wins of team \( i \) and the revenues it receives if a team’s own wins are most influential in generating its revenues, \( \partial R^i/\partial w^i > \partial R^i/\partial w^j \), since \( \partial w^i/\partial t^i = -\sum_{j^k=i} \partial w^j/\partial t^i \) owing to the zero-sum nature of the game. But expression (11) shows that with equal revenue sharing, \( \partial R^i/\partial w^i \) becomes less important, and the \( i \)th team may actually receive more revenue by losing to another team whose revenue it will share.

Proposition 1. If owners behave as profit maximizers, then the wage rate per unit of talent will equal \( MRP^j_i \) for all \( i \). Under equal revenue sharing \( MRP^j_i \), and thus the wage rate, will be equal to \( 1/n \) of the \( MRP^i \).

\(^{10}\) We expect the reservation wage per unit of talent to be relatively low. Consider that in professional football only 35% of the players active in 1980 had college degrees, and only 11% of these degrees were in higher salaried occupations. This formulation, however, does take into account that a more talented player has a higher reservation salary than a less talented player owing to increased public exposure.
Proof. This follows immediately from first-order condition (6) and expressions (11) and (12). Q.E.D.

We assume that the league’s objective is to maximize league profit, or the joint profits of the owners. Maximum profit could be attained if the league enforced the optimal distribution of talent from the available pool.

Definition. The optimal distribution of talent for the league is the vector, \( t^* \), that solves the problem:

\[
\max_{t^1, \ldots, t^n} \sum_{i=1}^{n} R'(\cdot) - c_o \sum_{i=1}^{n} t^i \tag{13}
\]

\[
\text{subject to } \sum_{i=1}^{n} t^i \leq T,
\]

where \( c_o \) is the reservation wage.

The reservation wage follows from the backwards L-shaped supply curve for talent and the assumption that under centralization the league would behave as a monopsonist. The optimal distribution may be consistent with parity or very unequal teams, depending on fan preferences for close contests and home-team victories. We shall refer to the solution to (13) as the enforced solution in contrast to the noncooperative solution, where the distribution is determined by individual owners’ actions.

Proposition 2. If owners behave as profit maximizers, and if \( T \) would be hired in either the enforced solution or the noncooperative solution, then the noncooperative solution under equal revenue sharing maximizes league revenues by yielding the optimal distribution of talent.\(^{11}\)

Proof. When we denote by \( \lambda \) the Lagrange multiplier for the constraint in (13), necessary and sufficient conditions for a maximum of (13)—recall that \( R'(\cdot) \) is strictly concave in \( t \) for all \( i \)—are that the \( MRP^t \)'s are equal to \( c_o + \lambda \), or that (12) is equal to \( c_o + \lambda \) for all \( i \). The multiplier \( \lambda \) is the shadow price of talent for the league (which could be zero). Under noncooperation and equal revenue sharing, an equilibrium\(^{12}\) requires that (11) equal \( c \) for all \( i \), which is the same as (12) equal to \( nc \) for all \( i \). Thus, under either enforcement or noncooperation with equal revenue sharing, \( MRP^t \)'s are equal for all \( i \). Moreover, in each case we have \( \sum_{i=1}^{n} t^i = T \). By strict concavity of \( \sum_{i=1}^{n} R'(\cdot) \) there is a unique point on the hyperplane defined by \( \sum_{i=1}^{n} t^i = T \) such that marginal revenue products are equal. Thus, the enforced and noncooperative solutions must be equivalent. Q.E.D.

The league’s profit under enforcement will generally exceed the league’s profit under noncooperation and equal revenue sharing even though, with the same talent distribution, the league’s revenue is the same. This is so since the competitively determined wage, \( c \), can be no lower than the monopsony or reservation wage, \( c_o \). Also, while increased revenue sharing when \( \alpha > 0 \) increases the league’s revenue, individual team revenues may increase or decrease. This has important implications for the league’s choice of revenue sharing as an incentive mechanism, and we return to this in Section 5.

Proposition 2 appears to be at odds with Holmström’s (1982, p. 326) Theorem 1. In

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\(^{11}\) We expect \( T \) to be hired in either case since the reservation wage will be relatively low (see footnote 10). The empirical work supports this assumption.

\(^{12}\) Since we assume that each owner maximizes with respect to his team’s talent, while taking other teams’ talents as given, the solution to the decentralized problem is a Nash equilibrium. In equilibrium all \( MRP^t \)'s are equal to \( c \), and \( \sum t^i = T \).
our terminology, he shows that if league revenues are fully allocated to the teams, there is
no sharing rule that yields an optimal distribution of talent. There are two reasons why, in
contrast with Holmström’s result, we find equal revenue sharing to be efficient. First, we
assume away the private, nonmonetary benefit from winning, and teams face no private,
nonmonetary costs of action. Adding nonmonetary benefits to an owner’s objective function
would add a term representing the marginal benefit of winning to the first-order condition,
and the proof would not apply. Second, we have a fixed supply of talent, while Holmström
does not fix the analogous aggregate action available to his agents. Without a fixed supply
of talent, we would obtain Holmström’s result, as the league would hire an inefficient level
of talent. For reasons explained earlier, however, assuming a fixed supply of talent is
appropriate for models of professional sports leagues.

Proposition 3. Assume that increases in \( t^i \) increase \( R^i(\cdot) \) more than \( R^j(\cdot) \), for all \( j \neq i \). Then
increased revenue sharing decreases league costs by lowering the competitive wage, \( c \).

Proof. In equilibrium

\[
\sum_{i=1}^{n} t^i(\alpha, c, A', n) = T.
\]

Using the implicit function theorem, we obtain

\[
\frac{\partial c}{\partial \alpha} = -\sum_{i=1}^{n} \frac{\partial t^i}{\partial \alpha} \left/ \sum_{i=1}^{n} \frac{\partial t^i}{\partial c} \right. > 0,
\]

where the sign follows from comparative-statics results for each owner’s maximization
problem.\(^\text{14}\)

4. Empirical analysis

We now empirically investigate the validity of this theory for explaining the principal-
agent relationship found in the NFL, which practices nearly equal revenue sharing (see
footnote 8). On the basis of our model, for pure profit-maximizing owners equal revenue
sharing results in: (1) a wage rate equal to \( 1/n \) of \( MRP^i \) (Proposition 1); (2) an optimal
distribution of talent (Proposition 2); and (3) a wage rate below what would be realized in
the absence of revenue sharing (Proposition 3). To examine the validity of (1), we estimate
current marginal revenue products and compare them with salaries. These estimates also
will provide information about the optimal distribution in (2). To examine (3) we estimate
projected marginal revenue products that would apply in the absence of revenue sharing.
The empirical work builds on Scully’s (1974) original work, but revenue sharing and the
nature of football require substantive modifications.

☐ **Estimating the production function.** Estimating the production function for wins, (7),
will provide the marginal product terms in (6). In football the offense performs as one tightly
knit unit, as does the defense. For example, while the yardage gained by a running back
reflects his talent, it also reflects the effectiveness of the offensive linemen. We can account
for these interdependencies among positions by specifying a production function that includes
interaction terms between performance at the various positions.

\(^{13}\) We are grateful to an anonymous referee for making this point.

\(^{14}\) Total differentiation of (6) yields \( \partial t^i/\partial \alpha > 0 \) and \( \partial t^i/\partial c < 0 \). This represents the change in owners’ demands,
and as demands change, the market wage also changes. El Hodiri and Quirk (1971) obtain a result similar to
Proposition 3. In their model, however, revenue sharing has no effect on the distribution of talent, so that they do
not obtain our Proposition 2. By admitting more general revenue functions, we can allow both the wage and
distribution to change in our model.
Model and data. Each observation used in the estimation of (7) represents a game played during either the 1980 or 1981 season. Each game yields two observations, one for each team. The variable WIN takes the value 1 if the team won or 0 if it lost, and WIN is explained by each team’s talent as measured by various performance statistics.

We obtained performance data from the Pro Football Weekly Almanac (1981, 1982). We included all statistics available on individual games as explanatory variables, except where both an average and total statistic measured performance at a single position (for example, total rush and average rush). Because we had only limited a priori knowledge about which statistic most accurately measured performance, we based our choice between average and total statistics on their ability to explain wins. We also included a variable measuring coaching ability (COACH), which is a 1 if the team’s coach had been named Coach of the Year any time between 1965 and 1981. We expect that an exceptional coach will be able to combine the same inputs more efficiently than an average coach.

We chose interaction terms on the basis of expected interdependencies among positions. For example, to measure the quarterback’s dependence on his offensive line, an interaction term between the quarterback performance statistics and the number of sacks was constructed on the assumption that the offensive line’s performance can be adequately measured by sacks. (A similar statistic was constructed for running backs.) Variables are defined in Table 1.

Results. Casual observation suggests a home-field advantage in producing wins. To test for the advantage we estimate separate production functions for home and away teams. We test the equality of slope coefficients by using a likelihood ratio test, and we reject the null hypothesis of equality at the .05 level for each of the specifications of (7) estimated below.

Using a logit specification, we estimate separate production functions for home and away teams. The results of estimating several models of the home-team production function and the away-team production function appear in Table 2. Models 1 and 2 are linear, with COACH included in model 2 but not in model 1. Model 3 includes all the relevant

<table>
<thead>
<tr>
<th>TABLE 1</th>
<th>Variables Used in the Production Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variable</td>
<td>Definition</td>
</tr>
<tr>
<td>RUSH</td>
<td>Total yards gained in game rushing.</td>
</tr>
<tr>
<td>PASS</td>
<td>Average yards gained per attempt, defined as total yards gained passing/number of attempts.</td>
</tr>
<tr>
<td>INT</td>
<td>Total passes intercepted by the opposing team.</td>
</tr>
<tr>
<td>QBSK*</td>
<td>20 — total time quarterback was sacked by the opposing team.</td>
</tr>
<tr>
<td>FG PCT</td>
<td>Average successful field goal percentage, defined as field goals made/field goals attempted.</td>
</tr>
<tr>
<td>QINT</td>
<td>Total passes intercepted by the defense.</td>
</tr>
<tr>
<td>OQBSK</td>
<td>Total times opposing quarterback was sacked by the defense.</td>
</tr>
<tr>
<td>OTYD*</td>
<td>1000 — total yards given up by the defense.</td>
</tr>
<tr>
<td>AVEPUNT</td>
<td>Average punting yardage, defined as total yards punted/number of punts.</td>
</tr>
<tr>
<td>COACH</td>
<td>1 = Coach of the Year between 1965 and 1981</td>
</tr>
<tr>
<td></td>
<td>0 = otherwise.</td>
</tr>
</tbody>
</table>

* We specified QBSK and OTYD this way simply so that the marginal revenue product of the positions corresponding to these performance statistics would be positive and ordered correctly.

15 Gains in efficiency could be achieved by taking account of possible correlation among the errors when estimating the two production functions. There may be correlation in the errors for a particular team over the two seasons, and the disturbances for a particular game are likely to be negatively correlated because of the win-lose nature of the game. We did not implement methods that account for these possible correlations.

16 The production function was initially specified as a quadratic function, but all squared terms were insignificant. We estimate a single production function for all teams.
### TABLE 2  Estimates of Production Functions for Wins for Home Teams and Away Teams*

<table>
<thead>
<tr>
<th>Variable</th>
<th>Home Teams Model</th>
<th></th>
<th></th>
<th>Away Teams Model</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>RUSH</td>
<td>.023* (6.04)</td>
<td>.024*</td>
<td>-.023</td>
<td>.014* (4.32)</td>
<td>.015*</td>
<td>-.071</td>
</tr>
<tr>
<td>PASS</td>
<td>.271* (3.73)</td>
<td>.265*</td>
<td>.297*</td>
<td>.271* (3.66)</td>
<td>.283*</td>
<td>.284*</td>
</tr>
<tr>
<td>INT</td>
<td>-.716* (-5.12)</td>
<td>-.706*</td>
<td>-.230</td>
<td>-.718* (-4.97)</td>
<td>-.735*</td>
<td>-.279</td>
</tr>
<tr>
<td>QBSK</td>
<td>.368* (3.73)</td>
<td>.348*</td>
<td>.135*</td>
<td>.388* (4.09)</td>
<td>.366*</td>
<td>.600</td>
</tr>
<tr>
<td>FGPT</td>
<td>.499 (.408)</td>
<td>.411</td>
<td>1.06*</td>
<td>.102* (2.89)</td>
<td>.108*</td>
<td>.907</td>
</tr>
<tr>
<td>OINT</td>
<td>1.05* (1.22)</td>
<td>1.06*</td>
<td>4.28*</td>
<td>.724* (2.99)</td>
<td>.722*</td>
<td>.838</td>
</tr>
<tr>
<td>OQBSK</td>
<td>.375* (3.81)</td>
<td>.371*</td>
<td>-.179</td>
<td>.379* (4.18)</td>
<td>.373*</td>
<td>-.410</td>
</tr>
<tr>
<td>OTYD</td>
<td>.007* (3.16)</td>
<td>.007*</td>
<td>.055*</td>
<td>.007* (4.09)</td>
<td>.007*</td>
<td>-.497</td>
</tr>
<tr>
<td>AVFUNT</td>
<td>.063* (2.18)</td>
<td>.068*</td>
<td>.073*</td>
<td>.024* (3.61)</td>
<td>.025*</td>
<td>.029</td>
</tr>
<tr>
<td>COACH</td>
<td>.754* (2.19)</td>
<td>.758*</td>
<td>.522</td>
<td>.496 (1.52)</td>
<td>.496</td>
<td></td>
</tr>
<tr>
<td>RUSH*OTYD</td>
<td>.0005 (.895)</td>
<td>.0002</td>
<td>.164</td>
<td>.004 (-3.94)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PASS*OTYD</td>
<td>.001 (3.68)</td>
<td>.037</td>
<td>.478</td>
<td>.004 (.599)</td>
<td>.404</td>
<td>.599</td>
</tr>
<tr>
<td>RUSH*QBSK</td>
<td>.154* (2.98)</td>
<td>.073*</td>
<td>.024</td>
<td>.025 (.921)</td>
<td>.025</td>
<td>.029</td>
</tr>
<tr>
<td>PASS*QBSK</td>
<td>-.193* (-3.94)</td>
<td>.008</td>
<td>.157</td>
<td>.004 (1.53)</td>
<td>.004</td>
<td></td>
</tr>
<tr>
<td>INT*QBSK</td>
<td>.016 (.561)</td>
<td>.022</td>
<td>.002</td>
<td>.001 (.931)</td>
<td>.001</td>
<td></td>
</tr>
<tr>
<td>OTYD*INT</td>
<td>.0002 (1.07)</td>
<td>.008</td>
<td>.002</td>
<td>.001 (.931)</td>
<td>.001</td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>-.19 51* (-2.58)</td>
<td>-.194*</td>
<td>-.257</td>
<td>-.178* (-2.67)</td>
<td>-.188*</td>
<td>-.126</td>
</tr>
<tr>
<td>R² between observed and predicted Log of likelihood function</td>
<td>.584</td>
<td>.592</td>
<td>.610</td>
<td>.537</td>
<td>.540</td>
<td>.560</td>
</tr>
<tr>
<td>Log of likelihood function</td>
<td>-.146.2</td>
<td>-.143.7</td>
<td>-.136.12</td>
<td>-.157.99</td>
<td>-.156.8</td>
<td>-.148.72</td>
</tr>
<tr>
<td>Global chi-squared</td>
<td>315.5(9)</td>
<td>320.5(10)</td>
<td>335.6(20)</td>
<td>284.9(9)</td>
<td>287.3(10)</td>
<td>303.5(20)</td>
</tr>
<tr>
<td>Chi-squared test that interaction terms as whole are insignificant</td>
<td>15.1(10)</td>
<td>16.2(10)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Asymptotic t-ratios in parentheses.
* Coefficient is significant at .05 level with a two-tailed test.
* Defined as $-2 \cdot (\text{log likelihood of restricted model} - \text{log likelihood of unrestricted model})$, which is asymptotically distributed as $\chi^2$, where degrees of freedom, in parentheses, equal the number of restrictions.
* Significant at .05 level.
* Not significant at .05 level.
interaction terms listed in Table 1.\textsuperscript{17} Coefficients in models 1 and 2 have the expected signs, and all but FGPTC for home teams and AVEPUNT and COACH for away teams are significant at the .05 level or better. As reported in Table 2, the log-likelihood value for model 2 is not significantly less than that for model 3, whose interaction terms as a whole are insignificant at the .05 level on the basis of a chi-squared test. In addition, the coefficients of QBK and OINT for away teams and RUSH, INT, QBK, and OTYD for both home and away teams become insignificant; some coefficients' signs change; and the interaction terms PASS*QBK and RUSH*INT for away teams and PASS*QBK and OTYD*OINT for home teams are significant. All of this indicates a lack of independent variation between the interaction terms and their components. Since the component terms cannot be identified independently of the interaction terms, we avoid an arbitrary specification by rejecting model 3.

Model 2 performs quite well in predicting wins of a professional football team; the $R^2$ between observed and predicted values for this model is .592 for home teams and .540 for away teams. From the estimated coefficients from model 2 we are able to compute the estimated marginal products for positions and for players at these positions when playing at home and away.

\begin{itemize}
\item \textbf{Estimating revenues.} To estimate the marginal revenue terms in (6), we estimate revenue functions for the two principal components of revenue: gate receipts and national television receipts. Gate receipts are approximately equal to the average ticket price multiplied by attendance. All but one team (Baltimore Colts) played to sellout crowds during our study period; thus, increasing attendance through wins is not an issue. With one exception, however, as a team wins more often, owners have been able to raise average ticket prices to increase gate receipts without reducing attendance.

Using data on ticket prices from the \textit{New York Times}, we calculated prices for each team (\textit{TICKET}) for the 1981 and 1982 seasons. The Minnesota Vikings were excluded since they moved to an indoor stadium before the 1982 season. One approach would be to explain \textit{TICKET} by the number of games won by the home team in the past season (\textit{PASTWIN}) plus all other variables that might influence \textit{TICKET}, such as stadium capacity, substitute activities available in the city, available transportation to the stadium, and the owner's pricing policy. Complete enumeration and accurate measurement of all such variables would be difficult. But since these variables did not change from 1981 to 1982, we estimate a first-difference equation. We regress the difference in \textit{TICKET} for each team between 1981 and 1982 on the corresponding difference in \textit{PASTWIN}, and we obtain the following ordinary least squares equation:

\begin{equation}
\Delta \text{TICKET} = .846 + .119 \Delta \text{PASTWIN}, \quad R^2 = .15, \quad (14)
\end{equation}

\begin{equation}
(3.76) \quad (2.2)
\end{equation}

where $t$-statistics are in parentheses. The intercept represents the effect of inflation on ticket prices. The coefficient on $\Delta \text{PASTWIN}$ has the anticipated sign and is significant at the .05 level. Improving a season record by one win allows an owner to increase average ticket prices by $1.12. Given the NFL average stadium size and eight-home-game schedule, one added win increases the next season's receipts by $62,155.

Previous studies of basketball and baseball that have calculated marginal revenue products have omitted television revenues. To do the same for football would engender substantial bias. In 1977 the NFL and the networks negotiated a 5-year $350 million contract; in 1982 the new contract skyrocketed to $2.2 billion. Television revenues now exceed gate receipts

\textsuperscript{17} We also estimated models incorporating various other combinations of relevant interaction terms. Because a comparison of these estimated models with model 2 yielded the same conclusions as the comparison between models 2 and 3 discussed in the text, we chose not to report the results of these estimations.
by approximately 250%. But since television revenues are shared equally among the 28 teams, using shared revenues to estimate marginal revenue products would yield zero variance in the dependent variable. What we need is a measure of each team's contribution to total league television revenues.

Greater television viewership translates into more expensive advertising time and more lucrative NFL television contracts. Teams contribute to a favorable contract by bolstering viewership through improvements in the quality of televised contests. Nielsen ratings, which measure the percentage of households viewing a televised program, are relied on by networks, advertising agencies, and television stations to assess a program's worth. Regressing these ratings on the variables suggested by (2) yields the "marginal rating contribution" of each team's wins and, hence, each team's contribution to total ratings. This marginal rating can be translated into marginal revenue by multiplying by the dollar value of a rating point.\footnote{18}

Ratings were obtained from the A.C. Nielsen Company for 144 televised time slots during the 1980 and 1981 seasons. On the basis of equation (2), the following covariates are used to explain a rating ($RAT$) in a given time slot:

$\text{LNWINS} =$ natural log of the average wins per team over the past four weeks of all teams playing in the time slot;\footnote{19}

$\text{LNCLOSE} =$ the natural log of the absolute value of the difference in win records over the past eight weeks of the teams involved in a contest averaged across all games in the time slot;

$\text{SUPER} =$ the average number of superstars per team playing in the time slot;\footnote{21}

$\text{PRIME} =$ a binary time slot variable ($1 =$ prime-time slot; $0 =$ other); and

$\text{POP} =$ the average SMSA population (1980 Census) of all home cities for teams in the time slot.

The variable $\text{PRIME}$ was included to control for the effect a prime-time slot may have on the rating owing to a greater potential audience. We were unable to employ the first-differencing technique used in equation (14), since the observations refer to time slots, and the corresponding time slots in the two years comprise different teams.\footnote{22}

The ordinary least squares results are:

$$
RAT = 12.45 + 3.03LNWINS - .047LNCLOSE + .022SUPER \\
\quad (11.65) \quad (3.02) \quad (-.274) \quad (.083)
$$

$$
+ 5.47\text{PRIME} + .110\text{POP}, \quad R^2 = .47, \quad (15) \\
\quad (9.34) \quad (9.28)
$$

where $t$-values are in parentheses. The coefficients of $\text{LNWINS}$ and $\text{PRIME}$ are of the expected sign and significant at the .01 level. Note that the coefficient on closeness of contest

\footnote{18}{Detailed data on the value of a rating point are not available. But dividing the total television contract by the total rating points for televised games yields $165,000 as an estimate of a rating point's value in 1982.}

\footnote{19}{Several games are televised simultaneously on one network in different parts of the country, but no information exists about where a game was televised. Thus, we average the variables over all teams playing during the same time slot on the same network. Since no a priori information exists on how past team performance affects fan viewing, we employed stepwise regression, where records over all past periods up to 16 weeks were included as possible explanatory variables. Our results suggest that the average fan weights most heavily the team's records in the past four weeks in his decision to view.}

\footnote{20}{We use the difference in win records over the past eight weeks, instead of four weeks we used for $\text{LNWINS}$ (see footnote 19), in an attempt to provide a better dispersion of data points in the regression. The variance of $\text{LNCLOSE}$ computed by using records over the past four weeks was so small (.51) as to provide little explanatory power to the equation. The variance of $\text{LNCLOSE}$ when using records over eight weeks was 2.10.}

\footnote{21}{A superstar is a player possessing charisma in addition to talent, and the measure is based on a random survey of football fans at the University of Wyoming. We omitted superstars from the theory for brevity.}

\footnote{22}{We initially included a dummy variable ($0 = 1980; 1 = 1981$) to account for time trends in ratings, but found it to be insignificant, and subsequently dropped it from the equation.}
is not significantly different from zero, which suggests that the uncertainty of an outcome does not marginally influence viewership. As stated previously, LNCLOSE does not vary significantly across observations, and this limits its power to explain wins. This lack of variation reflects both the aggregation across games in a time slot and the equality that had already been achieved in the NFL. In 1981 43% of the teams finished within one game of .500, while over 70% finished within two games of .500. Combined with the results reported in equation (15), this suggests that the NFL has achieved a near revenue-maximizing level of equality among teams (assuming a concave revenue function).

Prime-time slots are determined by teams’ records the previous season: the better a team’s record, the more prime-time slots it is assigned the following year. To complete the estimation of marginal ratings, we estimated the effect of past records on the probability of a team’s appearing in a prime-time slot. Although there was a significant relationship between the two, the contributions to the marginal revenue products from appearances in prime-time slots were negligible. Since including prime time in the analysis does not change any of our results, we shall omit it for reasons of brevity.

**Computing current marginal revenue product.** We now have all the necessary estimated relationships to show that the current marginal revenue products of talent on team \( i \) for television revenues are zero, while for gate receipts they are small. To do this, we use the following zero-sum-game relationship:

\[
\frac{\partial w^i}{\partial t^k} = -\sum_{j \neq i}^n \frac{\partial w^j}{\partial t^k}.
\]

(16)

In discrete terms if team \( i \) wins one more game by increasing \( t^k \) (its talent at position \( k \)), the opposition must lose one more game.

Considering television first, we calculate the effect of both \( w^i \) and \( w^j, j \neq i \), on ratings in one time slot. From (15) we have

\[
\frac{\partial RAT}{\partial (w^i + w^j)} = \frac{\partial RAT}{\partial w^i} = \frac{\partial RAT}{\partial w^j} = 3.03/(w^i + w^j)
\]

which follows from the insignificant coefficient on LNCLOSE and the summation of \( w^i \) and \( w^j \) before the application of the natural logarithm. Since the dependent variable in (15) is the total rating for a game, the coefficient 3.03 on LNWins reflects both the own and the external effects of an increase in \( w^i \), as defined in (10) and (12). Therefore, \( 3.03/(w^i + w^j) \) represents the marginal effect of \( w^i \) for a single game on league ratings.

We find the portion of \( t^k \)'s MRP\( ^i \) from television by multiplying \( 4 \times \frac{\partial RAT}{\partial w^i} \) (a win affects RAT for four weeks) by \( \frac{\partial w^i}{\partial t^k} \) and \( 4 \times (\partial RAT/\partial w^j) \) by \( \frac{\partial w^j}{\partial t^k}, \forall j \neq i \), and multiplying both resulting products by the value of a rating point. Because all games are potentially televised, we sum over all \( j (j \neq i) \). This portion of \( t^k \)'s MRP\( ^i \) is equal to

\[
4 \left[ \frac{\partial RAT}{\partial w^i} \frac{\partial w^i}{\partial t^k} + \frac{\partial RAT}{\partial w^j} \sum_{j \neq i}^n \frac{\partial w^j}{\partial t^k} \right] \times \text{(value of a rating point)}.
\]

(17)

From equation (16) and the equality between \( \frac{\partial RAT}{\partial w^i} \) and \( \frac{\partial RAT}{\partial w^j} \), the expression in (17) must necessarily be zero.

Although these zero marginal revenue products for television are intuitively appealing, they depend on the insignificant role of close contests. Nearly all games are televised, or at least stations are given the option of televising them. If team \( i \)'s viewership increases, it will most likely be at the expense of another's viewership. Likewise, one team's placement in a prime-time slot implies another's displacement with near zero effect. If increasing the close-

\text{23 We assume that } \frac{\partial RAT}{\partial w^k}, \forall k \neq i, j, \text{ equals zero. This assumption does not alter our conclusions.}
ness of the contest did, in fact, play a role in increasing viewership, improvement of team \( i \) at the expense of team \( j \) could bolster the ratings and the television contract; current \( MRP \)'s from television would then be nonzero.

Since gate receipts are split 60%-40% instead of equally across teams (see footnote 8), current marginal revenue products from gate receipts are equal to

\[
.6 \sum_{j=1}^{n} \frac{\partial R^j}{\partial w^j} \frac{\partial w^j}{\partial t^i} + .4 \sum_{k=1}^{n} \sum_{j=1}^{n} \frac{\partial R^j}{\partial w^k} \frac{\partial w^k}{\partial t^i},
\]

(18)

where \( R^j \) is team \( j \)'s gate receipts. Assuming that \( \frac{\partial R^j}{\partial w^j} = \frac{\partial R^k}{\partial w^k}, \forall j, k \), from (14),\(^{24} \)

we can use (16) to simplify (18):

\[
.2 \frac{\partial R^j}{\partial w^j} \frac{\partial w^j}{\partial t^i}.
\]

(19)

The value of \( \frac{\partial R^j}{\partial w^j} \) is calculated from (14) and stadium capacity, while \( \frac{\partial w^j}{\partial t^i} \) is calculated from the estimated production function using model 2 in Table 2.

In computing marginal revenue products the performance of the rushing unit can be adequately measured by \textit{RUSH} and that of the passing unit by \textit{PASS} and \textit{INT}.\(^{25} \)

On the other hand, the skills of the offensive line and the entire defense are more difficult to measure. Therefore, we confine our calculation of marginal revenue products to the rushing and passing units. The marginal products of these units for each team when playing at home are estimated by using model 2 in Table 2. The marginal contribution of the \( k \)th position to a win for a single game is given by \( \beta_k p_i (1 - p_i) \), where \( \beta_k \) is the coefficient on the performance variable for the \( k \)th position from model 2 and \( p_i \) is the estimated probability of winning evaluated at the mean of position \( k \) for team \( i \) in the 1981 season. Multiplying (19) by the total performance in 1981 for the rushing (passing) unit at home gives the estimated current marginal revenue products from gate receipts for the unit playing at home in 1982.

We use a similar procedure to compute the estimated current marginal revenue products of the units when playing away games. The home and away marginal revenue products are summed to arrive at the current marginal revenue products from gate receipts for a unit in 1982.

Estimated marginal revenue products from gate receipts for the rushing units range from $46,139 to $152,660 with a mean of $104,890. Since the estimated portion of marginal revenue products from television was zero, the current marginal revenue products (which are the sum of gate-receipts and television marginal revenue products) are simply those from gate receipts. Total salaries paid to the rushing units in 1982 ranged from $464,500 to $1,097,100, with a mean of $737,100. We found similar disparities between current marginal revenue products and salaries for the passing units. By Proposition 1 a necessary condition for profit-maximizing behavior is that salaries equal current marginal revenue products. With salaries approximately seven times greater than current marginal revenue products, we fail to accept profit maximization as the sole motivation for the owners' behavior.

\(^{24} \)This assumption implies equal stadium capacities, and it allows us to derive (19), which can be calculated from our previous estimates. Calculating (18) would require knowing the terms \( \frac{\partial w^j}{\partial t^i} \), \( j \neq i \), but our estimates do not yield \( \frac{\partial w^j}{\partial t^i} \) disaggregated by the positions that we use below. Assuming equal stadium capacities does not alter our conclusions; the largest stadium has 23% more capacity than the average, so that the marginal revenue products reported below could be 23% greater at most.

\(^{25} \)The rushing unit is defined as all running backs, offensive halfbacks, and fullbacks. The total performance for this unit is then the sum of yards gained at these positions on a team. The passing unit is defined as quarterbacks, wide receivers, and tight ends. The performance for this unit is the average passing yardage (\textit{PASS}) for the year \( \times \) 16 games per season and total interceptions for the entire year. Marginal product terms were calculated separately for each performance measure of the passing unit and then summed.
Casual observation and other writers (Sloane, 1971; Hunt and Lewis, 1976; Demsetz and Lehn, 1985) suggest that owners derive utility from other results beside profit. The most obvious result is winning, which we have termed the private, nonmonetary benefit. For an owner who maximizes utility as a function of profit and wins, an additional positive term will appear in (6) that accounts for the marginal utility of wins. This owner may then hire a stock of playing talent whose marginal cost is greater than its $M_{RP}^j$, and this could explain the difference between current marginal revenue products and salaries.

Next consider Proposition 2, which states that an optimal distribution of talent is a necessary condition for profit-maximizing behavior. Although we have not found evidence of strict profit-maximizing behavior, this does not rule out the possibility that the league still has achieved an optimal distribution as defined by (13). Moreover, the evidence indicates that the league has moved toward this distribution. Stanley (1985) has shown that revenue sharing has moved the league toward parity over the last two decades, and we previously indicated that the results reported in equation (15) suggest that this observed parity maximizes revenue.

Since talent appears to be optimally distributed, the current marginal revenue products calculated above are those that would obtain under profit-maximizing behavior. To examine Proposition 3 we compare these current marginal revenue products with projected marginal revenue products, that is, those that would obtain in the absence of revenue sharing. To calculate projected marginal revenue products we must estimate the own marginal revenue terms in (10) for television revenues. We can use equation (14) to calculate the own marginal revenues from gate receipts.

☐ Estimating own marginal television revenue. The left-hand side of equation (15) uses ratings attributed to both teams involved in a contest. In the absence of revenue sharing, team $i$ could bargain individually with the network, and we would expect it to receive the value of its contribution to total ratings. No information exists on the separate components of each rating or the amount a team would be paid in the absence of revenue sharing. Therefore, splitting a rating between pairs of contesting teams requires an additional procedure.

Let $RAT^k$ equal that part of the rating attributed to team $k$, $k = i, j$, so that $RAT^i + RAT^j = RAT^{ij}$, the observed rating for the contest. Assuming that $\partial RAT^{ij} / \partial w^i$ is equal to $\partial RAT^i / \partial w^i$, we can use the partial derivative of (15) with respect to $w^i$ to represent the effect on $RAT^i$ of increasing both $w^i$ and $w^j$:

$$\frac{\partial RAT^{ij}}{\partial w^i} = \frac{\partial RAT^i + RAT^j}{\partial w^i} = \frac{\partial RAT^i}{\partial w^i} + \frac{\partial RAT^j}{\partial w^i} = \frac{\partial RAT^i}{\partial w^i} + \frac{\partial RAT^j}{\partial w^i}. \tag{20}$$

To find own marginal revenue products we must split $\partial RAT^{ij} / \partial w^i$ into its component parts so that $\partial RAT^i / \partial w^i$ can be multiplied by $\partial w^i / \partial t^i$ and $\partial RAT^j / \partial w^j$ can be multiplied by $\partial w^j / \partial t^j$.

This decomposition cannot be obtained from the Nielson ratings; an alternative procedure involves estimating relative weights from attendance figures. Although football games sell out, some individuals who purchased tickets do not attend, and these “no-shows” are recorded. We hypothesize that stadium audiences and television audiences will react similarly to wins of the home and opposing teams in their decision to attend or to view the game. Therefore, regressing “no-shows” on $w^i$ and $w^j$ and taking the ratio of their coefficients give an approximation of the ratio of $\partial RAT^i / \partial w^i$ to $\partial RAT^j / \partial w^j$.

Fifty-two games were chosen from the 1980 and 1981 seasons where no-show information was available and weather did not affect the decision of individuals to attend. We computed the wins of the home and away teams in the same manner as in the previous
regression. No-shows as a percentage of tickets sold (NOSHOW) was the dependent variable.\textsuperscript{26} Statistical results are
\begin{equation}
\begin{aligned}
\text{NOSHOW} &= .233 - .13\text{LNHWINS} - .07\text{LNAWINS}, \\
R^2 &= .35, \\
(6.26)(-3.09) &= (-2.12)
\end{aligned}
\end{equation}
where $t$-statistics are in parentheses and $\text{LNHWINS}$ and $\text{LNAWINS}$ are the logarithms of home-team and visiting-team wins, respectively. We estimate that $\partial R^h/\partial w^i$ is approximately 1.9 times larger than $\partial R^h/\partial w^j$ for teams where $w^i = w^j$. This ratio decreases (increases) as $w^i$ becomes relatively larger (smaller).

\section*{Computing projected own marginal revenue product.}
In the absence of revenue sharing, team $i$’s projected own marginal revenue from winning derives from its own television revenue and its own gate receipts. The own marginal revenue of $w^i$ from television is the product of three terms: (1) the fraction of $\partial R^i/\partial w^i$ attributed to $i$ from (21); (2) $4 \times (\partial R^i/\partial w^i) = (4 \times 3.03)/(w^i + \bar{w})$ from (15), where $\bar{w}$ is an average of wins of team $i$’s opponents over a season (and the factor 4 appears again because a win affects $RAT$ for four weeks); and (3) the dollar value of a rating point. Note that the form of both (15) and (21) implies that the better (worse) a team is, the lower (higher) its own marginal revenue. The marginal revenue of $\bar{w}$ from television is equal to the dollar value of a rating point multiplied by $[(4 \times 3.03)/(w^i + \bar{w}) - (\partial R^i/\partial w^i)]$. The contribution of gate receipts to team $i$’s own marginal revenue is .119 (from equation (14)) times stadium capacity times 8, the number of games played at home.

The marginal-product and total-performance figures for home and away appearances are the same as those used above to calculate the current marginal revenue products from gate receipts. Projected marginal revenue products of the passing and rushing units for each team in the NFL are presented in columns (1) and (2) of Table 3. The projected marginal revenue products exceed the current ones reported above in the text by a wide margin. This result requires clarification. Our projected marginal revenue products apply in the absence of revenue sharing and at the actual talent distribution. But we expect that as revenue sharing is relaxed, the distribution will change; hence, marginal revenue products will change. Less revenue sharing will cause talent to flow toward (away from) teams with high (low) projected marginal revenue products. Given strictly concave revenue functions, the high (low) marginal revenue products will decrease (increase) as the team gains (loses) talent. In the limit no revenue sharing results in equal own marginal revenue products across teams that lie somewhere between the low and high projected marginal revenue products in Table 3. This is consistent with Proposition 3, since this intermediate marginal revenue product still exceeds current ones by a wide margin.

\section{Discussion}
Our principal-agent theory predicted that for pure profit-maximizing owners, equal revenue sharing results in: (1) a wage rate equal to $1/n$ of $\text{MRP}^i$; (2) an optimal distribution of talent; and (3) a wage rate below what would be realized in the absence of revenue sharing. We failed to find pure profit-maximizing behavior on the part of NFL owners, as postulated in Proposition 1. An alternative hypothesis is that owners are utility maximizers interested in both profit and the private, nonmonetary benefits associated with winning. This is sup-

\textsuperscript{26} We initially included superstar charisma and closeness of contest as independent variables, but owing to their inability to explain no-shows and their minimal effect on the ratio of the coefficients on the other independent variables, we do not report these regressions. The insignificance of these additional variables is consistent with the earlier proposition that an optimal level of equality has been achieved, especially since this data set is disaggregated.
Table 3
Projected Annual Marginal Revenue Products for the Rushing and Passing Units in Thousands of Dollars

<table>
<thead>
<tr>
<th>Team</th>
<th>Marginal Product of Rushing Unit</th>
<th>Marginal Product of Passing Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atlanta Falcons</td>
<td>1,440.427</td>
<td>962.533</td>
</tr>
<tr>
<td>Baltimore Colts</td>
<td>6,971.337</td>
<td>2,869.477</td>
</tr>
<tr>
<td>Buffalo Bills</td>
<td>1,693.319</td>
<td>1,106.493</td>
</tr>
<tr>
<td>Chicago Bears</td>
<td>3,040.597</td>
<td>1,143.556</td>
</tr>
<tr>
<td>Cincinnati Bengals</td>
<td>623.042</td>
<td>623.865</td>
</tr>
<tr>
<td>Cleveland Browns</td>
<td>2,277.321</td>
<td>1,631.578</td>
</tr>
<tr>
<td>Dallas Cowboys</td>
<td>514.902</td>
<td>447.167</td>
</tr>
<tr>
<td>Denver Broncos</td>
<td>983.605</td>
<td>830.417</td>
</tr>
<tr>
<td>Detroit Lions</td>
<td>1,423.343</td>
<td>923.712</td>
</tr>
<tr>
<td>Green Bay Packers</td>
<td>1,659.648</td>
<td>901.154</td>
</tr>
<tr>
<td>Houston Oilers</td>
<td>1,992.004</td>
<td>1,008.670</td>
</tr>
<tr>
<td>Kansas City Chiefs</td>
<td>1,105.358</td>
<td>896.365</td>
</tr>
<tr>
<td>Los Angeles Rams</td>
<td>1,757.529</td>
<td>947.338</td>
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<tr>
<td>Miami Dolphins</td>
<td>1,045.956</td>
<td>821.068</td>
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<tr>
<td>Minnesota Vikings</td>
<td>913.683</td>
<td>811.166</td>
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<tr>
<td>New England Patriots</td>
<td>3,309.827</td>
<td>1,508.472</td>
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<tr>
<td>New Orleans Saints</td>
<td>2,575.131</td>
<td>1,183.473</td>
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<td>1,690.823</td>
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<td>1,798.125</td>
<td>827.364</td>
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<td>1,388.967</td>
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<td>981.798</td>
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<tr>
<td>San Francisco 49’ers</td>
<td>808.136</td>
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</tr>
<tr>
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<td>1,290.277</td>
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<td>1,911.950</td>
<td>1,436.652</td>
</tr>
<tr>
<td>Washington Redskins</td>
<td>2,299.723</td>
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</table>

Porter observed that salaries significantly exceed current marginal revenue products and that they have a Pearson correlation of .6 with performance that is significant even at the .01 level. As owners compete for good players, salaries are bid up. In the absence of pure profit-maximizing behavior, revenue sharing’s effect on talent distribution and salaries is ambiguous. Nevertheless, we note that revenue sharing has moved the league toward an optimal distribution, and that, in accordance with Proposition 3, the marginal revenue products under equal revenue sharing are well below those in the absence of revenue sharing.

We conclude that for the NFL, revenue sharing has desirable properties, although its impact is mitigated by behavior consistent with the utility-maximizing hypothesis. But what can be said about revenue sharing as an incentive scheme in other environments? Although every principal-agent problem will have unique features, we can make some general observations based on our model. Consider why revenue sharing is not used more extensively in other professional team sports. While increased revenue sharing increases league profit, some teams’ revenues will decrease. If enough team owners expect reduced profit, revenue sharing will not be adopted. Unlike football, baseball and basketball teams rely heavily on gate receipts and local broadcasting, and they seldom have sell-out games. Therefore, owners in these sports see an opportunity to increase revenues by increasing their own wins, and not anticipating the lower wages under revenue sharing, they have little interest in a revenue-
sharing scheme. Of course, they cannot all be winners; but in trying to be, they are likely to bid up the wage rate.27

How useful is revenue sharing in other principal-agent problems? Our theory illustrated that revenue sharing’s effectiveness in sports is dependent on the fixed supply of talent and the hypothesis that owners behave as profit maximizers and ignore the private, nonmonetary benefits of winning. On the basis of our empirical work, we rejected this hypothesis, which suggests that private, nonmonetary benefits are important and may mitigate revenue sharing’s effectiveness. In other settings the private, nonmonetary costs of agents’ actions may also mitigate the effectiveness of revenue sharing, a result that is consistent with Holmström’s work. Nevertheless, revenue sharing is sometimes observed.

References


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27 In 1980 player salaries averaged over all positions in professional baseball, basketball, and football were $143,000, $186,000, and $43,000, respectively.